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RESEARCH OF ECONOMIC GROWTH IN THE CONTEXT OF SUSTAINABLE DEVELOPMENT: NEURAL NETWORK APPROACH

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Abstract. Analysis of the ecological situation in the world suggests that ensuring economic growth of any country should be based on the principles of sustainable development. The question of the relationship between the dynamics of GDP and the degree of pollution requires a detailed study. The relationship between economic growth and the amount of emissions based on statistics of Ukraine, Poland, Germany and Lithuania is shown. The amount of emissions is one of the factors influencing economic growth, so neural networks are constructed in the article that can be used to predict the amount of emissions for countries under the World Bank classification by the income level. Also, various factors that have the greatest impact on the predicted rate of CO2 are analyzed in the article. This analysis allows selecting a set of independent variables that can provide a better prediction of the studied parameters and make appropriate economic decisions in order to achieve economic growth in a sustainable development.

Keywords: economic growth, sustainable development, ecological balance, neural networks.
JEL classification: O44, E27.

Introduction

Economic growth is an extremely complex phenomenon. Famous economists and authors of economic growth theories do not claim to create a comprehensive and uni-

versal theory because each theory or model have appropriate assumptions and abstractions that allow to highlight and explore various aspects of economic growth. The main purpose of economic growth is to increase the economic benefits, which improve people's lives, creating a stable favorable socio-political situation in the country, increasing its international prestige. Economic growth is important to society because it gives an increase in the surplus product that is the only source of production development, consumption improvement, science, culture and education development. Only economic growth creates the conditions for solving the problem of limited resources, only developing economy has the ability to meet the new needs of society and to implement programs to combat environmental pollution without losses for current consumption. Overall, economic growth is an indicator of the economic power of the country. Economic growth is closely related to the amount of harmful emissions and, therefore, it is important to study how economic growth influences on the amount of CO2 emission.

The object of this paper is the economic growth in the context of sustainable development: neural network approach.

The aim of this work is the research of economic growth in the context of sustainable development, the study of relationship between economic growth and the amount of emissions for several countries, analysis of factors influencing on emissions using neural networks and the identification of the main problems of the transition of Ukrainian economy to sustainable development.

The aim is achieved by means of the following key tasks:

- explore the concept of economic growth in the context of sustainable development;
- analyze the relationship between economic growth and emissions for individual countries;
- use neural networks to analyze the impact of various factors that affect the CO2 emissions;
- identify the main obstacles to the transition of Ukrainian economy to sustainable development.

The concept of economic growth in the context of sustainable development

Economic growth is the main macroeconomic aim, the indicator of national economic development. It is defined as the increase of the national income value. The most common measures of economic growth are: 1) an increase of real GDP over time; 2) an increase of real GDP per capita; 3) an increase of real GDP per person employed.

The rates of GDP growth is a sufficiently accurate indicator of the national economy effectiveness. In order to show the efficiency of the economy and living standards, the GDP per capita is also used. The third of the above mentioned measures (per person employed) reflects the efficiency of the national economy; it is a kind of social productivity indicator.

In recent years, there have been serious doubts about the desirability of economic growth for countries that already have achieved prosperity. Basis for these doubts is a series of interconnected arguments against growth, such as the following:

- Pollution. Opponents of growth are primarily concerned about environmental degradation. All costs of economic growth arise because the production process only converts natural resources, but it does not utilize them fully. Practically, everything

that goes into production returns to the environment as waste. The greater economic growth and higher standards of living, the more waste should be absorbed in the environment. In any society that has achieved prosperity economic growth can only meet the increasingly insignificant needs with increasing threat of environmental crisis. Therefore, some economists believe that economic growth must be purposefully restrained;

- No guarantees. Workers of any level fear that their accumulated skills and experience can be obsolete with the growth of technological progress;
- Economic growth and human values. The critics of economic growth also put forward a number of arguments in favor of the fact that economic growth cannot bring us "a good life". Specifically, economic growth means industrialization and mass production that give no fun to the employee and the alienation of workers from vital decision making.

Given the above mentioned facts and ecological situation in the world, it can be stated that ensuring of economic growth of any country should be based on the principles of sustainable development. A modern competitive national economy formation in transformation period causes the relevance of the methodology development problem for long-term economic growth in terms of ecological and economic balance, i.e. sustainable development. Such interaction of the environment and human factors should be considered within a single eco-economic system on any level and combine economic, natural and social processes that are interrelated.

A wide range of theoretical and methodological issues of environmentally sustainable development of the world is the object of the latest scientific research and numerous publications of Ukrainian and foreign scientists. In modern scientific publications, there is an increasing interest to the problem of sustainable development, i.e., that "meets the needs of the current generation and does not undermine the ability of future generations to meet their own needs" (Gryniv, 2001; Shevchuk, 2006; Melnyk, 2007; etc.). Researchers analyze the principles and ways of sustainable development achieving, offer models of environmental management, which application should promote the economic growth and living standards improvement in the long-term. In the course of such studies, the question of the relationship between the dynamics of GDP and the degree of pollution requires careful research.

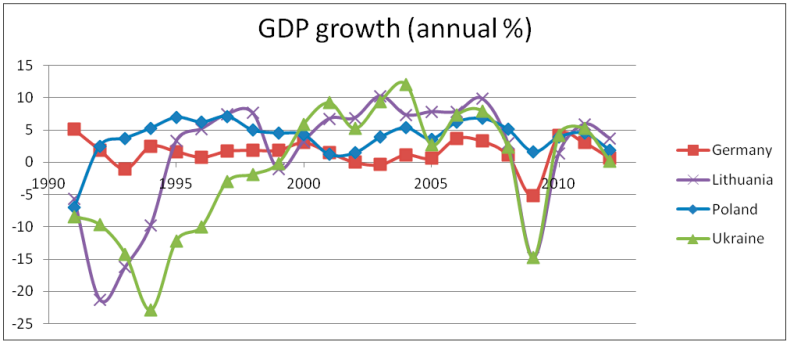
The relationship between economic growth and emissions

Researches of the relationship between economic growth and harmful emissions have been conducted by many scientists. In particular, David Cohen argues the close relationship between economic growth and carbon emissions in his article (Cohen, 2012). Karnjana Sanglimsuwan also researched the relationship between CO2 emission and GDP based on econometric models (Sanglimsuwan, 2011). Ali Acaravci and Ilhan Ozturk in their paper "On the Relationship between Energy Consumption, CO_2 Emissions and Economic Growth in Europe" examined the causal relationship between carbon dioxide emissions, energy consumption and economic growth by using autoregressive distributed lag (ARDL) bounds testing approach of co-integration for nineteen European countries (Acaravci *et al.*, 2009).

Next, the research of the relationship between economic growth and the impact on the environment in some countries based on World Bank statistics is presented.

Figure 1 filed charts of GDP change rate in Ukraine, Poland, Lithuania and Germany for the years 1991-2012.

Figure 1. Dynamics of the GDP change rate from 1991 to 2012

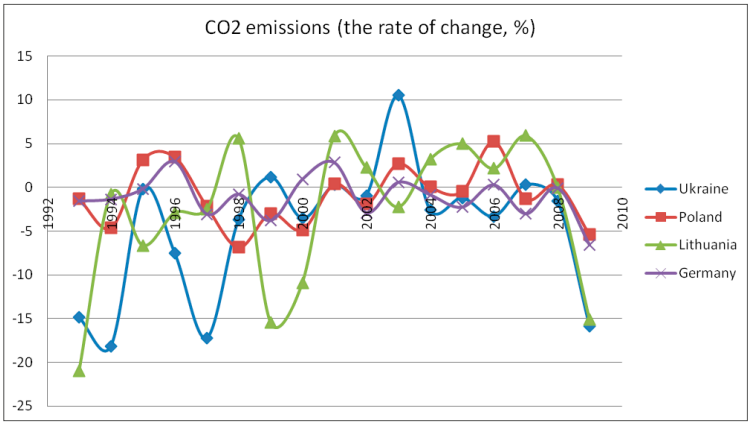


Source: The World Bank (2013)

As it can be seen from the graph for all countries in 2009, there was a significant slowdown in GDP growth, which was associated with the effects of the global financial crisis of 2008.

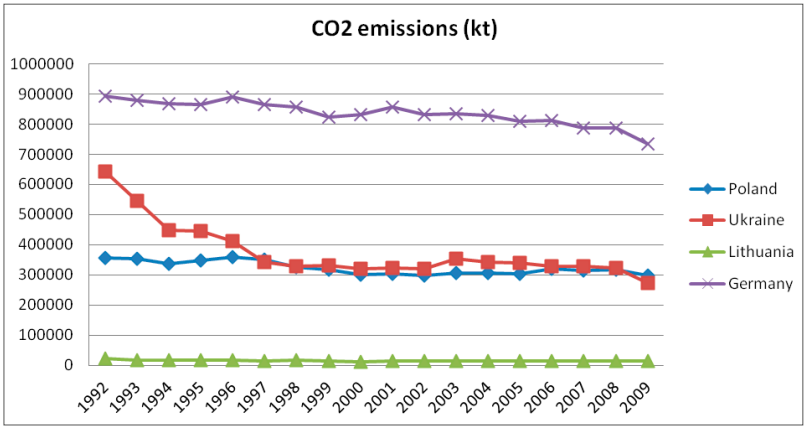
Economic growth of countries is relevant with dynamics of harmful emissions. Figures 2-4 show a comparative analysis of the harmful emissions change rate, harmful emissions in tons and CO2 emissions (metric tons per capita). Figure 2 shows that in Germany there was a steady emissions change rate, whereas in Ukraine changes were rapid. Figures 3 and 4 show that the lowest emissions observed were in Lithuania, and the largest emissions in Germany, which shows that this country is one of the largest industrial countries in the world (the higher value of industrial production is only in the USA and Japan). Ukraine and Poland have almost identical emissions.

Figure 2. Dynamics of the rate of CO2 emissions from 1993 to 2009



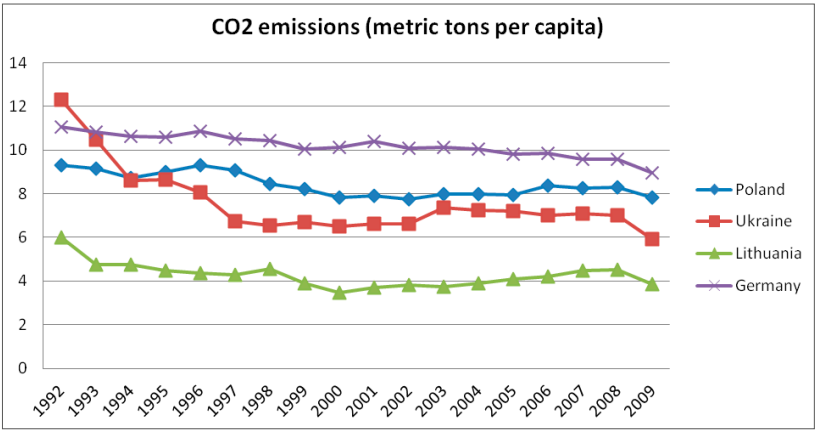
Source: The World Bank (2013)

Figure 3. The volume of CO2 emissions (kt) from 1992 to 2009



Source: The World Bank (2013)

Figure 4. Dynamics of CO2 emissions (metric tons per capita) from 1992 to 2009

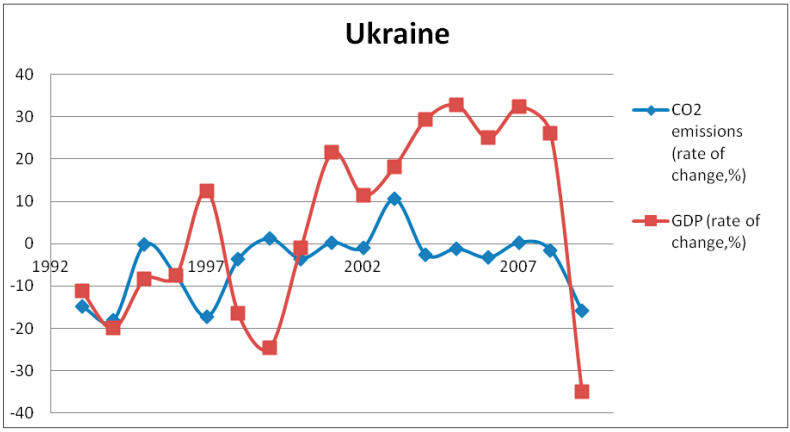


Source: The World Bank (2013)

As it can be seen from all the Figures, there was a simultaneous decrease in GDP and emissions in 2009 due to the close direct relationship between economic growth and harmful emissions. In particular, *Figure 2 strongly suggests that the dominant reason for the drop in CO2 emissions after 2007 was the large drop in GDP.*

Study of the GDP and emissions dynamics in Ukraine demonstrates the presence of persistent correlation between these two indicators (see Figure 5).

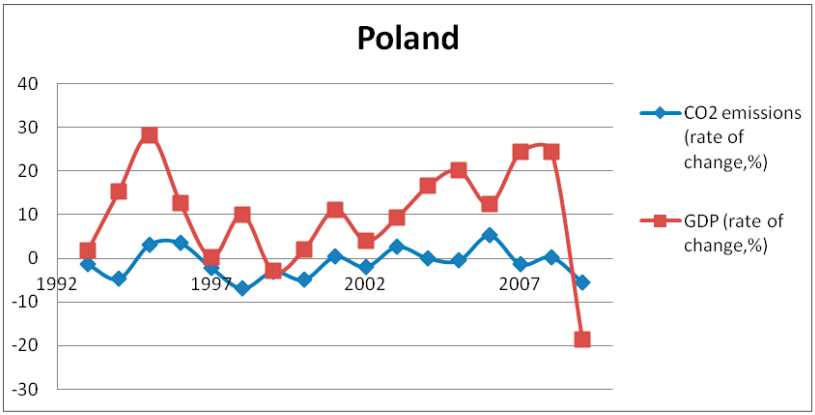
Figure 5. Dynamics of CO2 emissions and GDP (rate of change, %) in Ukraine



Source: The World Bank (2013)

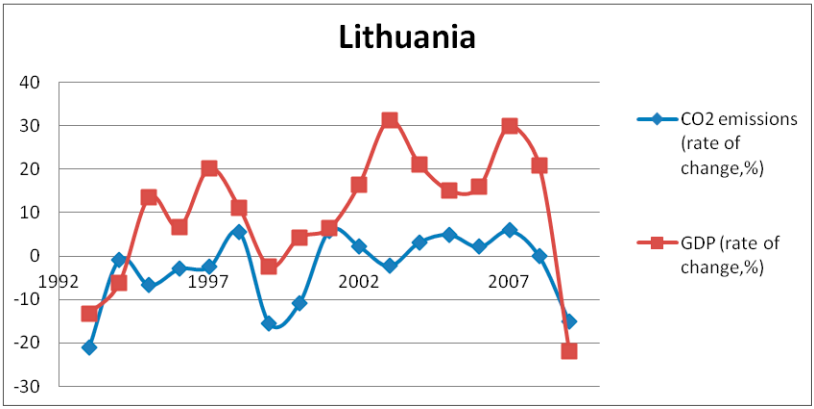
The trend towards the growth of emissions during the economic growth took place in Poland and Lithuania (Figures 6 and 7).

Figure 6. Dynamics of CO2 emissions and GDP (rate of change, %) in Poland



Source: The World Bank (2013)

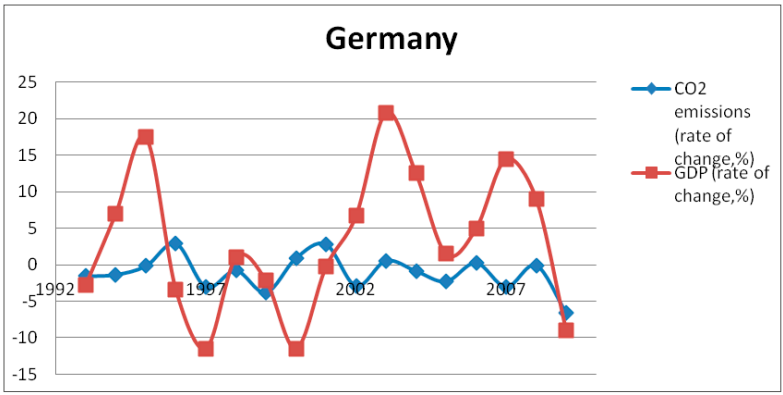
Figure 7. Dynamics of CO2 emissions and GDP (rate of change, %) in Lithuania



Source: The World Bank (2013)

Loose relationship was observed in Germany because this country has a policy of investment in clean technologies (Figure 7).

Figure 8. Dynamics of CO2 emissions and GDP (rate of change, %) in Germany



Source: The World Bank (2013)

Using correlation and regression analysis, basic correlation characteristics and parameters of regression equations are shown in Table 1.

Table 1. Results of correlation and regression analysis

Country	Coefficient of correlation	Coefficient of determination	The regression equation
Lithuania	0,7	0,49	CO2=53,32+0,39GDP
Poland	0,49	0,24	CO2=83,34+0,14GDP
Ukraine	0,48	0,24	CO2=77,44+0,17GDP
Germany	0,18	0,04	CO2=94,14+0,05GDP

Source: Calculated by the authors

The results of the correlation and regression analysis suggest that there is a direct relationship between GDP and CO2 emissions (positive values of correlation coefficients and regression parameters). Since the coefficients of determination are small values, it would probably make sense to build a non-linear specification.

Analysis of factors influencing on emission predictions using neural networks

The development of ecologically balanced economy depends on many factors. It is important to know how different factors affect the amount of harmful emissions and, therefore, choose a specific set of independent variables, which can provide a better forecasting of indicators. CO2 is one of the factors influencing on economic growth, thus, appropriate economic decisions can be made in order to achieve economic growth in the context of sustainable development based on this analysis. Different approaches were used for research of this analysis (Bhogeswara *et al*., 2011; Farhani, S. *et al*., 2012).

On the basis of the direct relationship between economic growth and CO2 emissions for some countries, the factors affecting the dynamics of emissions for groups of countries have to be explored according to the World Bank classification by the income level. The income level is defined as 2012 GNI per capita and is a main criterion for the analysis of economic development of the countries.

The analysis was carried out using the NeuralTools. Neural Networks are capable of learning complex relationships in data. NeuralTools is a Microsoft Excel neural networks add-in, which allows analyzing data in Excel worksheets and working in the familiar Microsoft Office environment. NeuralTools supports different neural network configurations to give the best possible predictions.

Modeling process using neural network consists of the following stages:

1. Data collection for the study. The following indicators from the World Bank were used for neural networks construction:
   - CO2 emissions (metric tons per capita);
   - GDP per capita (current US$);
   - Electric power consumption (kWh per capita);
   - Energy use (kg of oil equivalent per capita);
   - Electricity production (kWh per capita);
   - Electricity production from renewable sources (kWh per capita).

The empirical study was based on data of 133 countries (number of observations equals 4742), which were divided according to 2012 GNI per capita. The groups are listed in Table 2.

Table 2. Country classifications by the income level

Group of countries	Income level	Number of countries
High income: non OECD	12 616 $ and more	13
High income: OECD		31
Upper middle income	4 086 $ - 12 615 $	42
Lower middle income	1 036 $ - 4 085 $	32
Low income	1 035 $ or less	15

Source: The World Bank (2013)

The sample is restricted to those countries, for which data of CO2 emissions, GDP per capita, electric power consumption, energy use, electricity production, electricity production from renewable sources is available. Annual data of these indicators was sourced from the World Bank. All the data were standardized. The data was analyzed for such countries:

- High income: non OECD (Bahrain; Brunei Darussalam; Croatia; Cyprus; Hong Kong SAR, China; Kuwait; Malta; Oman; Qatar; Saudi Arabia; Singapore; Trinidad and Tobago; United Arab Emirates);
- High income: OECD (Australia; Austria; Belgium; Canada; the Czech Republic; Denmark; Estonia; Finland; France; Germany; Greece; Hungary; Iceland; Ireland; Israel; Italy; Japan; Korea, Rep.; Luxembourg; the Netherlands; New Zealand; Norway; Poland; Portugal; the Slovak Republic; Slovenia; Spain; Sweden; Switzerland; the United Kingdom; the United States);
- Low income (Bangladesh; Benin; Cambodia; Congo, Dem. Rep.; Eritrea; Ethiopia; Haiti; Kenya; the Kyrgyz Republic; Mozambique; Nepal; Tajikistan; Tanzania; Togo; Zimbabwe);
- Lower middle income (Albania; Armenia; Bolivia; Cameroon; Congo, Rep.; Cote d'Ivoire; Egypt, the Arab Republic; El Salvador; Georgia; Ghana; Guatemala; Honduras; India; Indonesia; Iraq; Moldova; Mongolia; Morocco; Nicaragua; Nigeria; Pakistan; Paraguay; the Philippines; Senegal; Sri Lanka; Sudan; the Syrian Arab Republic; Ukraine; Uzbekistan; Vietnam; Yemen, Rep.; Zambia);
- Upper middle income (Algeria; Angola; Argentina; Azerbaijan; Belarus; Bosnia and Herzegovina; Botswana; Brazil; Bulgaria; Chile; China; Colombia; Costa Rica; Cuba; the Dominican Republic; Ecuador; Gabon; Iran, the Islamic Republic; Jamaica; Jordan; Kazakhstan; Latvia; Lebanon; Libya; Lithuania; Macedonia, FYR; Malaysia; Mexico; Montenegro; Namibia; Panama; Peru; Romania; the Russian Federation; Serbia; South Africa; Thailand; Tunisia; Turkey; Turkmenistan; Uruguay; Venezuela, RB.

2. Selecting the network topology. As for numerical values prediction as GRNN (Generalized Regression Neural Networks) and MLF (Multi-Layer Feedforward Networks) can be used, in order to select the best network, "Best Net Search" option was chosen. Neural Tools selects the best network based on Root Mean Square Error. During the modeling process for each country, 6 models were built: GRNN and MLF with the number of hidden layers from 2 to 6.

3. Training network. To train the network, Data Sets for each country were created. For the stops criterion, two parameters were selected: the training time is 2 hours and the Number of Trials is 1200000.

4. Checking the adequacy of the model. To check the adequacy of neural network, its testing based on test samples was conducted. Test results showed that neural networks could be used for prediction, as they provided an acceptable level of error.

5. Simulation results. Table 3 shows what type of neural network is the best for each country group and the RMS Error for network.

Table 3. Results of the best network selection

Country	Network type	RMS Error
High income: non OECD	MLFN Numeric Predictor (3 nodes)	12,49
High income: OECD	GRNN Numeric Predictor	0,7
Upper middle income	GRNN Numeric Predictor	0,63
Lower middle income	GRNN Numeric Predictor	0,3
Low income	GRNN Numeric Predictor	0,05

Source: Defined by the authors using neural network report

6. Table 3 shows the results of the factors analysis, which influence the level of CO2 emissions. The table values are presented in percentage terms, and the sum of all values is equal to 100%. The higher the value, the greater the impact of the variable on the prediction, which is conducted in the resulting index.

Table 4. The analysis of impacts on CO2 emissions

Indicators	High income: non OECD	High income: OECD	Upper middle income	Lower middle income	Low income
Energy use (kg of oil equivalent per capita)	46,86	60,58	43,25	30,83	68,08
Electric power consumption (kWh per capita)	17,55	10,18	16,14	21,47	12,17
GDP per capita (the current US$)	27,98	3,94	4,86	7,96	11,85
Electricity production (kWh per capita)	3,4	11,49	18,56	20,56	3,03
Electricity production from renewable sources (kWh per capita)	4,21	13,81	17,19	19,18	4,87

Source: Defined by the authors using neural network report

Analyzing the table, some conclusions can be drawn. One of the advantages of using neural networks is the ability to analyze the impact of independent factors on the predicted value (CO2 emissions). Analyzing the results of the constructed neural networks for all groups of countries, the greatest impact on the predicted CO2 levels has an indicator of energy consumption, which on average reaches 49.92%, in second place is power consumption, reaching 15.5%, GDP per capita – 11.32%, electricity per capita – 11.41% and electricity from renewable sources per capita – 11.85%.

The amount of emissions is one of the factors influencing on economic growth, therefore, the constructed neural networks can be used to predict the amount of emissions. The analysis of prediction can develop appropriate scenarios, in which the desired sustainable economic growth can be achieved.

Thus, it can be argued that economic growth is closely related to the emissions and, therefore, appropriate scenarios need to be developed, in which the desired balanced eco-

nomic growth could be reached. This can be achieved by reducing energy intensity and increasing the amount of electricity produced from renewable resources.

The main obstacles for the transition to sustainable development of the Ukrainian economy

Today, the officials in Ukraine are realizing the need to move towards environmental and economic development, which is intended to preserve the ecological potential of the country and ensure the harmonious development of nature and society. However, the current economic conditions and accumulated environmental problems are the obstacle to the implementation of sustainable development policies. The transition to environmentally sustainable patterns of production and consumption is to eliminate correlation between economic growth and environmental degradation through improving efficiency of natural resources use, the organizational and economic system of production, etc.

Therefore, the environment is influenced not so much by the economic development and economic growth, but by their directions. The proportions of the economy should be formed with the need to respect environmental constraints. This will be achieved by coordination of economic and environmental components of sustainable development, i.e., economic growth must be accompanied by adequate social changes and facilitate the solution of the problem of improving the quality of the environment. Otherwise, the economy becomes devoid of any content because of the needs of mankind.

The current system of natural resources regulation and environmental taxation and the current level of fees and charges do not ensure steady progress in the accumulation of financial resources toward the implementation of environmental activities in Ukraine. Given the general trend of the formation, implementation and development of economic instruments of environmental policy, it should be noted that environmental indicators change according to the trends in economic growth. Analysis of the ecological situation in Ukraine revealed the major problems with the transition to sustainable development of the Ukrainian economy, which include the following:

- outdated production technology, high energy and material consumption, which are two or three times higher than the according rates in developed countries;
- unfavorable structure of industrial production with high concentrations of ecological dangerous industries;
- the absence of proper environmental systems (water treatment, recycled water systems, etc.) and the low efficiency of existing environmental objects;
- aging assets;
- the absence of proper control over the protection of the environment;
- the absence of environmental impact assessment of projects and plans of industrial complex, energy and transport;
- the absence of monitoring and objective information about the ecological environment, identifying violators and compensation for the damage caused;
- low environmental education leaders at various levels, entrepreneurs, engineers and specialists;
- low environmental culture and awareness;
- the absence of effective means of economic stimulus measures to preserve the environment.

These obstacles hinder the implementation of the principles of sustainable development and cover political, economic, environmental, educational, social and international aspects.

Therefore, it is necessary to review the definition of the nature of economic growth and its new dimensions. One of these dimensions in the reports of the Rome club called Ecological Barrier (growth barrier) defined it as depletion of natural resources and degradation of the environment. Another point of view is that the real cause of the environmental degradation is not just growth, but its structure and strategy. According to modern concepts, economic growth can not be measured only by national income, which does not include many undesirable consequences. Therefore, modern approaches to economic growth should include an involving ecological component.

Difficulties in consideration of the ecological component in the construction of the sustainable development concept can be elucidated by means of mathematical and computer modeling as the most powerful and effective means of research and forecasting ecological and economic systems.

Despite a number of scientific papers on mathematical modeling of economic growth, models of economic growth have not been fully used yet and may be useful in the research of many modern science objects, e.g., ecological and economic systems and processes of sustainable development.

Given these objects of research, it is obvious that there is a need for appropriate correction of the classical models of economic growth based on eco-economic balance. Some models of ecological-economic growth suggest that the informal approach to this case may be the subject of many studies. In particular, the nonlinear models of optimal growth of ecologically balanced economy were constructed. These models are adequate to reality and effective in research of sustainable development (Grygorkyv, V. *et al*., 2004; Grygorkyv, V., 2007; Vinnychuk, O.; 2011). The constructed models are certain modifications of neoclassical growth model and optimize the trajectory of economic development in terms of eco-economic balance. These models suggest that the level of not destroyed pollutants is constant. Due to this assumption, economic growth will be positive, and the amount of harmful emissions will be stable.

Conclusion

1. Economic growth in the context of sustainable development is a stable, coherent and long-term development of the economic system. Social and environmental spheres are based on sustainable use of resources to meet the needs of the current and future generations.

2. Revival of the economy in developing countries entails an increase in emissions, while the economic slowdown causes their contraction. On the other hand, the experience of European countries shows that reducing human impact on the environment is possible even during economic growth.

3. The results of the correlation and regression analysis suggest that there is a direct relationship between GDP and CO2 emissions. This analysis of the relationship between economic growth and emissions suggests that today it is necessary to transit to environmentally sustainable patterns of production and consumption. The aim of the transition to environmentally sustainable patterns of production and consumption is to eliminate correlation between economic growth and environmental degradation through

improving efficiency of natural resources use and the organizational and economic system of production.

4. Studying the influence of the factors on the emissions amount prediction, it was found out that among indicators, such as GDP per capita (the current US$), electric power consumption (kWh per capita), energy use (kg of oil equivalent per capita), electricity production (kWh), electricity production from renewable sources (kWh), in each group the greatest impact on the CO2 prediction had the indicator of energy use (kg of oil equivalent per capita) with an average value of 49.92%. In second place was power consumption with having 15.5%, GDP per capita – 11.32%, electricity per capita – 11.41% and electricity from renewable sources per capita – 11.85%. The constructed neural networks can be used to predict the amount of emissions. The analysis of prediction can develop appropriate scenarios, in which the desired sustainable economic growth can be achieved.

5. Today, in Ukraine the need of transition to eco-economic development is being realized, which is intended to preserve the ecological potential of the country and ensure the harmonious development of nature and society. However, the current economic conditions and accumulated environmental problems are the obstacle to the implementation of sustainable development policies. These obstacles hinder the implementation of the principles of sustainable development and cover political, economic, environmental, educational, social and international aspects.

6. Difficulties in consideration of the ecological component in the construction of the sustainable development concept can be elucidated by means of mathematical and computer modeling.

References

Gryniv, L. (2001). *Environmentally sustainable economy: problems of theory*: Monograph. Lviv: Publisher, pp. 25-30.

Shevchuk, V. (2006). *Macroeconomic problems of sustainable development*. Kyiv: Publisher, pp. 44-46.

Melnyk, L. (2007). *The socio-economic potential of sustainable development*. Sumy: Publisher, pp. 77-101.

Cohen, D. (2012). The Close Relationship between Economic Growth and Carbon Emissions. Retrieved month day, year from http://oilprice.com/Finance/the-Economy/The-Close-Relationship-between-Economic-Growth-and-Carbon-Emissions.html.

Sanglimsuwan, K. (2011). Carbon Dioxide Emissions and Economic Growth: An Econometric Analysis. *International Research Journal of Finance and Economics*. Retrieved month day, year from http://www.eurojournals.com /IRJFE_67_09.pdf.

Acaravci, A., and Ozturk, I. (2009). On the relationship between energy consumption, CO_2 emissions and economic growth in Europe. The 3rd International Conference on Sustainable Energy and Environmental Protection, SEEP 2009. Retrieved month day, year from http://www.sciencedirect.com/science/article/pii/S0360544210003737.

Bhogeswara, R.K., Sexton, R.S., and Hignite, M. (2011). Predicting CO2 Emissions: A Neural Network Approach. *Insights to a Changing World Journal*, (2): 58-99.

Farhani, S., and Ben Rejeb, J. (2012). Energy Consumption, Economic Growth and CO2 Emissions: Evidence from Panel Data for MENA Region. *International Journal of Energy Economics and Policy*, 2,(2): 71-81.

Grygorkyv, V.S, Yakutova, E.Y., and Tymku, S.N. (2004). Modelling economic dynamics in the ecological balance. *Cybernetics and Systems Analysis*, (3): 130-138.

Grygorkiv, V.S. (2007). *Environmental economic modeling*. Chernivtsi: Publisher, pp. 74-75.

Vinnychuk, O.Y. (2011). Software models ecologically balanced economy by using Matlab. *Scientific Journal of Chernivtsi Trade and Economics Institute KNTEU*, 1(41): 359-368.
The World Bank. (2013). GDP growth (annual %). Retrieved June 17, 2013 from http://data.worldbank.org/indicator/NY.GDP.MKTP.KD.ZG
The World Bank. (2013). CO2 emissions (kt). Retrieved June 17, 2013 from http://data.worldbank.org/indicator/EN.ATM.CO2E.KT
The World Bank. (2013). CO2 emissions (metric tons per capita). Retrieved June 17, 2013 from http://data.worldbank.org/indicator/EN.ATM.CO2E.PC
The World Bank. (2013). Electric power consumption (kWh per capita). Retrieved June 17, 2013 from http://data.worldbank.org/about/EG.USE.ELEC.KH.PC
The World Bank. (2013). Energy use (kg of oil equivalent per capita). Retrieved June 17, 2013 from http://data.worldbank.org/indicator/EG.USE.PCAP.KG.OE
The World Bank. (2013). Electricity production (kWh). Retrieved June 17, 2013 from http://data.worldbank.org/indicator/EG.ELC.PROD.KH
The World Bank. (2013). Electricity production from renewable sources (kWh). Retrieved June 17, 2013 from http://data.worldbank.org/indicator/EG.ELC.RNEW.KH
The World Bank. (2013). How we classify countries. Retrieved June 17, 2013 from http://data.worldbank.org/about/country-classifications
The World Bank [interactive]. [accessed on 17-16-2013]. <http://www.worldbank.org/>.

EKONOMIKOS AUGIMO TYRIMAS DARNAUS VYSTYMOSI KONTEKSTE: NEURONINIŲ TINKLŲ POŽIŪRIS

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Santrauka. Pasaulio ekologinės situacijos analizė rodo, kad kiekvienos šalies ekonomikos augimas turėtų būti pagrįstas darnios plėtros principais. Ryšys tarp BVP dinamikos ir taršos lygio reikalauja išsamaus tyrimo. Remiantis statistiniais duomenimis pateikti Ukrainos, Lenkijos, Vokietijos ir Lietuvos ekonomikos augimo ir išmetamų teršalų kiekio santykiniai rodikliai. Išmetamų teršalų kiekis yra vienas iš veiksnių, darančių įtaką ekonomikos augimui, todėl šiame straipsnyje yra konstruojami neuroniniai tinklai, kuriuos pasitelkiant siekiama prognozuoti taršos kiekį pasirinktose šalyse, kurias Pasaulio bankas klasifikuoja pagal pajamų lygį. Taip pat yra analizuojami įvairūs veiksniai, kurie turi didžiausią įtaką nustatant CO_2 normą. Ši analizė leidžia pasirinkti nepriklausomus kintamuosius, kurie padeda atlikti geresnę tiriamų parametrų prognozę ir priimti atitinkamus ekonominius sprendimus siekiant užtikrinti ekonomikos augimo darnų vystymąsi.

Reikšminiai žodžiai: ekonomikos augimas, darnus vystymasis, ekologinis balansas, neuroniniai tinklai.