Analysis of the Environmental Load Factor on the Economic System of the Region

O V Komarova¹, L A Kezhun²
¹Ural State University of Economics, Ekaterinburg, Russia
²Higher School of Economics National Research University, St. Petersburg, Russia

Abstract. The article considers different approaches to correspondence analysis of economic and environmental regional factors. The analysis is based on the ecological Kuznets curve and some investigations of regional ecological and economic problems. The empirical analysis demonstrates a stable correlation between environment exploitation indicators (atmospheric air and sewage pollution) and gross regional product value as well as high level of regions’ differentiation based on ecological indicators that can be explained by low level of regions’ economics development and, in addition, its rent-seeking nature. An in-depth analysis of some regions showed a correlation between sectorial structure of the region’s economy and environment pollution: manufacturing and mineral extraction have the most impact. These conclusions conform to the dynamic of the ecological Kuznets curve: the growth of traditional sector of economy has more significant impact on standards of living rather than environmental factors. The intensity of environment exploitation and dynamic of environment polluting define the need of regulatory leverage by the government through economic and institutional factors due to prevention of irreversible impact on region’s environment.

1. Introduction
Economic development is closely related to depletion of natural resources, environmental degradation and deterioration. Regions differ in level of natural resources endowment, infrastructure development, innovative and education systems, thus there is a need to estimate the environmental load on the economic system of the region. Environmental awareness is confirmed by creating the international rating - Global Cleantech Innovation Index according to which in 2017 Russia has improved its position a little bit, moved to 39th place up from 40th in 2014 [1].

Interest in studying the impact of environmental factors on the economy is rather extensive: the theory of correcting Pigouvian tax [2] and its impact on enterprises [3], the theory of limits to growth by Meadows D.H, Meadows D.L and others [4] and its contemporary interpretation by Nørgård J.S., Peet J., and Ragnarsson [5], principles of environmental economics by Hussem A.M. [6], Daly H.E., Farley J. [7], natural capital and interdisciplinary study of economic problems by Akerman M. [8].

In the analysis of relationship between economic forces and environmental factors, huge attention is put to analysis of environmental regulations impact on labor productivity growth by C.Zhang, H.Liu, H. Th.A.Bressers, K.S.Buchanan [9], command-and-control and market based mechanisms by R.Xie, Y.Yuan, J.Huang [10], relationship between institutional and environmental factors. A.Mavragani, I.E. Nikolau, K.P.Tsagarakis [11] showed the important role of institutional political and economic factors in environment polluting.
Figure 1. Relationship between environmental and economic factors

The analysis of sustainable development includes the search of key indicators of ecological and economic development and their patterns. These studies include the rationale of ecological footprint as an indicator by Wackernagel M., Rees W.E. [12]; Goldfinger, S., Wackernagel, M., Galli, A., Lazarus, E., Lin D. [13], Vigna S., Civitillo D.F., Cacciaquoti G., Ulgiati S. [14], Schröter H., Venghaus S., Hake J. [15] analyzed green economy innovations index (GEII) in Germany, designed its sub-index to measuring the implementation of sustainable development of ecological innovations. The system analysis of factors related to regions’ environmental pollution is usually of local character. So Bala B.K., Hossain M.A. [16] measured the status of food insecurity and ecological footprint as an indicator of region ecological stability. Yashalova N.N. [17] made the analysis of “green” economy indicators. Zheng H., Wang L., Peng F., Gu J., Lu Sh., Zhang D., Li L. [18] presented an ecological index calculation system (CFEICS) which provides quantitative and qualitative assessment of forestry ecosystems. Thus, regional analysis is meaningful for development of national economies and formation of cumulative environmental impact.

Economic content of environmental impact is essentially anthropogenic i.e. induced by human activity, both productive and consumptive. The complexity of the analysis of the relationship between environmental and economic factors is caused by the lack of certain resulting indicator (see Fig. 1).

This complex dependency is confirmed by the analysis made by A.Mavragani, I.E. Nikolaou, K.P.Tsagarakis [11], Badarchi K.B., Dabiev D.F. [19] and by the ecological Kuznets curve tested by Stern D., Common M., Barbier E. [20]. The ecological Kuznets curve, however, does not consider the irreversibility of environmental impact, physical limits to resources and human abilities, the impossibility of foreseeing the impact of modern technologies on human health and environment. In our view, the per-capita income certainly is an important indicator, but standards of living are more comprehensive indicator, additionally reflecting the impact of environmental changes on health and level of human capital.

2. Methods
The empirical analysis was performed based on real gross regional product as an indicator of region’s economy development level and the basic indicators characterizing the impact of economic activity on environment in Russian Federation. Following indicators have been selected from all available ones provided by Rosstat (the definitions are presented according to Rosstat methodology).

Emission of pollutants from stationary sources into atmospheric air is produced by manufacturing and by work and rendering services on large enterprises [21]. In Russia, more than 17000 thousand ton/year of pollutants is emitted into atmospheric air, while only 75.6% of them are the subject of cleaning.
The discharge of contaminated wastewater into surface water bodies is the result of the use of water for technological and supportive production processes [21]. The discharge of contaminated wastewater in Russia in 2014-2016 was more than 144000 million cubic meters.

Producing, usage, decontamination, and disposal of industrial and consumer waste i.e. substances or objects created in the processes of manufacturing, work performing, service delivery, or consumption, which are disposed, are intended for disposal, or are compulsory for disposal [21]. The volume of industrial and consumer waste in Russia in 2014 was more than 5400 million tons, but only 59.6% of them were used and decontaminated and 9% of them were buried.

Environmental costs are private and state expenditures dedicated to environmental needs [21]. Environmental costs include capital and current expenditures on environmental protection.

3. Results and discussion

A correlation analysis shows a weak correlation between regional average per-capita income and regional environmental costs, a weak reverse correlation between regional average per-capita income and emission of pollutants from stationary sources into atmospheric air. There was no correlation found between regional average per-capita income and the discharge of contaminated wastewater into surface water bodies. Relatively more stable correlation was found between environment exploitation indicators (atmospheric air and sewage pollution) and gross regional product. Table 1 consists of the correlations between GRP, REA, RDC, and RCE. All indicators examined are weakly correlated with one another.

Indicators values can be explained by the lack of correlation between average per-capita income in Russia and the dynamics of gross regional product as well as by Russian economy rent-seeking nature.

| Variable                                                                 | GRP | REA | RDC | RCE |
|--------------------------------------------------------------------------|-----|-----|-----|-----|
| Gross regional product (GRP)                                             | 1   | -   | -   | -   |
| Regional emission of pollutants from stationary sources into atmospheric air in Russia (REA) | 0,18 | 1   | -   | -   |
| Regional discharge of contaminated wastewater into surface water bodies in Russia (RDC) | 0,36 | 0,25 | 1   | -   |
| Regional environmental costs (RCE)                                       | 0,18 | 0,54 | 0,11 | 1   |

In order to analyze the differentiation in regions by environmental pollution level and key economic indicators dynamics the regions were ranked by the key indicators. The results are presented in Table 2.

| Variable                      | GRP | REA | RDC | RCE |
|-------------------------------|-----|-----|-----|-----|
| The highest indicator value   | 4   | 3   | 3   | 5   |
| High indicator value          | 13  | 6   | 6   | 13  |
| Above average                 | 18  | 9   | 11  | 11  |
| Average indicator value       | 18  | 23  | 16  | 25  |
| Below average                 | 23  | 13  | 18  | 12  |
| The lowest indicator value    | 9   | 31  | 31  | 19  |
| Total regions number          | 85  | 85  | 85  | 85  |
Further analysis was made for regions having high values of the key indicators. The regions’ differentiation in environmental pollution level is defined by sectoral structure of the region’s economy: manufacturing (metallurgy) and mineral extraction, especially crude oil and associated gas have the greatest impact.

The obtained data is consistent with the results of multidimensional statistical analysis by Badarchi K.B., Dabyev D.F.: the emergence and growing of industrial enterprises have the negative impact on the atmosphere, upon that the growth of extraction sector leads to the more significant atmosphere pollution and to the less significant one of water, while the growth of manufacturing sector leads to the more significant water pollution and to the less significant one of atmosphere [18]. Thus, environmental pollution has no direct impact on standards of living in Russian regions. The level low of production and the stagnation of resource-based development model have more significant impact on standards of living. These conclusions comply with the dynamic of the ecological Kuznets curve: the growth of the traditional sector (extracting and manufacturing enterprises) contributes to standards of living more than environmental factors. Due to the lack of detailed data by regions it is impossible to analyze the impact on region’s ecosystem. However, the intensity of its exploitation and the dynamic of environment pollution may affect the government regulatory impact through economical and institutional factors in order to prevent irreversible influence on region’s environment.

Despite the lack of clear correlation between economic and environmental factors, the assessment of environmental factors has the huge perspective value owing to the irreversibility of human and production impact on environment.

In the future, developing of detailed regional indicators, which allow performing differential environmental policy in regions, matters more than developing generic environmental indicators, while they allow complex assessing of environmental situation in the country.

4. References
[1] The Global Cleantech Innovation Index https://i3connect.com/gci/country_rank
[2] Pigou A C 1924 The economics of welfare Macmillan and Co (London)
[3] Carlton D W, Loury G C 1980 The Limitations of Pigouvian Taxes as a Long-Run Remedy for Externalities The Quarterly Journal of Economics vol 95 3 559-566
[4] Meadows D H, Meadows D L, Randers J, Behrens III 1972 WW.: The Limits to Growth. Universe Books (New York)
[5] Nørgård J S, Peet J, Ragnarsdóttir K V 2010 The History of the Limits to Growth. Solutions vol 2 1 59-63
[6] Hussen A M 2004 Principles of Environmental Economics 2nd edn. Routledge (New York)
[7] Daly H E, Farley J 2011 Ecological economics: principles and applications. 2nd ed. Island Press (Washington)
[8] Akerman M 2003 What Does 'Natural Capital' Do? The Role of Metaphor in Economic Understanding of the Environment Environmental Values 12 4 431–448 doi:10.3197/096327103129341397.
[9] Zhang C, Liu H, Bressers H, Buchanan K 2011 Productivity growth and environmental regulations – accounting for undesirable outputs: Analysis of China's thirty provincial regions using the Malmquist–Luenberger index Ecological Economics vol 70 12 pp 2369–2379 doi.org/10.1016/j.ecolecon.2011.07.019
[10] Xie R, Yuan Y, Huang J 2017 Different Types of Environmental Regulations and Heterogeneous Influence on «Green» Productivity: Evidence from China Ecological Economics vol 132 104–112 doi.org/10.1016/j.ecolecon.2016.10.019
[11] Mavragani A, Nikolau I, Tsagarakis K 2016 Open Economy, Institutional Quality, and Environmental Performance: A Macroeconomic Approach Sustainability 8(7) 601 doi:10.3390/su8070601
[12] Wackernagel M, Rees W E 1996 Our ecological footprint: Reducing human impact on the earth Gabrioala, BC: (New Society)
[13] Goldfinger S, Wackernagel M, Galli A, Lazarus E, Lin D 2014 Footprint facts and fallacies: A response to Giampietro and Saltelli Footprints to Nowhere Ecological Indicators vol 46 622-632 doi.org/10.1016/j.ecolind.2014.04.025

[14] Viglia S, Civitillo D F, Cacciapuoti G, Ulgiati S 2017 Indicators of environmental loading and sustainability of urban systems An energy-based environmental footprint Ecological Indicators doi. org/10.1016/j.ecolind.2017.03.060

[15] Schlör H, Venghaus S, Hake J 2017 Green Economy Innovation Index (GEII) a normative innovation approach for Germany & its FEW Nexus Energy Procedia vol 142 2310–2316

[16] Bala B K, Hossain M A 2010 Food security and ecological footprint of coastal zone of Bangladesh. Environment Development and Sustainability vol 12 4 531–545

[17] Yashalova N N 2016 The use of indicative approach to estimation of ecological-economic development of the region Scientific notes of the Cherepovets State University 1 35-40

[18] Zheng H, Wang L, Peng F, Gu J, Lu Sh, Zhang D, Li L 2018 Design and implementation of an index calculation system for forestry ecological assessment in China Computers and Electronics in Agriculture vol 145 253-274

[19] Badarchi K, Dabiev D 2013 Factor analysis of influence of mining on environment in the regions Economic Analysis: Theory and Practice 46 (349) 13–26

[20] Stern D, Common M, Barbier E 1996 Economic growth and environmental degradation: the environmental Kuznets Curve and sustainable development World Development vol 24 7 1151-1160

[21] 2016 Environmental protection in Russia: Compendium of statistics. Rosstat (Moscow)