The Jevons paradox and the problem of assessing the effectiveness of environmental institutions in Russia

I P Glazyrina¹, ², I A Zabelina¹

¹Institute of Natural Resources, Ecology and Cryology SB RAS, Russia, Chita
²Transbaikal State University, Russia, Chita

E-mail: iglazyrina@bk.ru, i_zabelina@mail.ru

Abstract. The paper presents an attempt to quantify and analyze the ecological and economic trends in the regions of Russia using the decoupling coefficient. The calculations showed high heterogeneity in the spatial distribution of the quantitative decoupling effect in Russia. The number of regions where this effect is steadily manifested concerning all (included in the analysis) types of negative impact is relatively small. In the regions actively developing cross-border ties with China, the decoupling effect is observed concerning the discharge of polluted wastewater. According to the negative impact on the atmospheric air in most cases, the effect of decoupling was also revealed. At the same time, in some regions, economic development is accompanied by an increase in air pollution, which is the most noticeable when considering the situation in the context of the main economic activities. We can also conclude that over the past decade there has been no significant environmental modernization in the basic industries of the regions actively developing cross-border ties with China. During the period of economic instability (from 2009 to 2016), the ecological and economic efficiency of economic activity decreased in all regions and the Russian Federation. The results of the study show that under these conditions, the effectiveness of existing environmental institutions is decreasing, and they do not provide sufficient "immunity" of regional ecological and economic systems concerning economic shocks.

1. Introduction

The study of the problems of the resource economy in the last three decades is inextricably linked with the issues of environmental protection, both in theoretical research and practical development. Since the consequences of negative anthropogenic impact, despite its initially local nature, are becoming increasingly important for large areas, there is a question of environmental modernization of not only individual industries but also socio-ecological and economic systems. State environmental institutions are designed to solve these problems.

The most common tool of state regulation to stimulate the greening of production processes, the introduction of payments for negative environmental impact, does not always give unambiguously positive results. Often, an effect similar to that described in the famous "Jevons paradox" during the industrial revolution. Although the initial motivation for the modernization of steam engines was to reduce coal consumption (coal was relatively expensive), it resulted in its increased consumption. As a consequence of economic stimulation of technology development, the efficiency of natural resources use increases, and the specific demand decreases (that is, per unit of economic result). However, the progress in efficiency increases the commercial attractiveness of the modernized sector for
investments. It ultimately increases the demand for natural resources and the anthropogenic pressure on natural systems. This paper presents an attempt to use quantitative environmental-economic decoupling indicator for the assessment of existing tendency.

2. Data and methods

One of the tools to quantify the effectiveness of environmental institutions can serve as a system of calculations based on the idea of decoupling. It consists in divergence or misalignment of rates of economic growth, consumption of resources and negative impact on the environment [1-4]. The following formula is used to measure the decoupling effect [5]:

$$D_t = 1 - \left( \frac{E_t}{T_t} \left( \frac{E_0}{Y_0} \right)^{-1} \right)^{1}$$

where $E_0$ and $E_t$ are quantities characterizing the negative impact on the environment in the base and current periods; $Y_0$ and $Y_t$ are quantities characterizing the economic result in the base and current periods, respectively.

The positive value of the indicator indicates the separation of economic development trends and negative environmental impact, i.e. the rate of economic growth exceeds the rate of pollution of natural environments. If the value of the $D_t$ coefficient is zero or negative, there is no decoupling effect.

It should be noted that this condition is weaker than the criterion used in the model of P. Victor [6] to assess the dynamics of environmental and economic development from the perspective of the "green" growth concept. However, the existence of the effect of misalignment of economic development and environmental pollution indicates a move towards a "green" economy [7, 8].

The study used official data of the Federal State Statistics Service. The time frame encompasses the following periods: 1) to identify the decoupling in regions and the entire territory of Russia: 2005–2016 (for the basic industries) and 2005–2017 (for the total regional economies); 2) to assess the environmental and economic development of the Eastern border regions: 2009–2016 and 2009–2017, respectively.

The spatial distribution of the decoupling effect was elaborated with GIS tools.

3. Results and discussion

The misalignment of trends in economic development and environmental pollution is associated with the discharge of contaminated wastewater in most Russian regions and the Russian Federation as a whole. Between 2005 and 2017, the coefficient $D_t$ is predominantly positive (figure 1a). The most unfavorable situation is observed in some subjects of the Ural, Central and Volga Federal districts. In the Eastern regions as active participants of cross-border cooperation with China, the $D_t$ coefficient is positive, and its value varies from 0.26 (the Jewish Autonomous Region) to 0.63 (the Irkutsk Region). Within the 2009-2017 period, the maximum value of the $D_t$ coefficient is observed in the Transbaikal territory (figure 1b), where the volume of contaminated wastewater during this time interval decreases significantly (by 54%). However, this relatively good situation may be due to insufficient quality of monitoring wastewater discharges and inadequate reflection of the consequences of violation of environmental legislation in statistical reporting, rather than a real decrease in the level of this type of environmental loads.

There is no decoupling effect for emissions into the atmosphere from stationary sources in some Russian regions located mainly in the Central and North-Western Federal district, (figure 2a). The Republic of Buryatia and the Amur region, whose economic development was accompanied by a high increase in emissions of air pollutants (due to coal power generation), also have a negative value of the decoupling coefficient. During the period of active development of cross-border relations with China (from 2009 to 2017), the Jewish Autonomous Region (figure 2b) joined the designated regions.
Figure 1. The decoupling coefficient \( (D_t) \) in Russian regions: polluted wastewater discharges.

The prospects for the socio-economic development of the Eastern territories are mainly associated with the expansion of the mining, fuel and timber industry. A significant part of the Russian-Chinese projects planned and already implemented in the Russian regions is primarily focused on the extraction and primary processing of mineral resources \([9, 10]\). Thus, an important aspect of this study is the analysis of the environmental and economic performance of the following economic activities: "Mining and quarrying", "Manufacturing", "Electricity, gas and water production and supply". Table 1 presents the results of calculations of the decoupling coefficient \( (D_t) \) for the regions of cross-border interaction and the Russian Federation, and figure 3 shows the spatial distribution of this quality characteristic of the economic growth among the regions of the Russian Federation.
Figure 2. The decoupling coefficient ($D_t$) in Russian regions: air emissions from stationary sources.
Figure 3. The decoupling coefficient ($D_t$) for main economic activities: air emissions from stationary sources (2005 and 2016).

The raw materials sector of the economy and the power industry remain the main polluters of the environment. In most of the regions, there was no mismatch in the rates of development of the sector "Mining and quarrying" and air pollution in the period from 2005 to 2016 in (figure 3a). Among the regions, the cross-border cooperation is highlighted in Amur Region, Jewish Autonomous Region and Primorye Territory. The minimum value of the $D_t$ coefficient in the field of mining is in the Jewish Autonomous region ($D_t = -2.41$), where the contribution of this economic activity to the gross value added of the region has been steadily increasing in recent years. In another bordering region, the Amur region, the decoupling effect was not detected in all the sectors under consideration, while the active development of cross-border relations with the dynamically developing China does not change the situation (table 1).
The effectiveness of existing environmental institutions is decreasing (except for the food industry and other basic industries of the regions actively developing cross-border interaction: the Amur region and the Republic of Buryatia (for the period from 2005 to 2016). In other cases, there is a separation of trends in economic development and air pollution (figure 3b).

The development of manufacturing industries in some regions was characterized by the absence of the decoupling effect: the Transbaikal territory, the Amur region, the Altai and Buryatia Republics (figure 3c). The minimum value of the $D_r$ coefficient is in the Transbaikal territory, where manufacturing provides a small contribution to gross value added ($2.8-4\%$ in current prices). At the same time, during the active development of Russian-Chinese relations, there is a more unfavorable situation: the value of the studied indicator is significantly lower ($D_r=-4.87$) than the value obtained for the time interval from 2005 to 2016 ($D_r=-2.34$). In recent years, the region has not overcome the trend of declining production in the manufacturing industry (except for the food industry and other industries). At the same time, the level of negative impact on the air provided by the manufacturing industry during the considered time interval has increased significantly: the volume of emissions of pollutants has increased more than 3 times compared to 2005.

### Table 1. The decoupling coefficient ($D_r$) in Russia and the regions of cross-border cooperation with China.

| Regions                  | Economy as a whole | Main economic activities: air emissions from stationary sources |
|--------------------------|--------------------|---------------------------------------------------------------|
|                          | Polluted wastewater discharges | Air emissions from stationary sources | Mining and quarrying | Manufacturing | Electricity, gas and water production and supply |
|                          | 2005-2017 | 2009-2017 | 2005-2017 | 2009-2017 | 2005-2016 | 2009-2016 | 2005-2016 | 2009-2016 | 2005-2016 | 2009-2016 |
| Amur Region Jewish Autonomous Region | 0.43 0.20 | -0.09 -0.13 | -0.65 -0.07 | -0.38 -0.34 | -0.09 -0.34 |
| Trans-Baikal Territory | 0.61 0.57 | 0.32 0.16 | 0.91 0.86 | -2.34 -0.002 | 0.82 0.35 |
| Irkutsk Region Primorye Territory | 0.63 0.41 | 0.25 0.15 | 0.46 -0.14 | 0.2 0.27 | 0.25 0.18 |
| Republic of Altai | 0.42 0.27 | 0.46 0.25 | -0.68 -0.98 | 0.46 0.41 | 0.29 0.23 |
| Republic of Buryatia Khabarovsk Territory | 0.51 0.05 | 0.58 0.35 | – – | -0.33 -0.75 | 0.75 0.38 |
| Russia as a whole | 0.48 0.21 | -0.21 -0.21 | 0.57 0.3 | 0.13 -0.34 | -0.54 0.3 |

Concerning the development of the electric power industry, we can conclude that there is no decoupling effect in two regions of cross-border interaction: the Amur region and the Republic of Buryatia (for the period from 2005 to 2016). In other cases, there is a separation of trends in economic development and air pollution (figure 3b).

4. Conclusion

Thus, the calculations showed high heterogeneity in the spatial distribution of the quantitative decoupling effect in Russia. The number of regions, where this effect is steadily manifested concerning all (included in the analysis) types of negative impact, is relatively small. We can also conclude that over the past decade there has been no significant environmental modernization in the basic industries of the regions actively developing cross-border ties with China. During the period of economic instability (2009-2016), the ecological and economic efficiency of economic activity decreased in all regions of the Russian Federation. The results of the study show that under these conditions, the effectiveness of existing environmental institutions is decreasing, and they do not
provide sufficient "immunity" of regional ecological and economic systems concerning economic shocks.

Acknowledgements
The work was carried out under the State task for project XI.174.1.8. of the SB RAS Basic research programs.

References
[1] UNEP 2011 Decoupling Natural Resource Use and Environmental Impacts from Economic Growth Income accessed online on 17th August 2019 via www.gci.org.uk/Documents/Decoupling_Report_English.pdf
[2] Bobylev S N, Kudryavtseva O V and Yakovleva Ye Yu 2015 Regional priorities of green economy Economy of Region 2 148–59
[3] Shkiperova G T 2014 Analysis and modeling of relationship between economic growth and environmental quality (the case of the Republic of Karelia) Economic Analysis: Theory and Practice 43(394) 41–9
[4] Zabelina I A 2019 Decoupling in environmental and economic development of regions-participants of cross-border cooperation Economic and Social Changes: Facts, Trends, Forecast 12(1) 241–55
[5] Nagvi A and Zwickl K 2017 Fifty shades of green: Revisiting decoupling by economic sector and air pollutants Ecol. Econ. 133 111–26
[6] Victor P A 2015 The Kenneth E Boulding Memorial Award 2014: Ecological economics: A personal journey Ecol. Econ. 109 93–100
[7] Glazyrina I P and Zabelina I A 2016 Prospects for "green" growth in eastern Russia and the New Silk Road Eco 7(505) 5–20
[8] Glazyrina I P and Zabelina I A 2018 Spatial heterogeneity of Russia in the light of the concept of green economy: the social context Geography and Natural Resources 2 14–22
[9] Antonova N E and Lomakina N V 2018 Natural resource-based industries of the Far East: New Drivers of Development. Economic and Social Changes: Facts, Trends, Forecast 11(1) 43–56
[10] Lomakina N V 2014 Industrial development of the Far East Russia and Northeast of China: the purposes, results and opportunities for cooperation Eco 6(480) 25–39