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The Eco-Efficiency of Russian Regions in North Asia: Their Green Direction of Regional Development

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Abstract: The green economy is one of the important and practical tools of sustainable development, which balances the two directions of regional development: economic growth and preservation of the natural environment. In this paper, we have developed a methodology for investigating the development and implementation of regional green economy policies, using the Russian regions in North Asia as an example. Three main tasks have been accomplished for this purpose: (1) assessment of how sustainable the socio-economic development of the Russian regions in North Asia is; (2) comparative analysis of the sustainability of regional policies (to what extent the federal targets and priorities for the green agenda implementation are reflected in the regional strategic documents); and (3) determination of the green direction for regional development by comparing the results of previous assessments. To assess the sustainability of regional development, we have used a methodology for DEA of eco-efficiency of socio-economic development in the Russian North Asian regions, using a non-oriented slacks-based measure (SBM) model. To assess the sustainability of regional policies, we used a content analysis of regional socio-economic development strategies. We have identified considerable variations among the Russian North Asian regions in the extent to which their socio-economic development is consistent with the principles of a green economy (both in the priorities, tools of regional policies, and the level of eco-efficiency). The content analysis of the regional strategic documents of the Russian North Asian regions, as well as the assessment of the eco-efficiency of their socio-economic development, show that regions with low actual eco-efficiency are planning in their strategies greater efforts for green development than more eco-efficient regions. The approaches we propose can support decision making in the field of eco-economic development as a tool to measure the degree of compliance of regional development with the principles of a green economy.

Keywords: green economy; North Asia; socio-economic development strategies; regional development; eco-efficiency; Russian regions

1. Introduction

Modern interpretations of the global concept of sustainable development are based on a new green economy and green growth strategies. [1,2]. The relevant Sustainable Development Goals and Principles are defined in the UN 2030 Agenda for Sustainable Development, which contains 17 goals and 169 targets, spanning the social, economic, and environmental priorities [3]. The goals and targets are comprehensive, global in nature and universally applicable. At the same time, they are flexible to a diversity of national strategies and priorities and different capacities and levels of economic development.

The concept of the green economy is not a substitute for sustainable development but is an important component of it. Important characteristics of this economic model are an efficient use of natural resources; preservation and increase of natural capital; reduction of pollution; low carbon emissions; prevention of loss of ecosystem services and biodiversity;
and income and employment growth [2]. The 2011 UNEP report defined a green economy as “one that results in improved human well-being and social equity, while significantly reducing environmental risks and ecological scarcities” [2]. Although the choice in favor of green economic development is not in doubt, in practical terms, all levels of decision making must balance both directions, which previously seemed incompatible: dynamic economic growth and long-term preservation of the natural environment [3]. In many countries, various models and tools for green development have been formed in accordance with national priorities [4]. This approach is enshrined in the Outcome document of the Rio+20 Conference: “... each country can choose an appropriate approach in accordance with national sustainable development plans, strategies and priorities” [5]. Examples of green economy development in different countries are very diverse. In 2009, member countries of the Organization for Economic Cooperation and Development adopted a declaration on green growth, and since 2011 they have been implementing it practically as a green growth strategy. Many countries implement a wide range of measures related to the green economy. In 2009, the OECD member countries adopted the green growth declaration, and since 2011 they have been implementing it as a green growth strategy [6]. In December 2019, the European Commission presented a roadmap for the European Green Deal, a new strategy for EU development [7]. The strategy aims to achieve carbon neutrality by 2050, reducing greenhouse gas emissions by at least 55% by 2030. As part of the Green Deal, the EU sets the goals of increasing resource efficiency, moving toward a circular economy, restoring biodiversity, and reducing pollution. Russia supports the initiatives put forward by the UN to develop and implement a new green economic course aimed at a balanced solution to social, economic, and environmental problems. Russia, in its national projects and Comprehensive Plan for the Modernization and Expansion of Backbone Infrastructure, provides for the implementation of 107 out of 169 SDG targets [8]. These are reflected in government programs at both the federal and regional levels, as well as in new approaches to doing business (environmental, social, and governance criteria). Almost all Russian regions attach great importance to this, including the principles of green development in regional strategies, while the formation of such regional policies has not been sufficiently studied.

The purpose of this article is to investigate the development and implementation of regional green economy policies, using the Russian regions in North Asia as an example. Two main tasks have been accomplished for this purpose: (1) assessment of how sustainable the socio-economic development of the Russian regions in North Asia is; (2) comparative analysis of the sustainability of regional policies (to what extent the federal targets and priorities for the green agenda implementation are reflected in the regional strategic documents).

2. Materials and Methods

2.1. Literature Review

The green economy is an important and practical tool for sustainable development and poverty eradication [1,9]. It is closely related to a number of theories and approaches that justify sustainable development [10]. Researchers from many countries emphasize the dynamic development of the theory of the green economy, which comes from the report published by D. Pierce et al. [10–13]. The most widely used green economy definition comes from UNEP: “[green economy is one that results in] improved human well-being and social equity, while significantly reducing environmental risks and ecological scarcities” [2]. According to A. Dvoretskaya, the green economy is not a sector of the entire economy, but its new adequate image. All sectors of the traditional economy must become environmentally responsible [14]. In modern theoretical and applied research, the term “green” increasingly describes the greening of social relations in the sphere of production, exchange, distribution, and consumption of goods and services (“green” construction, entrepreneurship, investments, jobs, etc.) [15]. However, the green economy is an umbrella concept because it includes various implications for growth and well-being, efficiency, and risk reduction when using natural resources [16].
The authors believe that the green economy implies rational consumption and production (including technological improvements and efficient use of natural resources), as well as the integration of green principles into the system of planning, financing, and management.

Many researchers define a green economy as an area of modern economics in which policy efforts, technological solutions, societal attitudes, and economic actions focus on ideas related to sustainable development [17,18]. In this vein, the theories of low-carbon, resource-efficient, and socially inclusive economies have also emerged, setting the course for nations to use natural resources efficiently, reduce carbon emissions, increase energy efficiency, increase income and employment, and prevent the degradation of ecosystem services and biodiversity. These theories encompass a variety of aspects of ecological-economic development, in practical terms fostering a step-by-step transformation of the linear economy and contributing to the development of the circular economy model [19].

In order to transition to a green economy, many countries have developed diverse approaches, models, and tools consistent with their national conditions and priorities [13,20,21]. In 2009, the OECD member countries adopted the Declaration on Green Growth, and since 2011 it has been implemented as a green growth strategy [6]. In December 2019, the European Commission unveiled the roadmap of the European Green Deal, a new strategy for the European Union [7]. Since 2009, the Republic of Korea has been implementing a long-term National Green Growth Strategy until 2050 [22]. Japan has adopted the “Green Growth Strategy through Achieving Carbon Neutrality in 2050” [23]. The Chinese government recognizes the transition to a green economy as a long-term strategy to accelerate sustainable economic growth and protect the environment from further deterioration [20].

Russia also supports the initiatives put forward by the UN (Agenda 2030) and supported by countries to develop and implement a new green economic course aimed at a balanced solution to social, economic, and environmental problems [24]. Most of the goals and objectives of sustainable development, as well as a set of measures to achieve them, are stipulated in the Russian official documents, including doctrines, concepts, strategies, state programs, and national projects [8]. At the end of 2021, the Russian government has adopted a long-term strategy for low-carbon development, which sets the goals of achieving carbon neutrality with sustainable economic growth. The scenario assumes economic growth with a reduction in greenhouse gas emissions by 2050—60% of the 2019 level (or 80% of the 1990 level) and the achievement of carbon neutrality by 2060 [25].

At the same time, national objectives and measures should be reflected in regional strategic and program documents. Given the heterogeneity of the Russian regions, these documents have very different targets and implementation mechanisms. It is at the regional level where the opportunities and limitations of environmental policy implementation become more evident.

Despite the growing number of studies on the development of a green economy in Russian regions [26,27], there are still not enough studies to assess the green direction of socio-economic development. Russia is just beginning to transition to a green economy, so it is important to assess current opportunities and prospects not only at the national level but also at the regional one [13]. A number of researchers consider the following scientific problems: how a region will achieve the SDGs and how it will affect its socio-economic development [28].

Various methods based on indicator systems are widely used to assess the transition of countries and regions to a green economy. One of the first such indicator systems was the Indicators of Sustainable Development, developed by the UN CSD. To date, almost all major international organizations (UN, World Bank, OECD, EU, etc.) have their own systems of sustainable development indicators. The weaknesses of this approach are a large number of indicators, often reflecting opposite trends, and sometimes the lack of a clear correlation between the indicators.

In recent years, simplified indicator frameworks have become more common. For example, the UN CSD reduced the original list of more than 130 indicators by more than half. In our opinion, the most promising approach to assessing the sustainability of a
territory and its green development level can be based on an integral indicator. Since 2010, the Global Green Economy Index (GGEI) has been used to measure how well each country performs in the global green economy based on four key dimensions: leadership and climate change, efficiency sectors, markets and investment, and environment and natural capital [29]. There are other authors’ approaches based on an integral indicator of sustainable development [17,30,31]. However, there is no widely recognized integral indicator yet, due to methodological, statistical, and calculation difficulties.

The eco-efficiency indicator is increasingly used as an integral indicator of compliance with the green principles. This term was first introduced by S. Schaltegger and A. Sturm in 1990 as the ratio of an economic value added to an environmental value added [32]. The concept has since been recognized by various international organizations. The OECD defines it as “the efficiency with which environmental resources are used to meet human needs” [33]. ESCAP defines eco-efficiency as “a key element for promoting fundamental changes in the way societies produce and consume resources, and thus for measuring progress in green growth” [34]. In the proposed approach, environmental efficiency is considered as the increasing scale effect of economic and population growth, which prevails over the growth of negative environmental impacts.

In recent years, Data Envelopment Analysis (DEA), a mathematical programming method, has been widely used to assess the eco-efficiency of economic development. The essence of DEA is identifying the efficient frontier to compare the relative efficiencies of operating units, where the efficiencies are represented as the ratios of weighed outputs (useful results) to weighed inputs (resources consumed). In other words, the objects can be considered efficient when they produce larger outputs with smaller inputs.

Data Envelopment Analysis was developed in 1978 by A. Charnes, W.V. Cooper, E. Rhodes [35], who were based on the ideas of M.J. Farrell [36]. Initially, this method was used for the purposes of microeconomic analysis [37–39], but later its scope expanded significantly. Currently, DEA is widely used to assess the eco-efficiency of socio-economic development of regions [40–44]. In Russia, this method is not yet widespread. There have been only a couple of studies assessing regional economic systems in terms of their comparative sustainability [42–44]. In this study, the authors have attempted to contribute to the existing methodology for DEA of eco-efficiency: the selection of the most adequate model based on the impact decoupling, as well as the choice of its parameters. The authors believe that this study will contribute to the existing knowledge on how the green agenda is implemented in regional policies, as well as help to assess the response of regional authorities to environmental challenges.

2.2. Study Area

The study area includes Russian regions located in Northern Asia. This macro-region occupies the northeast of the Eurasian continent [45]; it stretches from the Ural Mountains to the Pacific Ocean and from the Arctic Ocean to Russia’s southern border (Figure 1).

In Northern Asia, there are 22 Russian regions within 3 Federal Districts: Ural (1 region: Tyumen Region, which includes Khanty-Mansi Autonomous Okrug–Yugra, KhMAO and Yamalo-Nenets Autonomous Okrug, YaNAO), Siberian (10 regions), and Far Eastern (11 regions).

The Russian North Asian regions with significant natural resources produce 25.4% of the country’s gross domestic product. A large part of the economies of these regions is mining and non-ferrous metallurgy: oil and gas production (Tyumen Oblast), coal production (the Republic of Sakha (Yakutia), Kemerovo Oblast), extraction of ore (the Republic of Sakha (Yakutia), Zabaikalsky Krai, the Republic of Buryatia), and non-ferrous metallurgy (Krasnoyarsk Krai, Irkutsk Oblast).

Most of them (12 of 22) are border regions, and 11 have the status of priority geostrategic territories. The largest transport routes linking Asia and Europe pass through the regions of North Asia. The cities of Novosibirsk, Krasnoyarsk, Irkutsk, Khabarovsk, and Vladivostok are five major transportation centers. This macro-region is a world ecological
zone with large boreal forests. In addition, there are 9 of 11 Russian UNESCO World Natural Heritage sites: Lake Baikal, Volcanoes of Kamchatka, Golden Mountains of Altai, Central Sikhote-Alin, Uvs Nuur Basin, Wrangel Island, Putorana Plateau, Lena Pillars, and Landscapes of Dauria.

![Scheme map of the study area. (Source: Compiled by the authors).](image)

### 2.3. Methodology

The proposed methodology comprises the principles of a green economy and closely related ecological and economic theories aimed at sustainable economic growth and social justice.

The research approach includes three stages: (1) assessment of how sustainable the socio-economic development of the Russian regions in North Asia is; (2) comparative analysis of the sustainability of regional policies (to what extent the federal targets and priorities for the green agenda implementation are reflected in the regional strategic documents); and (3) determination of the green direction of regional development by comparing the results of the content analysis of the regional socio-economic development strategies and the estimates of the eco-efficiency of regional development (Figure 2).

![The stages of research.](image)
To assess the sustainability of regional development, we have developed a methodology for DEA of eco-efficiency of socio-economic development in the Russian North Asian regions, using a non-oriented slacks-based measure (SBM) model [46,47]. Radial DEA models, such as CCR and BCC, are widely used in environmental efficiency studies. However, they have some drawbacks and limitations [48–51]. For instance, Djordjević B. and Krmac E. noted that "radial DEA models lead to partial ranking in which most of the DMUs have the same score of efficiency, as well as occurrence of difficulties in ranking the environmental performance of efficient DMUs" [52]. Park, Y.S. et al. noted that "when an environmental pollutant is present in the model, the efficiency assessment becomes a challenging task, since an environmental pollutant need not increase or decrease equal-proportionally with outputs or inputs" [53]. Further, Sueyoshi, T. and Goto, M. noted that the radial models “do not have the property of ‘translation invariance’ (cannot directly handle zero) and they need to especially treat negative values in a data set” [54].

The radial DEA models are based on the basic assumption that efficiency is that the input should be maximally reduced and the output maximally expanded. However, the assessment of eco-efficiency includes consideration of undesirable results (environmental pollutants), so the value of the measurement efficiency may be inaccurate or biased.

There are various approaches to overcoming this problem in the DEA radial models (ignoring undesirable outputs, accounting for undesirable outputs as inputs, and applying a linear monotonic transformation) [55,56]. Although these heuristic approaches provide quite plausible quantitative estimates of efficiency [57], they do not look flawed from an economic point of view. In particular, ignoring undesirable results leads to the loss of a substantial amount of data, reducing the validity of the effectiveness evaluation. Accounting undesirable outputs as inputs is obviously at odds with the understanding of resources within the production function of the DEA model. Monotonically decreasing transformations (both linear and nonlinear) do not have a clear economic interpretation and are associated with several problems related to the choice of transformation type and determination of parameters.

To solve this problem, Tone K. constructed a nonradial and nonoriented SBM model [46,58]. Unlike the radial models CCR and BCC, the slack variables of the SBM model better solve the relationship between inputs and undesirable outputs, so its performance is better than the radial DEA models in reflecting the essence of efficiency measurement. The formula can be written as follows (more information can be seen in [58]).

The efficiency of each of \( n \) decision-making units (DMUs) (regions) is evaluated, each DMU is described by two vectors \((x_j, y_j)\). The vector \( x_j = (x_{1j}, \ldots, x_{mj}) > 0 \) is a vector of \( m \) input variables for the \( j \)-th object. The vector \( y_j = (y_{1j}, \ldots, y_{sj}) > 0 \) is a vector of \( s \) output variables for the \( j \)-th object. The matrix \( X = x_j \) of dimension \( m \times n \) contains the input data for all \( n \) DMUs, and the matrix \( Y = y_j \) of dimension \( s \times n \) contains the output data for all \( n \) DMUs.

The non-oriented SBM model can be formulated as follows:

\[
\begin{align*}
\min \rho &= \frac{1 - \frac{1}{m} \sum_{i=1}^{m} s_i^- / x_{i0}}{1 + \frac{1}{s} \sum_{r=1}^{s} s_r^+ / y_{r0}} \\
\text{s.t.} \\
x_0 &= X\lambda + s^- \\
y_0 &= Y\lambda + s^+ \\
\lambda &\geq 0, \quad s^- \geq 0, \quad s^+ \geq 0
\end{align*}
\]

where \( s^- \), \( s^+ \) are the slacks;

\( \rho \) is a measure of the efficiency of the \( j \)-th DMU, while \( \rho \in (0; 1] \);

\( \lambda \) is the degree of similarity of the \( j \)-th DMU to other DMUs of the of the studied set by the ratios of the values of the variables.

The problem is solved for each object, i.e., \( n \) times. DMU (region) is effective if the following condition is met: \( \rho = 1 \).
Most often, to select indicators as input and output variables of the DEA model, an approach based on the traditional idea of a production function is used, in which the main factors of production from an economic point of view are land, labor, and capital. Indicators characterizing the consumption of these resources are used as input variables, and as an output, the gross domestic or regional product is considered a desirable output and environmental pollution indicators as undesirable [59,60].

At the same time, another approach is used to select indicators based on the “impact decoupling” effect, the essence of which is the mismatch between the rates of economic growth and the negative impact on the environment [61]. In this case, environmental impact indicators are used as input variables of the model, and indicators characterizing economic growth as output variables [42,62–65]. For example, in a study analyzing the eco-efficiency of industry in China’s six central provinces, the authors considered the volume of wastewater discharges, emissions, and energy consumption as input variables and the value added of the industry as an output variable [65].

In our opinion, the second approach most accurately reflects the principles of sustainable development as maintaining the balance of two vectors of regional development: economic growth and environmental conservation. When developing the assessment methodology, we used this approach to the selection of indicators. In the framework of our model, we used the following input variables: emissions of pollutants into the atmospheric air from stationary and mobile sources, the volumes of non-treated or non-sufficiently treated wastewaters that were discharged into water bodies, amount of landfilled waste, and volume of freshwater abstraction (surface and groundwater). In order to consider the environmental, economic, and social aspects of regional development, we used the gross regional product (GRP) and the resident population as the output variables (Table 1). The choice of the indicators was due to their basic importance and availability.

**Table 1. Input and output variables to assess the eco-efficiency of socio-economic development of regions.**

| Variable | Indicator | Unit | Mean | Max  | Min  | Std.dev. |
|----------|-----------|------|------|------|------|----------|
| Input    | Total annual emissions of pollutants into the atmospheric air from stationary sources | million tons | 0.419 | 3.520 | 0.004 | 0.741    |
| Input    | Total annual emissions of pollutants into the atmospheric air from mobile sources | million tons | 0.130 | 0.531 | 0.001 | 0.117    |
| Input    | Volumes of non-treated or non-sufficiently treated wastewaters that were discharged into water bodies | million cubic meters | 133.25 | 1009.24 | 0.24 | 177.21   |
| Input    | Amount of landfilled waste | million tons | 96.91 | 1897.89 | 0.001 | 498.04   |
| Input    | Volume of freshwater abstraction (surface and groundwater) | million cubic meters | 580.40 | 4158.19 | 6.95 | 835.28   |
| Output   | Gross regional product in constant prices | millions of chained 2010 rubles | 467,565.07 | 3,812,654.47 | 22,393.7 | 718,071.7 |
| Output   | Resident population | million person | 1.321 | 3.74 | 0.05 | 1.048    |

Source: Compiled by the authors.

The calculations were performed in the Open Source DEA (OSDEA) software using official data from the Russian Federal State Statistics Service and Ministry of Natural Resources and Environment for the years 2010–2019.

To assess the sustainability of regional policies, we performed a content analysis of regional socio-economic development strategies (SEDS) to determine the extent to which they reflect the federal targets and priorities for the green agenda implementation. In this...
study, we used the scientific method of qualitative and quantitative analysis of the content of documents, namely content analysis of regional socio-economic development strategies up to 2030 among the Russian regions of North Asia. The methodology and technique of content analysis are fully described in scientific sources [66]; content analysis is most useful for processing large text arrays [67].

When conducting content analysis, we used the manifest approach, which is a quantitative approach based on the frequency of occurrence of keywords and phrases [66].

SEDS are fundamental documents for strategic planning and decision making in the Russian regions. As a rule, this document presents an “image of the desired future” of a region and the ways to achieve it. Generally, SEDS are based on legislative, strategic, and conceptual documents of Russia. At the same time, each regional SEDS recognizes the competitive advantages of a region and its role in the spatial development of the country.

We concede that regional documents may include green agenda policy provisions in either identical terms or varied, sometimes vague language. Hence, for the content analysis, we used keywords/combinations of words (hereinafter referred to as marker words) describing different aspects of the green economy, as well as related low-carbon, resource-efficient, bio-, and circular economies. We propose the following marker words associated with green growth while focusing on specific sectors or parameters of eco-economic development:

- greening of key economic sectors;
- green energy;
- recycling;
- zero-waste production;
- model areas for green economy development;
- green enterprises;
- green technologies;
- green innovations;
- green products (environmentally friendly products, organic products);
- green skills and green jobs;
- green standards;
- green bonds;
- environmental sustainability in the development of cities and territories;
- eco-tourism;
- green image;
- environmental regulation;
- pro-environmental behavior.

We performed the content analysis of SEDS using marker words manually to ensure their correct interpretation in four key sections of a SEDS: (1) goals; (2) priorities; (3) areas of development; and (4) SEDS indicators.

In order to compare the results of the content analysis of regional strategies and assess the environmental efficiency of the socio-economic development of the regions of North Asia, it is proposed to cluster the regions based on the results of the first two stages: the values of the environmental efficiency of socio-economic development and the number of green areas of development of the considered regions of North Asia identified in the SEDS. On the basis of the selected clusters, it is supposed to identify the existing patterns and relationships between the current state of the ecological trajectory of the socio-economic development of the regions and the green orientation of the regional policy.

3. Results

3.1. Assessment of Eco-Efficiency of the Socio-Economic Development in the Russian North Asian Regions from 2010 to 2019

The assessment results of the eco-efficiency of socio-economic development in the Russian North Asian regions from 2010 to 2019 are presented in Table 2. The increasing scale effect (value is equal to 1) means that the relative GRP growth and the rate of population
increase in a region prevail over relative growth of respective negative environmental impact, i.e., the development of a region can be recognized as eco-efficient. On the contrary, the decreasing scale effect (value less than 1) indicates that economic and population growth in a region is not as intense as the negative environmental impact.

Table 2. The assessment results of the eco-efficiency of socio-economic development in the Russian North Asian regions, 2010–2019.

| Regions                | 2010  | 2011  | 2012  | 2013  | 2014  | 2015  | 2016  | 2017  | 2018  | 2019  | Average Value for 2010–2019 |
|------------------------|-------|-------|-------|-------|-------|-------|-------|-------|-------|-------|-----------------------------|
| Altai Krai             | 1.000 | 0.661 | 0.661 | 1.000 | 1.000 | 1.000 | 0.754 | 0.711 | 0.340 | 0.813 |                             |
| Amur Oblast            | 0.503 | 0.507 | 0.507 | 0.450 | 0.596 | 0.505 | 0.631 | 0.562 | 0.700 | 1.000 | 0.596                       |
| Jewish Autonomous Oblast | 1.000 | 1.000 | 1.000 | 0.540 | 0.488 | 0.446 | 1.000 | 1.000 | 1.000 | 0.783 | 0.826                       |
| Zabaikalsky Krai       | 0.315 | 0.320 | 0.320 | 0.391 | 0.402 | 0.325 | 0.353 | 0.328 | 0.337 | 0.414 | 0.351                       |
| Irkutsk Oblast         | 0.253 | 0.237 | 0.237 | 0.227 | 0.472 | 0.327 | 0.338 | 0.551 | 0.356 | 0.370 | 0.337                       |
| Kamchatka Krai         | 0.535 | 0.563 | 0.563 | 0.414 | 1.000 | 0.469 | 0.563 | 0.413 | 0.414 | 0.224 | 0.516                       |
| Kemerovo Oblast        | 0.267 | 0.258 | 0.258 | 0.253 | 0.266 | 0.203 | 0.205 | 0.212 | 0.196 | 0.215 | 0.233                       |
| Krasnoyarsk Krai       | 0.288 | 0.292 | 0.292 | 0.274 | 0.539 | 0.298 | 0.332 | 0.384 | 0.412 | 0.244 | 0.335                       |
| Magadan Oblast         | 0.307 | 0.305 | 0.305 | 0.311 | 0.310 | 0.303 | 0.287 | 0.297 | 0.279 | 0.110 | 0.281                       |
| Novosibirsk Oblast     | 0.745 | 0.770 | 0.770 | 0.626 | 1.000 | 0.543 | 1.000 | 0.553 | 0.557 | 0.572 | 0.714                       |
| Omsk Oblast            | 0.622 | 0.537 | 0.537 | 0.602 | 0.723 | 0.529 | 0.684 | 1.000 | 1.000 | 0.668 | 0.690                       |
| Primorsky Krai         | 0.355 | 0.379 | 0.379 | 0.377 | 0.395 | 0.313 | 0.333 | 0.400 | 0.428 | 0.419 | 0.378                       |
| Republic of Altai      | 1.000 | 1.000 | 1.000 | 1.000 | 1.000 | 1.000 | 1.000 | 1.000 | 1.000 | 1.000 | 1.000                       |
| Republic of Buryatia   | 0.399 | 0.362 | 0.362 | 0.317 | 0.268 | 0.223 | 0.241 | 0.257 | 0.250 | 0.263 | 0.294                       |
| Republic of Sakha (Yakutia) | 0.613 | 0.506 | 0.506 | 0.552 | 1.000 | 1.000 | 1.000 | 1.000 | 0.477 | 1.000 | 0.765                       |
| Republic of Tyva       | 1.000 | 1.000 | 1.000 | 1.000 | 1.000 | 1.000 | 1.000 | 1.000 | 1.000 | 1.000 | 1.000                       |
| Republic of Khakassia  | 0.379 | 0.423 | 0.423 | 0.479 | 0.467 | 0.428 | 0.461 | 0.446 | 0.319 | 0.467 | 0.429                       |
| Sakhalin Oblast        | 1.000 | 1.000 | 1.000 | 1.000 | 1.000 | 1.000 | 1.000 | 1.000 | 1.000 | 1.000 | 1.000                       |
| Tomsk Oblast           | 1.000 | 1.000 | 1.000 | 0.815 | 1.000 | 0.610 | 1.000 | 1.000 | 0.845 | 0.370 | 0.864                       |
| Tyumen Oblast          | 1.000 | 1.000 | 1.000 | 1.000 | 1.000 | 1.000 | 1.000 | 1.000 | 1.000 | 1.000 | 1.000                       |
| Khabarovsk Krai        | 0.569 | 0.518 | 0.518 | 0.572 | 0.461 | 0.419 | 0.417 | 0.477 | 0.456 | 0.380 | 0.479                       |
| Chukotka Autonomous Okrug | 1.000 | 1.000 | 1.000 | 1.000 | 0.519 | 1.000 | 1.000 | 1.000 | 1.000 | 0.952 |                             |

1 Data presented for Tyumen Oblast together with KhMAO and YaNAO. Source: Calculated by the authors.

The results obtained indicate that only four regions are environmentally efficient on average for the period 2010–2019: Sakhalin Region, Tyumen Region, Altai Republic, and Tyva Republic (Figure 3). It should be noted that of the first two regions, the Sakhalin Oblast is characterized as a region with large agglomerations and a relatively diversified economy, while the Tyumen Oblast is characterized as a region with a highly efficient
mining industry. This also includes two regions with a high share of agriculture and the public sector: the Republic of Altai and the Republic of Tyva.

Figure 3. Eco-efficiency of the socio-economic development of the Russian North Asian regions (average for 2010–2019). Source: Compiled by the authors.

In general, the Russian North Asian regions have seen a decline in the eco-efficiency of socio-economic development from 2010 to 2019. There is a fairly high variation in the indicators among the regions, with unstable growth of the coefficient of variation over the period (Figure 4).

The interregional differentiation of this indicator for the period under review remained high, and an unstable increase in the coefficient of variation was observed.

3.2. Analysis of SEDS of the Russian North Asian Regions

To determine how the regions are going to comply with Russia’s decisions to implement the green agenda, we conducted a content analysis of the regional SEDS, focusing on the inclusion of the federal targets and priorities. The strategies of the regions for the period up to 2030 were analyzed during the content analysis.

Virtually all regional SEDS recognize the worth of each human being, its prosperity and full realization of human potential, thus contributing to the achievement of the SDGs in the following key areas: health and well-being, quality education, decent work, social inclusion, poverty reduction, gender equality, and cultural values. So as to describe their strategic goal, 17 regions have chosen the phrase “high quality of life”, three regions—“development of human capital”. In order to achieve modern standards of living, the Republic of Altai, in its strategy, is committed to effective territorial management in light of the principles of
The regions share the same vision of development goals, which are the key benchmarks of sustainable development: social justice, environmental protection, and economic prosperity; however, they imply various approaches (Table 3). In general, the regions identified their strategic priorities in social (21 regions), economic (21), infrastructure (11), spatial development (11), and environmental (9) policies. Four regions attribute the desired image of the future to greening the economy. The priority of Kemerovo Oblast, a region with highly developed extractive industries, is to become the center of a green economy. Common priorities are the development of effective public administration (6 regions) and science and innovation (6). Less common priorities include foreign economic (3), new positioning in the Far East and in the Asia-Pacific region (1); digital society infrastructure (1). Strategic priorities are primarily related to the development of a competitive economy and economic growth.

As our study shows, there is a convergence of “pure” economic and environmental policies toward a green economy (and to related low-carbon, resource-efficient, circular economies, and bioeconomy).

We summarized and ranked by frequency of occurrence the green priorities indicated in SEDS of the regions (Figure 5).

The green economy priority areas, indicated in the regional SEDS, are the following: greening of key economic sectors (energy, agriculture, transport, industry, fishery, forestry, waste management, housing and utilities (22 regions); development of eco-tourism (20), the introduction of green technologies in the regional economy (19). The regions develop pro-environmental behavior through eco-education (16); production of eco-friendly goods (16); enhancement of environmental regulation in 13 regions (voluntary environmental audits, environmental expertise, environmental control, monitoring, and supervision); green energy (11); comfortable environment and urban greening (10).
Table 3. The results of the content analysis of SEDS of the Russian North Asian regions by strategic priorities.

| Regions                      | Social Policy | Economic Policy | Infrastructure Policy | Spatial Development Policy | Environmental Policy | Effective Public Administration | Science and Innovation | Foreign Economic | Digital Society Infrastructure | New Positioning in the Far East and in the Asia-Pacific Region |
|------------------------------|---------------|-----------------|-----------------------|---------------------------|----------------------|----------------------------------|-----------------------|-----------------|---------------------------------|--------------------------------------------------|
| 1-11 Altai Krai              |               |                 |                       |                           |                      |                                  |                       |                 |                                 |                                                  |
| 1-11 Amur Oblast             |               |                 |                       |                           |                      |                                  |                       |                 |                                 |                                                  |
| 1-11 Jewish Autonomous Oblast|               |                 |                       |                           |                      |                                  |                       |                 |                                 |                                                  |
| 1-11 Zabaikalsky Krai        |               |                 |                       |                           |                      |                                  |                       |                 |                                 |                                                  |
| 1-11 Irkutsk Oblast          |               |                 |                       |                           |                      |                                  |                       |                 |                                 |                                                  |
| 1-11 Kamchatka Krai          |               |                 |                       |                           |                      |                                  |                       |                 |                                 |                                                  |
| 1-11 Kemerovo Oblast         |               |                 |                       |                           |                      |                                  |                       |                 |                                 |                                                  |
| 1-11 Krasnoyarsk Krai        |               |                 |                       |                           |                      |                                  |                       |                 |                                 |                                                  |
| 1-11 Magadan Oblast          |               |                 |                       |                           |                      |                                  |                       |                 |                                 |                                                  |
| 1-11 Novosibirsk Oblast      |               |                 |                       |                           |                      |                                  |                       |                 |                                 |                                                  |
| 1-11 Omsk Oblast             |               |                 |                       |                           |                      |                                  |                       |                 |                                 |                                                  |
| 1-11 Primorsky Krai          |               |                 |                       |                           |                      |                                  |                       |                 |                                 |                                                  |
| 1-11 Republic of Altai       |               |                 |                       |                           |                      |                                  |                       |                 |                                 |                                                  |
| 1-11 Republic of Buryatia     |               |                 |                       |                           |                      |                                  |                       |                 |                                 |                                                  |
| 1-11 Republic of Sakha (Yakutia)|           |                 |                       |                           |                      |                                  |                       |                 |                                 |                                                  |
| 1-11 Republic of Tyva         |               |                 |                       |                           |                      |                                  |                       |                 |                                 |                                                  |
| 1-11 Republic of Khakassia    |               |                 |                       |                           |                      |                                  |                       |                 |                                 |                                                  |
| 1-11 Sakhalin Oblast         |               |                 |                       |                           |                      |                                  |                       |                 |                                 |                                                  |
| 1-11 Tomsk Oblast            |               |                 |                       |                           |                      |                                  |                       |                 |                                 |                                                  |
| 1-11 Tyumen Oblast           |               |                 |                       |                           |                      |                                  |                       |                 |                                 |                                                  |
| 1-11 Khabarovsk Krai         |               |                 |                       |                           |                      |                                  |                       |                 |                                 |                                                  |
| 1-11 Chukotka Autonomous Okrug|               |                 |                       |                           |                      |                                  |                       |                 |                                 |                                                  |
| **1-11 Total**               | **21**        | **21**          | **11**                | **11**                    | **9**                | **6**                           | **6**                 | **3**           | **1**                           | **1**                                            |

1 Data presented for Tyumen Oblast together with KhMAO and YaNAO. Source: Calculated by the authors.

In 9 regions, green growth is based on zero-waste production, green innovations (9), and recycling (8).

Although 7 regions plan to build green enterprises, only Kemerovo Oblast intends to create green skills and green job centers. Five regions noted the improvement of their green image, and four regions allocated model areas for green economy development.
Our study has shown that regional priorities had been formulated with regard to the strategic goals of the eco-economic development of Russia. These regional priorities of socio-economic development pertain to the transition to a green economy, as well as to resource-efficient, low-carbon, circular economies, and bioeconomy. Regions are striving to implement the green agenda with different efforts. The most comprehensive approaches were found in the SEDS of Krasnoyarsk Krai, Kamchatka Krai, Primorsky Krai, Tomsk Oblast, and Jewish Autonomous Oblast. The clustering of regions by the number of green directions of development in the SEDS was carried out on the basis of equal intervals: the values from 8 to 12 correspond to the high green orientation of the regional policy, from 4 to 8—to the average, from 0 to 4—to the low orientation (Figure 6). As a result of the clustering 10 regions of North Asia are characterized by a high green orientation of the regional policy, and 12 regions are medium.

The results of assessing the level of environmental efficiency of socio-economic development and content analysis of the strategies of the regions of North Asia were summarized in a common matrix (Figure 7).
The following clusters of regions were identified: environmentally efficient with an average green focus of regional policy—4 regions; environmentally inefficient with an average green orientation of the regional policy—8 regions; and environmentally inefficient with a high green orientation of the regional policy—10 regions. Most of the environmentally inefficient regions (55.6%) are characterized by a high green policy orientation, while the policy of 100% efficient regions was rated as medium green orientation.

A comparison of the results of the content analysis of regional strategies and the assessment of the environmental efficiency of the socio-economic development of the regions of North Asia indicate that regions with low environmental efficiency determine a greater focus on “green” development in strategic documents than more prosperous regions. The results show the adequate regional response to the environmental challenges and the current progress in green regional development.

The regions continue to work on increasing the role of ecology in people’s lives. Further course can be adjusted by state policy measures to create incentives for resource and energy saving, reducing the negative impact on the environment. Appropriate measures of state support could adjust the course of development by creating incentives for resource and energy saving, reducing the negative impacts on the environment.
Figure 7. Greenness of regional policies and eco-efficiency of the Russian North Asian regions. Source: compiled by the authors.

4. Discussion

The main indicators of compliance of regional socio-economic development with the principles of a green economy characterize the consumption of natural capital and ecosystem services. In our DEA of eco-efficiency of regional social-economic development, we used five input variables (characterizing the impact on the air and water environment, amount of landfilled waste and volume of freshwater abstraction—surface and groundwater), and two output variables—GRP and resident population. This set of variables made it possible to capture the environmental, economic, and social development trends in the regions.

From the results obtained, it follows that both regions with large agglomerations and a relatively diversified economy (Sakhalin Region), regions with highly efficient extractive industries (Tyumen Region), and individual regions with a high share of agriculture and the public sector (Republic of Altai, Republic of Tyva) are environmentally efficient. In general, the Russian North Asian regions have demonstrated a decline in the eco-efficiency of socio-economic development from 2010 to 2019. There is a fairly high scatter of the indicators between the regions.
We characterized the regional transition to a green economy and its prospects based on the results of the content analysis of regional strategies using marker words. It is shown that regional priorities were defined to meet the strategic goals of the eco-economic development of Russia. We found that regional SEDS recognize the shared goals of social justice, environmental protection, and economic well-being; however, the strategic priorities differ between regions and are related to social, economic, infrastructural, spatial development and environmental policies, and development of effective public administration, science, and innovations.

Strategic priorities are primarily related to the development of a competitive economy and economic growth, combining economic and environmental policies to form a green economy with the features of low-carbon, resource-efficient, circular economies, and bioeconomy. The identified green priorities of SEDS (socio-economic development strategies) of the Russian North Asian regions largely correspond to the objectives of the EU Green Deal concept. Indeed, the regional development strategy of Kemerovo Oblast (which we classified as an environmentally inefficient region due to the high share of extractive industries) includes such priorities as the greening of key economic sectors, zero-waste production, green enterprises, green technologies, green innovations, green skills and green jobs, green bonds, and a green image. These priorities are close to such goals of the EU Green Deal as the transition to a circular economy, striving for a zero-pollution environment, increasing the scale of sustainable investments, and reducing greenhouse gas emissions. The following areas become more important: development of human potential, economically attractive activities, infrastructure and transport accessibility, innovation and technological development, comfortable living space, efficient use of resources, environmental safety and protection, improving management, and strengthening cooperation with other regions and countries.

According to our findings, the regions implement the green agenda with different efforts. The most comprehensive approaches were found in the SEDS of Krasnoyarsk Krai, Kamchatka Krai, Primorsky Krai, Tomsk Oblast, and Jewish Autonomous Oblast.

We found considerable variations among the Russian North Asian regions in the extent to which their socio-economic development was consistent with the principles of a green economy. These variations have been observed in the priorities and tools of regional policies and in the level of eco-efficiency. In fact, the variations found indicated both the successes already achieved today and the existing prospects for the greening of regional development.

The approaches we propose can support decision making in the field of eco-economic development as a tool to measure the degree of compliance of regional development with the principles of a green economy.

Limitations and Suggestions for Future Research

This study analyzes the regional socio-economic development in terms of its sustainability and regional green economy policies, as well as the effectiveness of their implementation involving both federal and regional mechanisms. In future studies, we intend to include this aspect in the methodology.

It should be noted that the model used covers the economic and environmental aspects of sustainability and partially the social aspect (population size). However, in future studies, we plan to cover the social dimension of sustainability in more detail by including indicators reflecting equality in the distribution of economic benefits, the priorities of the younger generation, etc.

The method was tested for the part of the Russian regions located in North Asia, so the study may lack the basis for the applicability of the results in other countries. Future studies are also planned to examine the regions of Mongolia, Kazakhstan, and China.

In our opinion, despite these limitations, this study offers methodological approaches and conclusions that have a scientific novelty. These results and approaches can be used in public administration, as well as in future research.
5. Concluding Remarks

New approaches to regional management are needed in light of the global climate agenda and increased anthropogenic pressures. The methodology proposed in this paper helped to investigate the development and implementation of regional green economy policies, using the Russian regions in North Asia as an example. Calculated based on the SBM-DEA model, the environmental efficiency indicators of the studied regions reflect the environmental and economic situation. The content analysis of SEDS was used to determine the extent to which the federal targets and priorities for the green agenda implementation are reflected in the regional strategic documents.

A comparison of the content analysis results and the environmental efficiency indicators revealed considerable variations among the Russian North Asian regions in the extent to which their socio-economic development is consistent with the principles of a green economy (in terms of regional policy priorities and environmental efficiency). Although these results are largely driven by independent factors (such as the natural and geographic location, the structure of the economy, etc.), they may also indicate the need to adjust the greening of regional development and revise strategic documents in a particular region. The proposed methodology can be an important tool for regulating the green economy and regional development.

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