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Environmental investment, the main condition for the COVID-19 post-pandemic recovery of Russian economy and transition to sustainable economic growth

Ludmila Aleksandrovna Kormishkina, Evgenii Danilovich Kormishkin, Dmitrii Aleksandrovich Koloskov*

Department of Economics, Ogarev Mordovia State University, Saransk, Russia

** Corresponding author's Email: aba.kol356@gmail.com*

ABSTRACT

The relevance of the article is due to the search for the possibility of a COVID-19 post-pandemic recovery of the Russian economy and a return to long-term sustainable growth in total factor productivity (TFP), taking into account the recognition of the priority of the environmental aspect of development. The purpose of the study is to develop an original scientific hypothesis, according to which, in the context of planetary manifestations of large-scale environmental challenges, on the one hand, and unprecedented external sanctions pressure on the Russian Federation, on the other hand. At first, environmental investment should become the main condition and a powerful factor in the long-term sustainable growth of TFP, as well as a radical transformation of the "pro-crisis" Russian economic model in accordance with the principles of the global ESG agenda. Environmental investments are positioned as responsible, in fact, and transformative in terms of their functional role in the economy. An econometric model has been constructed that reflects the dependence of per capita GDP growth rates on the volume of investments in fixed assets directed in the Russian Federation for environmental protection and rational use of natural resources, which has the form of a system of dynamic economic regressions with a distributed lag of a polynomial structure. Such a model can be used to assess the long-term and short-term responses of economic growth indicators from green investment. The methodological basis for the development of the aforementioned model was the methods of correlation, linear and nonlinear regression, factorial and dispersion analysis, the generalized least squares method, the method of instrumental variables. The main restrictions on environmental investment in modern Russia are established and proposals are made to stimulate it.

Keywords: Environmental challenges, Economic growth, Total factor productivity, Environmental investment, Economic incentives, Green economy.
Article type: Research Article.

INTRODUCTION

Introducing the problem

The extremely difficult situation that has developed after the global crisis of 2008-2009 in different countries of the world, including Russia, and was characterized by "everywhere chronically low economic efficiency" (Spence 2021) combined with a progressive "social recession" even in developed economies (Jackson 2017) and "planetary manifestations of environmental growth constraints" (Gubanov 2014), nowadays is compounded by the devastating effects on business and other aspects of society from the ongoing COVID-19 pandemic and unprecedented external sanctions pressure on the Russian Federation. The current crisis, e.g., for the Russian Federation can be displayed through such indicators as inflation growth; a drop in demand for Russian exports, in which about 90% is occupied by raw materials and semi-raw materials; loss of working days; decline in production due to a decrease in investment activity. Obviously, in such conditions, not only Russia, but all countries of the world- poor, rich and moderately developed- for the next decades are programmed for economic growth and this

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is quite understandable. Economic growth is, at first, an opportunity to provide the majority of people with a decent level of income and wealth (Jackson 2009; Mdehheb *et al.* 2020; Safiullin *et al.* 2020; Tatuev *et al.* 2020; Khadom *et al.* 2021; Kitsai *et al.* 2021). In addition, it increases their chances for productive and creative employment, the ability to be valuable to society, education and health, in the one word, everything that creates freedom and the possibility of self-realization (Spence 2012). In other words, "while the economy is growing, positive feedback mechanisms tend to push the system in the direction of further development" (Jackson 2009).
In this context, we note that in accordance with the UN Sustainable Development Goals (SDGs) for the period of 2016–2030, which are a kind of call to action coming from all countries of the world, the annual increase in GDP per capita (the most adequate indicator of the growth of welfare) is set for the least developed economies at 7% (target 8%). The Supreme Eurasian Economic Council has set 5–5.5% as a target for this indicator for the EAEU member countries. Noteworthy, according to RAS academician S. Yu. Glazyev, even under the conditions of external sanctions pressure on Russia, a "normal workable" model of the national economy, not export-oriented (rental), but tuned to constant technological modernization as a built-in, organic component, can provide annual economic growth of at least 10% (Glazyev 2018). In addition, it should be recognized that the growth of the economy in its neoliberal model (in relation to modern Russia - the export of raw materials), in which its main "locomotive" is gross consumption, leads to an increase in the burden on the environment under the influence of an increase in the ecological footprint and ecological debt of mankind deterioration of the quality of the environment (oversaturation of the atmosphere with greenhouse gases and climate change, increasing harmful waste and emissions, reducing biodiversity and fresh water reserves, soil degradation, depletion of mineral resources, etc.). Designated environmental challenges that in the coming XXI century acquired a planetary character, dictate the need to change the economic paradigm: "the transition to an economic structure that functions not against the productive forces of nature, but together with them" (Füks 2016), provided by radical transformations of the economy in accordance with the global ESG agenda (Bobylev 2020). Notably, even in the context of a pandemic world, it was the environmental and economic development priorities of countries that were emphasized at the World Economic Forum held in Davos in 2020. In this context, it is of fundamental importance for modern economic science and practice to raise the question of the need to move from a consumer model of economic growth to an investment one (Sukharev 2019), on the development of a new investment strategy, in which environmental investments, which are inherently adequate to the principles of the global ESG agenda, become the "locomotive of growth".

Exploring Importance of the problem

For Russia in the current conditions, when the unprecedented external sanctions pressure actually coincided with the exhaustion of the possibilities of the export-raw material (consumer, rental) model of economic growth that has established itself here, it is difficult not to admit that the country's economy is arriving at a bifurcation point of its development, in a state of unstable equilibrium, when there are several main development options that continue this unstable trend. It should be noted that adopted decision in accordance with the Decree of the President of the Russian Federation of 07.05.2018. №204 National projects, new proposals for post-crisis economic recovery in the face of external sanctions pressure are certainly necessary and capable of supporting the development of the domestic economy. At the same time, from the point view of a strategic perspective, they are insufficient to ensure GDP growth rates that outpace world dynamics. The current situation forces us to look for ways to form a new model of the national economy that can develop and provide a high level of income not at the expense of natural and market rent, but at the expense of science-intensive, high-tech and energy-efficient production. In this context, the actions taken should be adequate to the general patterns and trends of the modern era, among which environmental ones undoubtedly occupy a priority place (Fishman *et al.* 2019). In other words, we are talking about such a model of the national economy, which should be adequate to the principles of the global ESG agenda and have the following important features:

• Science-intensive and high-tech manufacturing and infrastructure types of economic activity with minimal impact on the environment receive priority in development;

• Environmentally efficient interactions between production and consumption that reduce environmental pollution;

• Non-waste and recycling of resources;

• Ensuring environmental safety as a special social benefit, etc.

So, nowadays, Russia is facing a problem that can be called the "problem of transition", when the generally-accepted formulation of the question of ensuring economic growth based on such a component of aggregate demand as "investment costs" becomes of fundamental importance (Sukharev 2019, 2020; Spence 2021). In the context outlined above, the main condition and powerful factor "triggering the increasing dynamics of positive economic growth" (Spence 2012) should be environmental investments "that create the right environment for such a flourishing of innovations and such a transformation of the environment that we can not even imagine" (Gordon & Mokyr 2016). Importantly, Russia can benefit from a shift in emphasis to environmental investment for a number of reasons: 1) ignoring its growing role, due to the preservation of the raw material export model of the economy in our country, reproduces unsustainable environmental trends (high level of environmental intensity of production and pollution intensity); depletion of natural capital; the predominance in the structure of the economy of nature-exploiting and environmentally polluting types of economic activity; natural resource nature of exports, etc.), which, in turn, jeopardize the achieved economic and social results; 2) a significant excess of economic costs from environmental degradation in the Russian Federation (according to WB experts, they amount to 1–6% of GDP) compared to the value of this indicator for developed countries (Damianova 2018), which reduces the competitiveness of the Russian economy in the world market ; 3) such investments can create new jobs, provide meaningful jobs with a low carbon footprint, reduce poverty, improve the standard and quality of life of the population (Banerjee & Duflo 2019); 4) in the current situation, Russia does not have to choose between economic growth and environmental protection. It can achieve these two goals simultaneously due to the available bio-capacity reserve. The economic recession driven by the COVID-19 pandemic and unprecedented external sanctions pressure on Russia provide it with a unique opportunity to invest in the radical transformation of the economy of the 21st century, ensured by the implementation of the principles of the global ESG agenda, in order to make a decisive turn from the sidelines to the mainstream of socio-economic progress.

Background/literature review

As part of the complex discussion that has unfolded in modern economics about the quality of the environment during economic growth, a growing number of scientists and specialists associate the possibility of a return to sustainable growth of "total factor productivity" (TFP), which ensures income and wealth growth (Gordon 2016), with a change in the balance between consumption and investment in the economy in favor of the latter (Jackson, 2009, 2017; Spence 2012, 2021; Sukharev 2019, 2020). So the Nobel Prize winner in economics M. Spence argues that "growth requires investment - the sacrifice that is being made now for the sake of future benefits", and innovation generates growth (Spence 2021). In a number of works, "significant early environmental investments" are positioned as a possible "support" and a powerful factor in the sustainable growth of TFP under extreme environmental restrictions (Jackson 2009, 2017; Banerjee & Duflo 2019; Spiridonova 2020; Kormishkina 2021). For example, the Nobel Prize winner in economics A. Banerjee and E. Duflo, refining the theory of creative destruction developed by J. Schumter, note that "...total factor productivity also increases when we discover new ways to reduce waste or waste time associated with underutilization raw materials or workers. Notably to date, environmental investments have been little studied and do not have a generally accepted clear terminological definition, often identified with "green" finance. Drawing on the UNEP Green Economy interpretation and multiple competing green investment goals (reducing carbon emissions, productive use of natural capital, replacing non-renewable natural resources with renewable ones, adapting and improving ecosystems, creating public assets, etc.; Jackson 2017), it is legitimate to consider the indicated investments as all types of property and intellectual investments in economic activities that provide investors not only with income, but also with the achievement of a certain environmental benefit and positive social change in the context of environmentally sustainable development. Such an approach to the essence of environmental investment forms a clear understanding: it is wrong to harm the environment through economic activity, just as it is wrong to receive income from an environmental catastrophe. This means that environmental investments simultaneously generate deinvestments, i.e. withdrawal of funds and directing them to other, environmentally friendly industries, refusal to invest in securities and funds that carry out unethical or morally questionable activities from the perspective of the global ESG agenda (Fishman 2019; Animitsa 2020). Finally, in the context of ensuring long-term sustainable growth of TFP, environmental investments are adequate to the criteria and driving forces of the "fourth industrial revolution" (Schwab 2017) and the neo-industrial paradigm of Russia's modern development, justified even

before the pandemic economic recession and external sanctions pressure on the Russian Federation by domestic scientists and economists (Gubanov 2012; Daskovsky & Kiselev 2016). The above, of course, creates the need to form the subject area of economic investment, requires a detailed study of its structure, a set of conditions (rate of return, nature of profit, repayment period, etc.) that determines how such investments interact with supply and demand. However, this task is beyond the scope of this study. At the same time, some considerations can already be made about the consequences of a significant increase in the role of environmental investments.

Stating hypotheses and their correspondence to research design

Hypothesis 1. In today's Russia, there is an objective need for environmental investment, which is, in its essence, responsible and transformative - in terms of its functional role in the economy. Hypothesis 2. In a situation of post-pandemic recession and external sanctions pressure on the Russian Federation, environmental investment can become the main condition and a powerful factor in ensuring long-term sustainable growth of TFP, an "active start" for radical transformations of the economy of the 21st century, provided by the formation of a "green" economy. Hypothesis 3. To assess the long-term and short-term responses of economic growth indicators from environmental investment in the Russian Federation, it is advisable to use the constructed econometric model of the dependence of GDP per capita growth rates on the volume of investments in fixed assets aimed at protecting the environment and rational use of natural resources, which has the form of a system dynamic economic regressions with a distributed lag of a polynomial structure.

MATERIALS AND METHODS

To test the abovementioned scientific hypothesis, econometric methods and models were used. The specification of which takes into account, among other things, the time lag of endogenous and exogenous indicators. At the same time, the creation of an estimated econometric model that reflects long-term and short-term responses of economic growth indicators to the volume of environmental investments was based on a conceptual approach, which consists in combining in one form or another the components of aggregate demand from the well-known Keynesian macroeconomic model (Keynes 1936) with modified production function of Cobb-Douglas, which, in addition to traditional components, additionally includes the factor of generation and processing of production and consumption waste (Pittel 2010). As an indicator of environmental investment, we consider (in accordance with the order of Rosstat "On approval of methodological guidelines for calculating the index of the physical volume of environmental expenditures" dated November 21, 2018 No. 682) the indicator "investments in fixed capital aimed at protecting the environment and rational use of natural resources" (source for Russia URL: https://rosstat.gov.ru); for other countries of the world - "public environmental expenditures" (Bubble environmental expenditures) and "green" business investments (Business "green" investments; Source: OECD: Stat.URL:http://stats.oecd.org) .

The hypothesis was tested using the constructed system of two dynamic regressions by Sh. Almon (The Almon Polynomial Distributed Lag; Griffiths 1993) with distributed lags of the form (1):

$$\begin{cases} Y_{1t} = \delta + \beta_0 X_{1t} + \beta_1 X_{1t-1} + \beta_2 X_{1t-2} + \cdots + \beta_l X_{1t-l} + \varepsilon_t \\ \ln(Y_{2t}) = \alpha + \gamma_0 \ln(Y_{1t}) + \gamma_1 \ln(Y_{1t-1}) + \gamma_2 ln(Y_{1t-2}) + \cdots + \gamma_l \ln(Y_{1t-l}) + u_t, \end{cases} \quad \textbf{(1)}$$

where Y_{2t} – volume of GDP per capita of the Russian Federation (indicator of economic growth);

Y_{1t} – the volume of investments in fixed assets aimed at protecting the environment and rational use of natural resources in the Russian Federation;

X_t – the volume of generation and processing of production and consumption waste.

To identify, analyze and verify the econometric model (1), its economic interpretation, the methods of correlation, linear and non-linear regression, factor and variance analysis, the generalized least squares method, and the method of instrumental variables were used.

In the model 1 β_0,γ_0 – short-term multiples, $\sum_{k=1}^{l} \beta_k$; $\sum_{k=1}^{l} \gamma_k$– long-term multipliers (1) that characterize the change in performance indicators under the influence of a single change in exogenous variables in each of the considered future time periods. According to Sh. Almon's method, if the effective indicator depends on the current and lag values of exogenous indicators, then the weights in β_j,γ_i in (1) obey the polynomial distribution (2; Ivanova 2021):

$$\beta_j = c_0 + c_1 j + c_2 j^2 + ... + c_k j^k, \gamma_i = d_0 + d_1 i + d_2 i^2 + ... + d_k i^k \quad \textbf{(2)}$$

The procedure for applying the Sh. Almon method for estimating the parameters of models with a distributed lag 1 assumes:
– Determination of the maximum value of the lag l;
– Determination of the degree of the polynomial k describing the structure of the lag 2;
– Introduction of instrumental variables (3):

$$Z_0 = X_t + X_{t-1} + X_{t-2} + X_{t-3} + \cdots + X_{t-l};$$
$$Z_1 = X_{t-1} + 2X_{t-2} + 3X_{t-3} + \cdots + l \cdot X_{t-l};$$
$$Z_2 = X_{t-1} + 4X_{t-2} + 9X_{t-3} + \cdots + l^2 \cdot X_{t-l}$$
$$\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots..$$
$$Z_k = X_{t-1} + +2^k X_{t-2} + 3^k X_{t-3} + \cdots l^k \cdot X_{t-l}\ ; \quad (\mathbf{3})$$

– Definition of parameters c_i multiple linear regression 4:

$$Y_t = \delta + c_0 \cdot Z_0 + c_1 \cdot Z_1 + c_2 \cdot Z_2 + \cdots + c_k \cdot Z_k + \varepsilon_t; \quad (\mathbf{4})$$

– Using relations 5, the parameters of the initial models with a distributed lag 1 are calculated:

$$\beta_0 = c_0$$

$$\beta_1 = c_0 + c_1 + c_2 + c_3 + \cdots + c_k$$

$$\beta_2 = c_0 + 2c_1 + 4c_2 + 8c_3 + \cdots 2^k c_k$$

……..……..……

$$\beta_l = c_0 + l \cdot c_1 + l^2 \cdot c_2 + \ l^3 \cdot c_3 \cdot + \cdots + l^k \cdot \ c_k \quad (\mathbf{5})$$

The methodological approach used, in our opinion, makes it possible to assess the contribution of the main types of environmental investments within their structure not only to aggregate demand, but to the production potential of the economy; to ensure long-term sustainable economic growth.

RESULTS

The study shows uneven progress even in the world's largest economies in the field of policies and investments that ensure the formation of a "green" economy, which is clearly confirmed by the values of the Global Green Economy Index (GGEI). According to the results of the GGEI 2018 calculation, which was carried out in 130 countries around the world in four dimensions (leadership and climate change, sectors of efficiency, markets and investments, environment), among the 5 largest economies, Germany had the highest performance in the overall index (6th place; GGEI = 0.69), Japan (19th place with an index of 0.59), China (28th place; index = 0.55); USA (31st place, with an index of 0.55) and India (36th place, with an index of 0.54; Fig. 1).

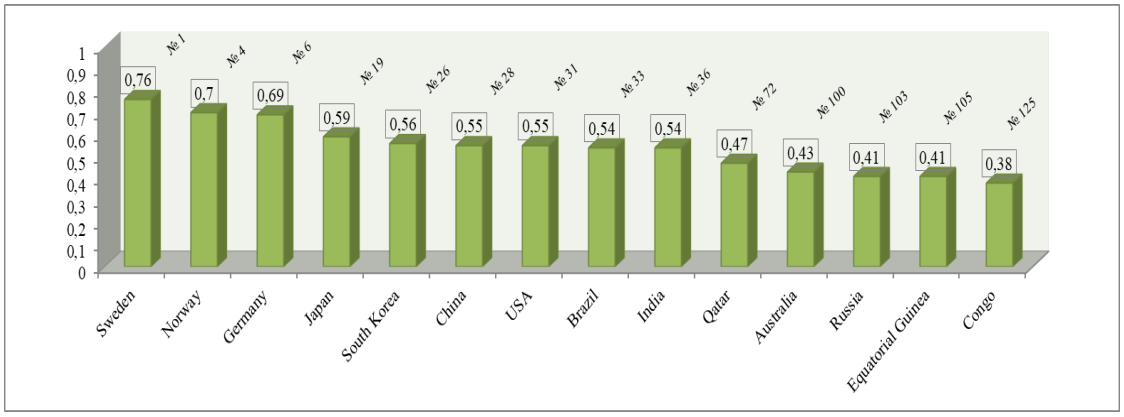

Fig. 1. Global green economy index by country (2018); Source: American consulting company Dual Citizen: official website. New York. URL: https://dualcitizeninc.com (date of access: 04/04/2022).

Russia in this ranking took only 103rd place (GGEI = 0.41), despite the 6th place in the world ranking in terms of Green Economic Opportunities, the value of which was 37.17%. For comparison: in Germany, the GEO value was 63.73 and in China - 48.57 (Fig. 2).

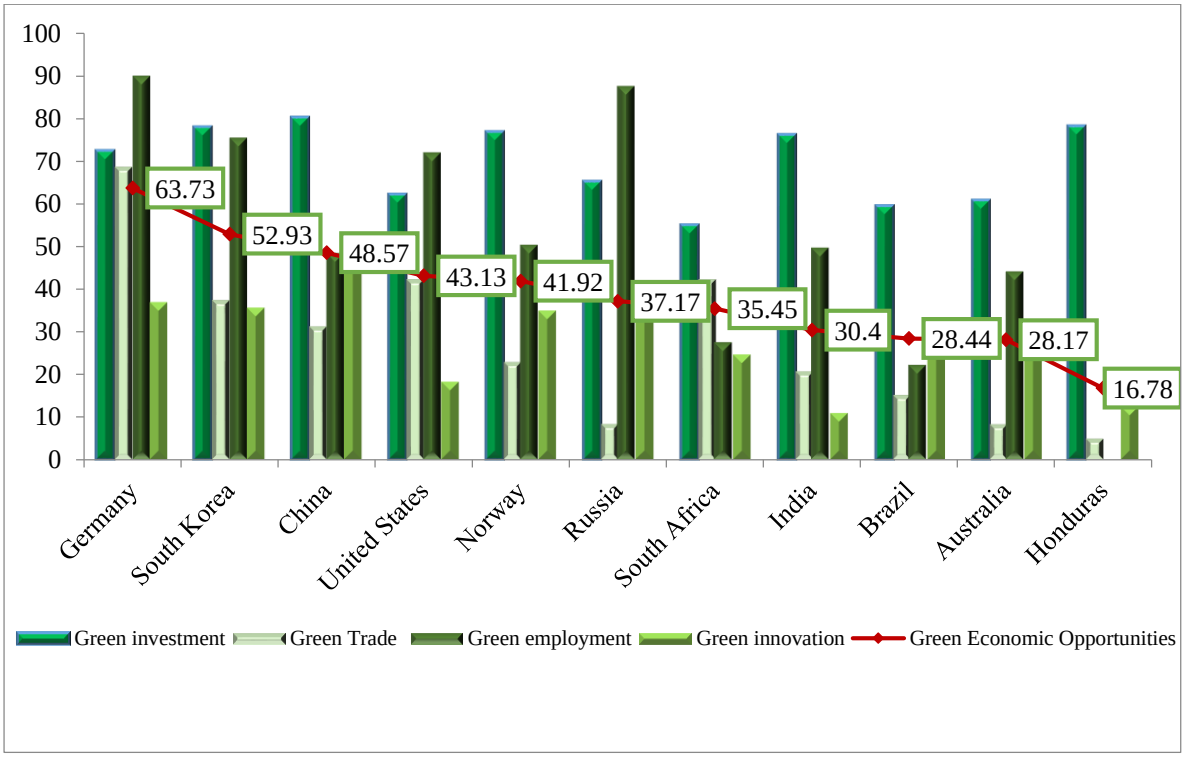

Fig. 2. Green economic opportunities of some countries in the world, 2020; Source: GGGI Technical Report. 2020. No 16 (date of access: 04.04.2022).

The need to recognize the environmental aspect of economic activity as imperative is indicated, among other things, by the persistence in most countries of the world of such a negative trend as the increasing ecological footprint of humanity and/or the growing deficit of bio-capacity (our environmental assets; Table 1). According to Table 1, in the Russian Federation, despite the autonomous economic recession of 2013-2017, there was an increase in the ecological footprint and a decrease in bio-capacity per person. In addition, although the "green" environmental opportunities available to the country (Fig. 2) allow it to maintain a surplus of bio-capacity for the time being, the resource and environmental limitations of the raw material export growth model that has established itself here are becoming more and more clear. In general, the situation today is such that it is fundamental to propose a new, adequate to the global ESG agenda solution to the urgent problem of restoring the long-term sustainable growth of TFP. The latter should be generated by environmental ("green") innovations - new technologies, production processes, supply chains that can solve the issues of recycling and industrial reproduction of raw materials from waste resources, as well as the use of alternative energy sources (Banerjee & Duflo 2019). The solution of this super-global task, which is not yet fully understood by society, requires advance massive environmental investments. Based on the foregoing, it seems possible to consider environmental investments as a specific type of economic resources (monetary, material and intellectual investments), which can be directed to:

• Improving the efficiency of resource use; leading to their savings (e.g., energy efficiency and energy saving, waste reduction and recycling);

• Replacement of traditional technologies with environmentally friendly or low-carbon technologies operating in accordance with the principles of a closed resource cycle (e.g., renewable energy sources; fundamentally new, breakthrough technologies that exclude the appearance of waste, industrial reproduction of raw materials from waste);

• Improving the state of ecosystems and improving the quality of the environment (climate adaptation, planting forests, renewal of wetlands, etc.; Kormishkina 2021).

Table 1. Dynamics of ecological footprint and deficit (surplus) of bio-capacity per person in 2008-2018, GHA.

Country	years	2008	2009	2010	2011	2012	2013	2014	2015	2016	2017	2018
PRC	Biocapacity per person	0.88	0.88	0.9	0.9	0.91	0.9	0.9	0.93	0.92	0.92	0.92
	Ecological footprint per person	2.81	3.05	3.22	3.39	3.45	3.56	3.53	3.51	3.45	3.62	3.8
	Biocapacity reserve/deficit	-1.93	-2.17	-2.32	-2.49	-2.54	-2.66	-2.63	-2.58	-2.53	-2.7	-2.88
South Korea	Biocapacity per person	0.7	0.7	0.68	0.67	0.65	0.66	0.66	0.65	0.65	0.65	0.64
	Ecological footprint per person	5.7	5.42	5.86	5.9	5.76	5.73	5.64	5.77	5.88	6.17	6.32
	Biocapacity reserve/deficit	-5	-4.72	-5.18	-5.23	-5.11	-5.07	-4.98	-5.12	-5.23	-5.52	-5.68
Germany	Biocapacity per person	1.8	1.82	1.76	1.65	1.7	1.72	1.78	1.7	1.63	1.6	1.49
	Ecological footprint per person	5.57	5,15	5.55	5.42	5.22	5.24	5.06	4.95	4.83	4.81	4.67
	Biocapacity reserve/deficit	-3.77	-3.33	-3.79	-3.77	-3.52	-3.52	-3.28	-3.25	-3.2	-3.21	-3.18
USA	Biocapacity per person	3.6	3.63	3.56	3.43	3.4	3.45	3.47	3.44	3.54	3.4	3.39
	Ecological footprint per person	9.26	8.46	8.79	8.34	7.95	8.18	8.11	7.96	8.06	7.97	8.12
	Biocapacity reserve/deficit	-5.66	-4.83	-5.23	-4.91	-4.55	-4.73	-4.64	-4.52	-4.52	-4.57	-4.73
Norway	Biocapacity per person	8.01	7.82	7.77	7.58	7.45	7.32	7.29	7.23	7.16	7.08	6.91
	Ecological footprint per person	6.94	6.13	7.15	6.36	6.17	6.42	6.12	5.8	5.44	5.73	5.67
	Biocapacity reserve/deficit	1.07	1,69	0.62	1.22	1.28	0.9	1.17	1.43	1.72	1.35	1.24
RF	Biocapacity per person	6.86	6.77	6.49	6.75	6.5	6.62	6.68	6.66	6.75	6.83	6.72
	Ecological footprint per person	5.57	5.08	5.28	5.79	5.48	5.56	5.41	5.08	5.07	5.27	5.31
	Biocapacity reserve/deficit	1.29	1.69	1.21	0.96	1.02	1.06	1.27	1.58	1.68	1.56	1.41

Compiled by: Data Sources: National Footprint and Bio-capacity Accounts 2022 edition (Data Year 2018); GDP, World Development Indicators, The World Bank 2020; Population, UN Food and Agriculture Organization).

In this understanding, environmental investment is consistent with the well-known 17 sustainable development goals (SDGs) for the period of 2016–2030. For all countries of the world, which were formulated in the UN conceptual documents and approved at the UN conference in 2015. Noteworthy, 7 goals (6, 7, 11 and 12–15) in this list are of an environmental nature (they relate to water energy, environmental sustainability of cities and towns, climate change, land ecosystems, seas and oceans, etc.).

A comparative analysis of the content of the SDGs and areas of environmental investment is the basis for the conclusion that a significant part of them are not only interconnected, but also complement each other, and their joint solution can give, along with environmental, economic and social effects (Table 2). Given the noted interrelationship and complementarity of the SDGs and the priorities of environmental investments, it is fair to say that the latter can be considered as responsible, in essence, and transformative, in terms of their functional role. Such investments, under certain market conditions, can bring high profits to economic entities and meet their growing need for environmental protection systems, and to society - the creation of new high-tech jobs in sectors of the economy with low CO_2 emissions, the preservation of natural capital and the improvement of ecosystems, energy independence and the transition to a progressive ("green") model of the economy.

Table 2. Sustainable development goals and priority areas for environmental investment.

Main priorities for green investment	Sustainable Development Goals																
	1	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**	**10**	**11**	**12**	**13**	**14**	**15**	**16**	**17**
1. Improving the efficiency of resource use (e.g. waste reduction, energy efficiency)						+	+	+	+		+	+		+			
2. Replacing traditional technologies with environmentally friendly or low-carbon ones in accordance with the principles of a closed cycle (RES, waste recycling)		+		+		+	+	+	+			+					+
3. Improvement of the state of ecosystems and environmental quality (climate adaptation, planting of forests, renewal of wetlands, etc.)	+		+			+		+	+	+	+	+	+	+	+		

Compiled by the authors

The conclusion about the transformative role of environmental investment can be specified from the standpoint of the theory of endogenous economic growth and the well-known concept of J. Schumpeter, which in precise terms explain "what are the economic incentives for innovation and how this dynamics works" (Spence 2012). Based on the previously identified priority areas for environmental investments, they are a priori associated with "green" innovations in the form of the latest, breakthrough environmentally friendly technologies (or waste-free technologies) that provide deep cleaning of the final product and all target components of the environment; exclusion of the appearance of non-utilized waste and the use of alternative energy sources; creation of new high-tech products as a result of industrial reproduction of raw materials. Against this background, it can be argued that environmental investment gives impetus to the following radical changes in the economy of the 21st century:

• Economic development will not depend on the consumption of raw materials;
• reducing the employment of non-renewable energy sources (oil, gas and coal);
• The technogenic impact of energy on the environment will decrease;
• New high-tech jobs will appear in sectors of the economy with low CO_2 emissions, etc.

Thus, the prospects for the formation and development of such technologies are limitless, creating a large field of activity for innovative business, and hence for ensuring the long-term sustainable growth of TFP.

Awareness of the growing role of environmental investments in the development of a new economic model of the 21st century and long-term sustainable growth of TFP is accompanied by their positive dynamics in different countries of the world. Thus, in South Korea, the share of such expenses in the 2020 anti-crisis packages reached 81%, in the EU countries 59%, in China - 38%, and in the USA 12% (Mirkin 2020). At the same time, despite the possibility of obtaining the previously mentioned benefits from environmental investment, in today's Russia there are still a number of factors hindering the activity of this process, among which are: imperfection of the market in the field of ecology (problems of the so-called negative externalities and the collective failure effect); inertia in the development of the technological base and its renewal, which indicates the underdevelopment in the Russian Federation of institutions that regulate the process of replacing technologies; lack of a clear and understandable system of state support for such investments; uncertainty of investors in the "green" and "circular" economy, their commitment to the current concept of production; weak development of relevant competencies in the financial sector. Taking into account the stability of such factors in Russia, within the framework of this study, regression models were built to predict the volume of investments in fixed assets aimed at protecting the environment and rational use of natural resources in the Russian Federation for 2022–2024 (Fig. 3). The statistics presented in Fig. 3 depicted the 3 regression models (growth curves) are shown in Table 3.

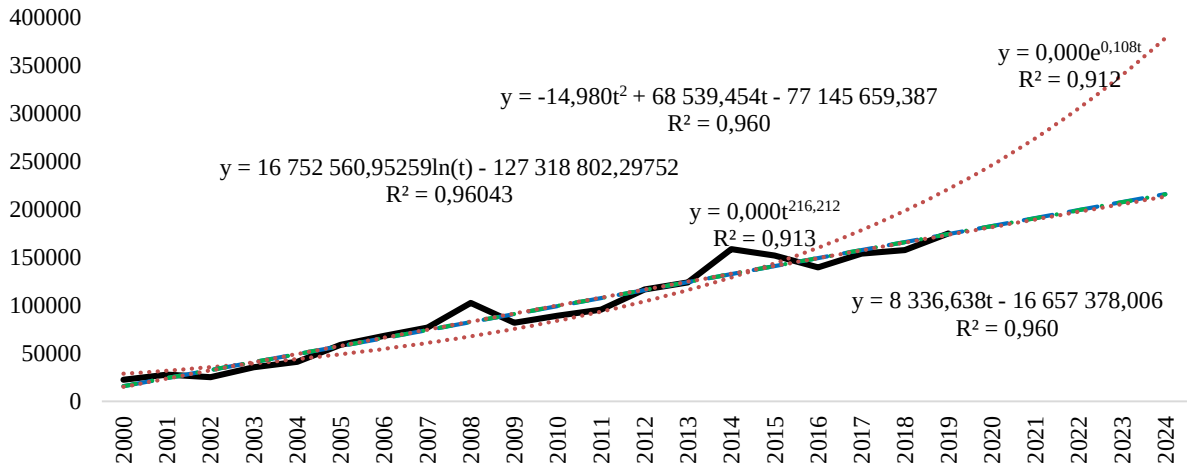

Fig. 3. Dynamics and forecasting for 2022–2024 the volume of investments in fixed capital in the Russian Federation aimed at protecting the environment and rational use of natural resources in the Russian Federation; Source: authors' calculations.

Table 3. Trend models (growth curves) for analyzing and forecasting the dynamics of investment in fixed assets in the Russian Federation aimed at protecting the environment and rational use of natural resources.

Trend equation (growth curve)	**Criterion of model quality**		**Forecast**		
	Coefficient of determination	**Average approximation error, %**	**2022 г.**	**2023 г.**	**2024 г.**
$Y = 8336.63835t + 7562.04737 + \varepsilon$	0.960	10.39	199 304.73	207641.37	215978.01
$Y = -14.97955t^2 + 8651.20892t + 6408.62193 + \varepsilon$	0.960	10.57	205 386.43	214037.64	222688.85
$Y = 25719.78432 \cdot e^{0.10756t} \cdot \varepsilon$	0.912	16.66	305255.75	339920.03	378520.71
$Y = 56151.83796lnt - 23764.38378 + \varepsilon$	0.8222	32.36	152299.38	154689.18	156981.41
$Y = 14874.28795 \cdot t^{0.79225} \cdot \varepsilon$	0.934	12.50	178344.35	184460.24	190523.39

Authors' calculations

An analysis of the data in Table 3 allows us to conclude that the general trend in the volume of investments in fixed capital in the Russian Federation, aimed at protecting the environment and rational use of natural resources, in the forecast perspective can be most accurately expressed by a linear trend model with the smallest approximation error (10.39%):

$$Y_t = 8336{,}63835t + 7562{,}04737 + \varepsilon \quad (6)$$

This regression model, in addition, emphasizes the insufficient intensity of environmental investment, as well as the still weak economic instruments used in the Russian Federation for its state support. In addition, as part of the study, an econometric model was built that reflects the dependence of economic growth (the volume of the Russian GDP per capita) on the volume of investments in fixed capital aimed at protecting the environment and rational use of natural resources, to assess the long- and short-term responses of economic indicators. Growth from the volume of designated investments, taking into account their main priorities (resource saving and resource efficiency; improving the state of the ecosystem and improving the quality of the environment) and including lag independent variables as regressors. In accordance with the hypothesis of this study, the maximum values of the lag l and the degree k of the polynomial (2), describing the structure of the lag for each dynamic regression (1),

were determined, while experimentally (using correlation-regression analysis, testing Student's hypotheses, t–statisticians) it was found that to estimate the regression parameters β_j and γ_i (1) it is advisable to use polynomials of the 3rd degree (7):

$$\beta_j = c_0 + c_1 j + c_2 j^2 + c_3 j^3, \gamma_i = d_0 + d_1 i + d_2 i^2 + d_3 i^3 \quad \textbf{(7)}$$

Using the method of instrumental variables (in order to reduce the multicollinearity of exogenous variables, the parameters of model 4 were estimated for the first equation with a distributed lag of system (1):

$$Y_{1t} = -25638.55 + 17.14Z_0 - 30.90Z_1 + 14.39Z_2 + \varepsilon_t, F = 73{,}83, \quad \textbf{(8)}$$

(0.02) (0.07) (0.03)

where the new instrumental variables have the form (8)

$$Z_0 = X_{1t} + X_{1t-1} + X_{1t-2} + X_{1t-3}, \quad \textbf{(9)}$$

$$Z_1 = X_{1t-1} + 2X_{1t-2} + 3X_{1t-3},$$

$$Z_2 = X_{1t-1} + 4X_{1t-2} + 9X_{1t-3},$$

Calculating the values of lag variables $X_{1t-1}, X_{1t-2}, X_{1t-3}$ and variables Z_0, Z_1 and Z_2 (9) to assess the parameters of a dynamic econometric model of the dependence of the growth rate of investments in fixed capital in the Russian Federation aimed at protecting the environment and rational use of natural resources (Y_{1t}), on the growth rate of generation and processing of production and consumption waste (X_{1t}), built a multiple regression equation (10):

$$Y_{1t} = -25638.55 + 17.14X_{1t} + 0.63X_{1t-1} + 12.88X_{1t-2} + \varepsilon_t, \quad \textbf{(10)}$$

An analysis of the constructed econometric model 10 allows us to conclude that an increase in the generation of production and consumption waste by 1 million tons in the current period in a year should be accompanied by an increase in investment in fixed assets in the Russian Federation aimed at protecting the environment and rational use of natural resources, by 17.80 million rubles, after 2 years - by 30.68 million rubles to protect the integrity of the environment. Since the initial data for the second equation of the model 1 have a log-normal distribution, the parameters were estimated for the logarithms of the considered time series. Dynamic regression model of GDP per capita (Y_{2t}) from the volume of investments in fixed assets aimed at protecting the environment and rational use of natural resources (Y_{1t}), has the form 11:

$$\ln(Y_{2t}) = \alpha + \gamma_0 \ln(Y_{1t}) + \gamma_1 \ln(Y_{1t-1}) + \gamma_2 ln(Y_{1t-2}) + \cdots + \gamma_l \ln(Y_{1t-l}) + u_t \quad \textbf{(11)}$$

Using the method of instrumental variables for model 11, we estimate the parameters for new variables Z_0, Z_1, Z_2 (12):

$$\ln(Y_{2t}) = -9584.504 + 0.366 \cdot Z_0 - 0.462 \cdot Z_1 + 0.143 \cdot Z_2 + \varepsilon_t, F = 201.46, \quad \textbf{(12)}$$

(0,001) (0,044) (0,056)

After performing inverse transformations (5) of model parameters (12), we obtained the second dynamic regression equation with distributed lag (13) of system (1):

$$\ln(Y_{2t}) = -9584.504 + 0.366 \cdot \ln(Y_{1t}) + 0.047 \cdot \ln(Y_{1t-1}) +$$

$$+0.014 \cdot ln(Y_{1t-2}) + 0.266 \cdot \ln(Y_{1t-3}) + u_t \quad \textbf{(13)}$$

An analysis of the constructed model 13 allows us to conclude that with an increase in the volume of investments in fixed assets aimed at protecting the environment and rational use of natural resources (Y_{1t}) by 1% in the current period will lead to an increase in the volume of gross domestic product per capita on average (Y_{2t}) on the 0.366 %; on the 0.413 % - next year; on the 0.426% – in one year; on the 0.693 % – after 2 years.

$$\begin{cases} \ln(Y_{2t}) = -9584.504 + 0.366 \cdot \ln(Y_{1t}) + 0.047 \cdot \ln(Y_{1t-1}) + 0.014 \cdot ln(Y_{1t-2}) + 0.266 \cdot \ln(Y_{1t-3}) + u_t \\ Y_{1t} = -25638.55 + 17.14 \cdot X_{1t} + 0.63 \cdot X_{1t-1} + 12.88 \cdot X_{1t-2} + \varepsilon_t \end{cases} \quad (\mathbf{14})$$

Thus, the system of dynamic regression models 14 confirms the expediency of abandoning the raw-material-export growth model of the Russian economy in favor of a long-term sustainable model. In addition, it is the basis for considering environmental investment as an "active principle" and a powerful factor in such a transformation of the Russian economy.

DISCUSSION

The study of the practical experience of the leading countries of the world in using various mechanisms and economic tools of state policy in the field of stimulating environmental investment was the basis for putting forward the following main recommendations to ensure an integrated approach to the formation of such a policy in post-pandemic Russia:

1) Achieving a rational (limiting) value for such a general indicator of stability and security of investment activity as the share of accumulation of gross investments in GDP. Obviously, environmental investment, which involves replacing traditional technologies with environmentally friendly or low-carbon ones, improving the quality of the environment, etc., focuses on the development of science-intensive and innovative, and, consequently, capital-intensive industries and sectors of the economy. Under these conditions, it seems appropriate to increase the share of accumulation of gross investments in the GDP of the Russian Federation from the current 21.9% (2020) to at least 28-30% of GDP. To increase the share of gross capital formation in the GDP of the Russian Federation, it is important to create a reliable mechanism for transforming the funds accumulated by the population into environmental investments, by guaranteeing the full return of deposits in the case of any defaults and charging increased interest when they are invested in "green" securities lending to environmental investment projects;

2) Increasing the attractiveness of environmental investments for private capital by pursuing a policy of lowering prices for low-carbon investment projects. Such a policy means the development and implementation in economic practice of environmental standards and norms, eco-management and audit (ISO14000, EMAS), an increase in taxation and the using natural resources while reducing the tax burden on other factors of production; employing government guarantees for loans to cleantech and green firms; rejection of subsidies that encourage using hydrocarbon energy (oil, coal) and depleting natural capital and, on the contrary, subsidize clean energy and clean technologies; development of a system of benchmarks to test the "reliability" of environmental investments; creation of “test” territories (an initiative of the PRC) and approbation of the system of trading in carbon rights for emissions, units of their reduction (credits or mutual offsets, units of CO_2 absorption and other carbon units) on them. Undoubtedly, such a policy requires strong political will. At the same time, clearly, at the end, it contributes to the gradual transformation of environmental responsibility into an economic asset;

3) The formation of a new financial and economic mechanism, the distinguishing feature of which is the resource conservation and the maximum involvement of production and consumption waste in economic circulation as sources of raw materials and for energy generation adequate to the latest global environmental challenges. The implementation of this direction of stimulating environmental investment involves:

- Modernization of pricing, taking into account the observance of the principle of social justice, which means the need to determine the total cost of production of products, including the cost of waste processing, with the payment for further recycling of this product (in the form of an insignificant amount) tied to its consumer. For example, in France this amount is called the "eco-participation tax".
- State guarantees in the form of subsidies to reimburse part of the cost of paying interest on loans and borrowings attracted by private investors for the implementation of projects related to:

• With the development of new technologies and / or adaptation of existing ones for the processing of production and consumption waste, focused on the principles of the ZeroWaste concept, selection and localization of the best technological practices for the neutralization and disposal of waste (e.g., pyrolysis);
• With the construction, technical re-equipment or reconstruction of the production facilities of waste processing enterprises;
- Providing a set of benefits and preferences (e.g., tax breaks and deductions, preferential rates on loans) to enterprises that process waste using circular technologies and supply secondary raw materials with improved environmental qualities, and, on the contrary, create conditions under which the owner of the waste becomes economically unprofitable store waste (waste collection and disposal tax);
4) Increasing the environmental awareness of the population and business: business understanding of the harm to the environment and human health caused by the current concept of production; preparedness of public consciousness in this matter.

CONCLUSION

The study makes a certain contribution to the development of the theory of endogenous economic growth by taking into account the impact of environmental investment, initially focused on the efficient use of natural capital, on the maximum involvement of waste resources in economic circulation, the replacement of traditional technologies with environmentally friendly or low-carbon ones, improving ecosystems, etc., on the production potential economy, environmental quality and social change.
Summarizing the above, we consider it necessary to note that the increments of scientific knowledge of this study areas follows:
1) In putting forward and theoretically substantiating the scientific idea of the objective need to intensify environmental investment in post-pandemic Russia in order to overcome the “anti-sustainable environmental trends” that have developed here and ensure radical transformations of its economy in accordance with the ESG agenda. In this regard, it has been proven that it is environmental investments that are important for sustainability, but less attractive for business, that can bring profit to business entities and satisfy their growing need for environmental protection systems, and society - the creation of new high-tech jobs in sectors of the economy with low CO_2 emissions, conservation of natural capital and improvement of ecosystems, energy security and transition to a "green" (circular) economy;
2) In the theoretical substantiation of the scientific hypothesis that environmental investment, in the face of planetary manifestations of environmental growth constraints, should be recognized as a key factor in ensuring long-term sustainable growth in total factor productivity (TFP). The article contains original scientific judgments about the impact of environmental investment on the activation of "green" innovations (environmentally friendly technologies or waste-free technologies; new high-tech products obtained as a result of the industrial reproduction of raw materials, etc.);
3) In the construction of an econometric model for the Russian Federation, which confirms the dependence of economic growth rates on the dynamics of environmental investment volumes. The model is a system of dynamic economic regressions with a distributed lag of a polynomial structure. It can be applied to assess the long- and short-term responses of economic growth indicators from green investment;
4) In the formulated minimum necessary economic tools of the state policy in the field of stimulating environmental investment in modern Russia.
Notably, the subject area of environmental investment is still in its infancy. In this regard, the authors of this study will have to study in more depth the nature and characteristics of environmental investments (new investment conditions, the rate and nature of profit, payback periods, the structure of the capital market, etc.) in order to more clearly specify the mechanisms of their influence on economic growth and transformation of the economy and society.
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