Econometric model of pro-ecological behavior of the population of the Arctic zone of Russia

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***Abstract*—The article is devoted to identifying factors of pro-ecological activity of the population of the Arctic territories. The results of a sociological survey in the municipalities of the Murmansk region in 2023 were used. A combination of sociological and econometric methods was used.**

Keywords—pro-environmental behavior, Arctic, logit regression, ecological economics

I. INTRODUCTION

In the study of environmental and economic processes, the Arctic territories of Russia, as an object of scientific consideration, occupy a special position. The low capacity of their ecosystems to overcome anthropogenic load and the existing trends in the accumulation of pollutants in the natural environment [1], the focal-dispersed nature of settlement and the high concentration of the extractive industry [2], low transport connectivity and underdeveloped waste management infrastructure [3] determine the exceptional relevance of studying not only aspects of pollution, but also issues of involving all socio-economic entities in its minimization. However, to date, scientific papers have not presented a comprehensive analysis of the factors of pro-environmental behavior of the population of the Arctic zone of Russia. The purpose of the work is to identify the factors determining the pro-environmental activity of the population of the Arctic region (based on the materials of municipalities of the Murmansk region) and to compare their significance in the context of types of pro-environmental activity. The scientific novelty of the study is determined by the critical underexploration of the factors of formation of pro-environmental behavior and environmental responsibility of the population in the Arctic regions of Russia.

II. THEORETICAL BACKGROUND

A. Theoretical basis of the research

In the subject area under consideration, several conceptual approaches have been formed that have proven their effectiveness. Among the key ones, we can note the theory of planned behavior [4], norm activation theory [5], and the theory of reasoned action [6]. At the same time, the integration of behavioral concepts into formalized models of socio-ecological-economic systems is a certain problem due to the existing methodological limitations of each approach. In these conditions, a combination of several approaches is becoming increasingly widespread in research in order to expand the subject coverage and universalize the methods [7]. Stern distinguishes several types of pro-ecological behavior and identifies actions related to: environmental activism, nonactivist behaviors in the public sphere, private-sphere environmentalism, and behaviors in organizations [8]. Often, researchers examine individual types of behavior (e.g., [9]) or a combination of the first three (e.g., [10]). The presented work studies the practices of environmental activism and nonactivist behavior in the public sphere.

B. Application of the VBN concept in research

The concept of "values-beliefs-norms" has found wide application in the analysis of aspects of public acceptance of state or corporate policies. In particular, the work [11] analyzed the influence of pro-environmental attitudes of the population on the public acceptance of transport demand management policies (aimed at minimizing the use of private vehicles and prioritizing the development of public transport). Tolentino et al., using materials from the Philippines, consider the problem of public acceptance of the idea of restarting a nuclear power plant that had previously exhausted its resource and was closed. Based on the conceptual VBN model, the authors carried out structural equation modeling (SEM) in the context of studying the indicators of biospheric, altruistic and egoistic values, environmental worldview, awareness of the consequences of one's actions, personal value norms, social norms in the context of the final acceptance by individuals of the idea of restarting a nuclear power plant [12]. Among the significant results of the study [13] it can be noted that people with a more pronounced value orientation towards transforming the surrounding world (self-transcendence value orientation) are more receptive to environmental problems, are more inclined to accept personal responsibility for the state of the environment and to pro-environmental activities within the framework of consumption and everyday issues.

III. MODEL AND DATA

The conceptual basis of the study is the concept of sustainable development and the «value-belief-norm» theory

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[8]. Among the private scientific methods, one can note sociological methods of collecting information (population questionnaire survey), econometric methods (ordered logit regression models). As a methodological tool aimed at substantiating factors significant for the implementation of pro-ecological practices, logit models in the ordered choice specification were used, which are used in cases where dependent variables take a discrete form and are ordered [14]. Such an organization of the endogenous variable is characteristic of sociological data, which are the result of measuring the evaluative judgments of individuals on special scales. Within the framework of the presented work, data on the quantity and qualitative composition of practices implemented by a particular respondent were aggregated to identify the factors of environmental activist and nonactivist behavior in the public sphere. The endogenous variable in the case of studying activist practices takes the values [0; 4], in the case of nonactivist practices [0; 3]. Within the framework of these models, pro-ecological practices were divided in accordance with the approach implemented in the work [8] into the following types:

— environmental activism: "I am a member of environmental organizations"; "I deal with polluters of nature on my own initiative"; "I come forward with environmental initiatives and appeals to government bodies"; "I initiate clean-up days, garbage collection in public areas and in the forest";

— nonactivist behavior in the public sphere: "I donate funds to environmental organizations"; "I report violations of environmental and ecological legislation to the police"; "I go to clean-up days, garbage collection in public areas, in the forest and other places".

Based on the applied conceptual model, the following groups of factors were classified according to their content, corresponding to the blocks of the concept: basic characteristics of individuals (gender, age, etc.), territory of residence, values, respondent's awareness of existing environmental problems and their importance, attribution of responsibility for the emergence of environmental problems, attribution of responsibility for their solution, forms of pro-environmental activity. The models were assessed according to the following specifications: basic factors (gender, age, level of education and income of the individual) and factors of one of the blocks, substantiated by the concept of "values-beliefs-norms". In this way, the issue of maintaining the proportion between the number of observations in samples for individual territories and the number of factors analyzed in one model was resolved. In addition, such an approach makes it possible to identify and substantiate which of the blocks of factors identified within the framework of the theoretical concept is more significant for the implementation of specific practices. Basic factors, which are repeated in all specifications, in addition to the task associated with identifying their influence on pro-environmental practices, solved the problem of monitoring the stability of coefficients in regressions. The assessment was carried out using logit regressions (logistic distribution function) using the maximum likelihood method (formula 1).

$$p = \frac{1}{1 + e^{z}}$$

where p is the probability that the endogenous variable will take a certain value, z is a linear combination of explanatory factors of the form: $z = b_0 + b_1x_1 + \ldots + b_nx_n$. The significance level was assessed using the z-test.

The empirical basis of the study was the data from a survey of the population of 11 municipalities of the Murmansk region (autumn 2023). The total sample size was 1258 people. The sampling error does not exceed 2.8%, the average deviation of the sample structure from the general population in the municipal context is 4.8%. The average age of the respondent is 41.2 years. The survey sample is quota, the sample parameters are formed on the basis of age and sex characteristics of the population in all municipal districts and districts of the Murmansk region (except for closed administrative-territorial entities). Respondents were selected randomly, by door-to-door canvassing. Mainly the population of the administrative centers of districts and districts was surveyed.

IV. RESULTS AND DISCUSSION

The obtained models made it possible to identify significant factors for the three blocks of the VBN model for each territory (Table 1). The significance level was assessed using the z-criterion, on this basis, the factors by significance level were distributed into: *** — significant at 1% error level; ** — significant at 5% error level; * — significant at 10% error level.

TABLE I. SUMMARY OF MODELING RESULTS: FACTORS DETERMINING PRO-ENVIRONMENTAL BEHAVIOR

The significant factors	***Coeff.***
Apatity MO	
Income	0,617**
Family well-being	2,146**
Frugality, Interesting and varied pastime	0,526***
Career	−0,548***
Climate change	0,475***
Income	−0,387**
Kandalakshskiy MO	
Family well-being	−1,188***
Interesting and varied pastime	1,883**
Household garbage and industrial waste	−2,679**
Depletion of natural resources	0,855***
-	-
Kirovsk MO	
Family well-being	−5,425*
Traditional values	3,277***
Career	2,632*
Sex	−4,006*
Education level	−1,995***
The danger to human health associated with environmental pollution	1,268***
Depletion of natural resources	0,951**
Acid rain	1,008**
Soil pollution	−1,715*
Sex	−3,065***
Income	3,431***
Kovdorskiy MO	
Age	0,055***

The significant factors	*Coeff.*
Personal well-being	−1,856*
Frugality	1,467**
Work and mastery in your field	−1,896*
Interesting and varied pastime	1,233***
Public recognition	0,572***
-	-
My daily habits are harmful to the environment in my place of residence	0,695**
Lovozerskiy MO	
Sex	1,743***
Education level	1,659***
Career	0,724***
-	-
The environmental problems in my place of residence should be solved by business	1,273**
Monchegorsk MO	
Age	−0,079***
Acid rain	0,885**
-	-
Murmansk UO and Kolskiy MO	
Income	0,553***
Personal well-being	−0,461***
Welfare of the surrounding society	0,511**
-	-
Income	0,542***
The environmental problems in my place of residence are largely caused by the policies of the state and local authorities	−0,338***
I have to contribute to solving environmental problems in my place of residence	0,619*
Olenegorsk MO	
Income	2,960**
Education level	−2,955**
Clean environment	−1,475***
Work and mastery in your field	3,813**
Public recognition	1,413***
-	-
Age	−0,123**
Income	1,730***
Education level	−2,297***
My daily habits are harmful to the environment in my place of residence	1,152***
The environmental problems in my place of residence are largely caused by the policies of the state and local authorities	1,902*
The environmental problems in my place of residence are largely related to business activities	−3,080*
Environmental problems in my place of residence must be solved by the state and municipal authorities	−1,254***
The environmental problems in my place of residence should be solved by business	1,240***
Only joint actions of the government, business and the population can truly solve the environmental problems in my place of residence	1,647*
Pechengskiy MO	
Family well-being	0,930**
Frugality	−0,602**
Public recognition	0,642**
Career	−0,812*
Power	0,473***
Income	−0,436***
Water pollution	−0,786***
Air pollution	1,322*
Depletion of natural resources	0,579**

The significant factors	*Coeff.*
I have to contribute to solving environmental problems in my place of residence	0,590***
Only joint actions of the government, business and the population can truly solve the environmental problems in my place of residence	0,750**
Polyarnye Zori MO	
Sex	1,076***
Income	2,688***
Water pollution	1,300**
Sex	1,166***
The environmental problems in my place of residence are largely caused by the policies of the state and local authorities	0,652**
The environmental problems in my place of residence should be solved by business	1,230***
Terskiy MO	
Age	0,092***
Income	−1,483**
Family well-being	−2,577**
Clean environment	2,410***
Work and mastery in your field	−2,585*
Income	−1,147***
Acid rain	−0,754***
Soil pollution	−1,319***
-	-

Moving on to the analysis of the substantive side, it is worth noting that the territories differ in the specific profile of factors determining the implementation of the considered types of pro-ecological behavior, in particular, activist behavior.

Thus, for the MO Apatity, the factor reflecting the basic characteristics of respondents, the logarithm of income, turned out to be significant for the implementation of activist practices in two of the three models. Among the values, the positive influence of the value of family well-being, thrift and career stands out, and the negative influence of the value of interesting pastime. Within the group of factors "awareness of the importance of environmental problems", the negative impact of climate change and depletion of natural resources stood out significantly. Factors associated with the awareness of responsibility for the emergence, as well as for solving environmental problems, turned out to be insignificant.

As part of the study of nonactivist behavior in the public sphere in the MO Apatity, for all models among the factors reflecting the basic characteristics of individuals, a significant negative influence of gender stood out. For the value model, a negative influence of income and a positive one of the level of education also stood out. Among the values, the positive influence of family well-being and the negative influence of personal well-being and work and skill stand out. In the context of problem awareness (belief model), only the basic factors of gender (negative) and education (positive) are significant. For the norm model, only the basic factor of gender is also significant. One of the two decisive boundaries is significant. The analysis for other territories was carried out in a similar way. According to its results, it was found that the smallest share of those involved in activist behavior in the public sphere is observed in the urban district of Apatity, urban district of Kirovsk, urban district of Murmansk and the Kolsky MR,

urban district of Polyarnye Zori, urban district of Monchegorsk and the Kovdorsky MO, however, it is worth noting that the average number of practices implemented by activists in large cities is higher. Here, the urban districts of Apatity, urban district of Kirovsk, urban district of Murmansk and the Kolsky MR and urban district of Polyarnye Zori stand out. I.e. it can be concluded that the more urbanized the area of residence and the larger the city, the less the population is inclined to directly participate in pro-ecological practices of this type, however, for people who adhere to such activity, the opportunities for their implementation are more extensive, it is also worth noting a greater willingness to donate funds to the pro-ecological activity of others. It is necessary to note both the territorial specificity of the factors determining pro-ecological behavior, and intertype features, within which factors are distinguished that are more characteristic of activism or nonactivist behavior in the public sphere. Some factors are quite common and can be considered common to all or most territories, while others are specific. Quite pronounced differences in the actions of the same factors are observed for activist and nonactivist behavior. For example, the gender factor has a positive effect on activist behavior, and a negative one for nonactivist behavior. The education factor, on the contrary, shows a positive effect on nonactivist behavior, and a predominantly negative one for activist behavior (the Lovozersky District is an exception). The impact of income on activist practices is predominantly positive, while for nonactivist practices it is multidirectional and differentiated by territory. Age has a negative impact on nonactivist practices, while for activist practices the impact of this factor is multidirectional.

In the context of examining the influence of values on pro-ecological activity, it is possible to note a fairly pronounced positive influence of traditional values, the value of a clean environment and public recognition on the implementation of nonactivist practices. The values of public recognition and the well-being of the surrounding society also have a positive effect on activist practices. The influence of other values is differentiated. For example, the influence of the value of work and mastery in one's business has a predominantly negative effect on both types of pro-ecological practices, but we see exceptions for the Olenegorsk urban district (within the activist behavior) and the Kandalaksha district (within the nonactivist), for which this factor has a positive effect. In the models for activist and nonactivist behavior, recognizing one's contribution to the formation of environmental problems and accepting personal responsibility for their solution leads to an increase in the likelihood of adhering to the corresponding practices. From the point of view of attribution of responsibility, nonactivist behavior is characterized by a negative influence on the awareness of the responsibility of the authorities and a positive influence on business. At the same time, transferring responsibility for solving problems to the authorities and business reduces the likelihood of adhering to nonactivist practices. And only the acceptance of collective responsibility leads to an increase in the probability of adhering to nonactivist practices. For activist behavior, on the contrary, when attributing responsibility to the authorities, we observe an increase in the probability of adhering to activist practices, while when recognizing the responsibility of business, we see a decrease in the probability of such behavior. On the other hand, when distributing responsibility for solving problems to the authorities, we observe a decrease in the probability of adhering to activist practices, while when attributing responsibility to business, it increases. I.e. prerequisites for the co-organization of the population and business in terms of solving environmental problems arise. Recognition of joint responsibility for solving problems also increases the probability of adhering to activist practices. For the spread of nonactivist behavior in a significant part of the territories, it is important to recognize the problem of climate change, and for the spread of activist behavior, it is important to recognize the problem of depletion of natural resources.

The multidirectional action of the same factors in individual territories can be explained by the spatial features of the natural environment, economy, society, and local institutions. Here, several interesting observations can be noted. For example, the value of interesting pastime acts as a negative factor in a number of territories (in the urban district of Apatity for activism, in the Tersky district for inactivism), and as a positive factor in a number of territories (in the Kandalaksha district, the MO Kovdor - for activism, the Pechenga district and in the urban district of Polyarnye Zori - for inactivist behavior in the public sphere). In those territories whose natural and social environment is more conducive to combining pro-ecological practices and interesting pastime, the value of the latter acts as a positive factor. We associate this with the specificity of leisure and more frequent stay in nature of people with the corresponding values and with a peculiar form of "filling" the free time of residents of peripheral territories with public activity in the field of ecology.

The specificity of the action of factors related to the awareness of a particular environmental problem reveals a number of interesting patterns. Thus, the influence of awareness of the climate change problem is differentiated by the type of pro-ecological activity and has an exceptionally positive effect on nonactivist behavior in the public sphere, while it has a less pronounced negative effect on activist behavior.

A rather unexpected and new result is the identified differentiated influence of the education factor in a number of territories depending on the type of pro-ecological practices. Thus, the education factor has a negative value in the Kirovsk and Olenegorsk urban districts for environmental activism, while in the sphere of nonactivist behavior in the public sphere, it is pronounced and exceptionally positive in the territories of the Apatity urban district, the Murmansk urban district and the Kolsky district, the Kandalaksha district, and the Olenegorsk urban district. Summarizing the obtained results, it should be noted that the picture of the factors determining pro-environmental behavior of the population generally coincides with the findings of earlier studies, although it brings in several new and significant observations. Thus, the positive influence of biospheric and altruistic values was previously noted by Tolentino et al. [12], acceptance of personal and shared responsibility - in the work of Liobikienė et al. [13]. The negative impact of belonging to the male gender on pro-environmental activity was considered in the work of Uram et al. [15], and values attributed to egoistic or personally oriented - in the work of Minelgaitė et al. [16]. A number of aspects

related to the limitations of the study should be noted. The models used made it possible to identify the factors determining pro-environmental behavior of the population at the municipal level and, within the framework of the overall assessment, at the regional level. However, the factors were more clearly manifested in the territories with relatively large values of the quantitative characteristics of the sample, and in the territory with a relatively small sample - the Olenegorsk municipality, not all models could be built. This indicates the need to increase the detail of the sample at the municipal level, as well as the possibility of conducting a specialized study of peripheral sparsely populated areas in the context of the subject and purpose of the study.

V. Conclusion

Based on the results of the study, we can talk about the most significant prerequisites for active participation of the population in pro-ecological activities in the territories of the Murmansk Urban District and the Kola District, the Polyarnye Zori Municipality, the Monchegorsk Municipality, and the Lovozero District. It is advisable to base the nature of measures to facilitate the involvement of the local population in the relevant practices on the factors of assistance or obstacles to the implementation of pro-ecological practices at the municipal level identified during the analysis. In addition to the formation of values of environmental cleanliness and the well-being of the surrounding society, as well as promoting the formation of personal and joint responsibility for solving environmental problems, it is justified to further develop mechanisms for indirect participation of the population in environmental practices in urbanized areas, and the development of direct participation mechanisms in areas with a dispersed settlement pattern. Implementing the policy of targeted impact, authorities in popularizing pro-ecological activity should rely on the most predisposed groups of the population: young people, women with above-average incomes. The results of the study can be used to identify target population groups in the context of the implementation of regulatory, information and educational policies in the environmental sphere by the authorities, as well as co-organization of ESG transformation subjects in the socio-ecological-economic systems of the Arctic territories. Prospects for further research are associated with an in-depth analysis of the obtained data at the regional level, the implementation of a comparative analysis in the context of an expanded data set, including spatial analysis of data at the municipal level using weight matrices, a modified accounting of generational and socio-cultural characteristics of the population of the territories, as well as the dissemination of the research methodology to other Arctic regions, in particular to Arctic single-industry towns.

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