



## Tax Incentives for Economic Growth in the Russian Far East: Broad vs. Targeted Stimuli

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### Abstract

The purpose of this study is to justify the choice of tax incentive policy instruments aimed at the economic development of the Russian Far East, which is facing acute demographic and environmental problems. To model the dynamics of the region's real economic system, this study employed a mathematical model based on actual data from 2010 to 2021, covering economic, technological, and socio-ecological aspects. Using the versatile AnyLogic 8.0 platform for agent-based and system dynamics modeling, experiments on alternative tax incentive policy options involving both broad tax incentives and targeted economic development measures were conducted. Specifically, a 50% investment tax deduction for residents in special economic zones in the Russian Far East was implemented. The experimental results show that, despite comparable population dynamics, targeted stimulation of growth poles through public-private partnership programs outperforms broad tax incentives for economic entities in the Russian Far East. This is evident in higher economic growth rates in the region, particularly during the experimental period, except for 2040–2050, where adverse demographic trends constrain growth in both scenarios. The theoretical significance of the application of this method has shown that it allows us to obtain new significant results in the subject area of research due to the consideration of the complex interaction of factors of influence both at the micro- and macro-level, primarily behavioral factors that are fundamentally important for understanding the action of taxes. The practical implications of this study lie in defining the parameters of tax policy to target and stimulate growth poles in regions serving as hubs for generating and disseminating new technologies. The planned perspective is to encourage population growth and ensure sustained economic development in Russia's Far East. It is advisable to explore comprehensive tax and budgetary regulations that simultaneously address economic, socio-demographic, and environmental issues in the region.

### Keywords:

Sustainable Regional Development;  
Far East; Tax Policy;  
Tax Incentives;  
Economic-Mathematical Model;  
System Dynamics;  
Agent-Based Modeling.

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## 1- Introduction

The main subject of this study is the search for fiscal ways to ensure economic growth in a large region that faces demographic and environmental problems. This is a typical problem in many regions of the modern world, including the Far Eastern Federal District, which does not yet have a clear solution.

The Far Eastern Federal District (FEFD) is a vast region (6.9 million km<sup>2</sup>), which is significantly larger than, for example, the area of India (3.3 million km<sup>2</sup>). However, its population remains relatively small — 7.9 million in 2022. This figure has experienced a gradual decline over the past few decades, despite maintaining steady growth until 1990. This fact reflects a complex set of problems that have accumulated in regional development—economic, social, environmental, and others. It is clear that a change is necessary, considering the potential global consequences: measures should be taken to help the region transition toward a new trajectory of sustainable development.

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In such situations, a common approach is to use tax incentives to stimulate the economy, especially considering that monetary tools for support in many countries are currently facing substantial limitations [1, 2]. Taxes are a necessary tool for achieving economic growth. This point is confirmed by the experience of China, which, through measures like tax incentives, successfully steered its economy toward a path of stable growth [3, 4]. However, it is worth noting that while achieving economic success, China faced serious environmental and demographic issues. Something similar could be done in Russia's Far East, either in addition to or as an alternative to what the government is already doing [5].

The significance of analyzing tax incentives for the economic growth of the FEFD is determined by the fact that they can give a new impetus to the development of the region through their influence on the economic activities of economic entities in conditions where the possibilities of regional monetary policy are limited.

However, the question arises as to how exactly to proceed and what policy to implement. In principle, two main strategies are possible: the first involves creating a better tax climate for economic development, the importance of which is recognized by many experts [6–9]. This can be achieved using extensive tax incentives, including lowering effective tax rates. The other alternative approach is to focus on specific areas in the region and provide targeted tax incentives, aiming to later apply the resulting expertise and technological advancements across a wider area [10, 11].

Special economic zones in regions where targeted tax incentives operate are widely used worldwide as a tool for promoting economic growth. At the same time, some researchers have assessed the positive impact of these territories and the targeted tax benefits provided by them. For example, Alder et al. [12] noted that in the PRC, the creation of provincial-level SEZs contributed to an increase in GDP levels by approximately 20% and also increased total factor productivity and investment in human capital [12]. Lu et al. [13] found that the net benefit of China's special zone program over three years was approximately USD15.62 billion, with positive impacts on capital investment, employment, output, productivity, and wages, and increased the number of companies in these zones [13]. Assessing the performance of Chinese industrial enterprises (CIED) from 1998 to 2007, Li et. al. [14] substantiated that firms in SEZs, on average, show better results than those outside them [14]. Wang et al. [15] revealed that a pilot free trade zone has a significant impact on the green innovation performance of enterprises through the effects of cost reduction, tax incentives, and reverse diffusion of technology [15]. The establishment of free trade zones promotes local green economic development. In particular, technological progress and modernization of industrial structures are two important channels to achieve the positive effect of green economy development [16].

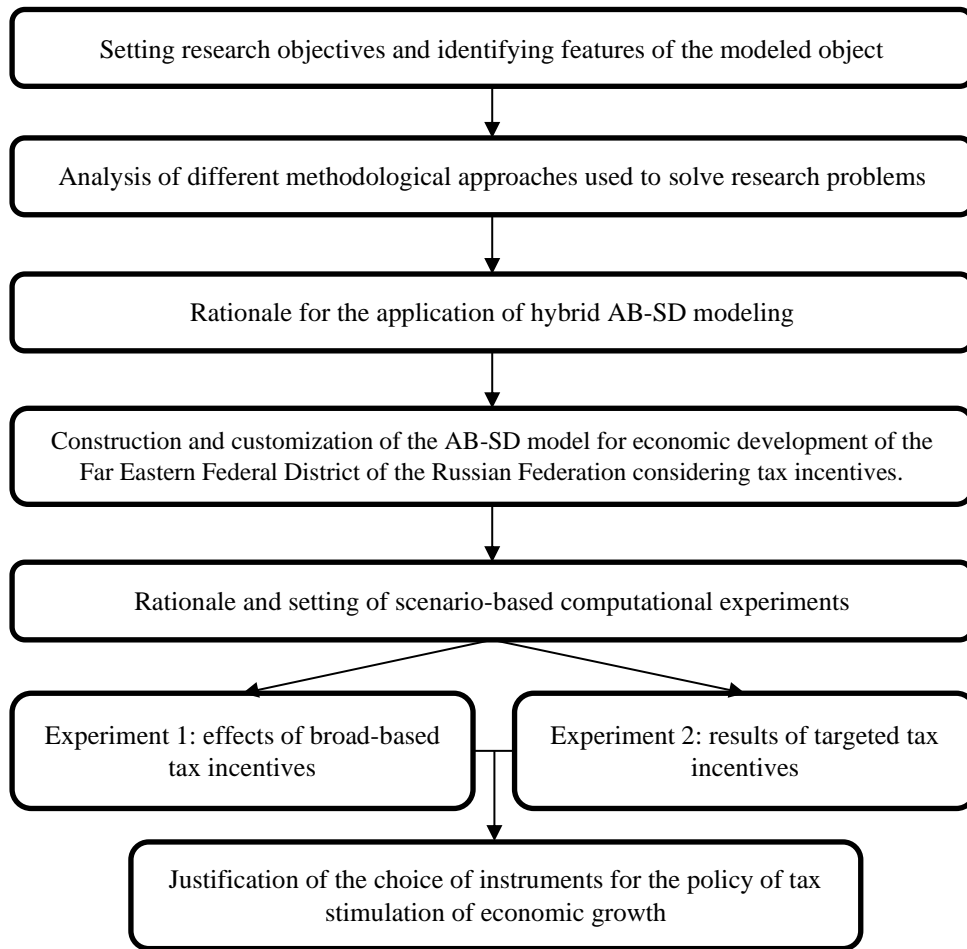
On the other hand, the application of targeted tax incentives within SEZs may encounter problems and does not always bring the expected positive results. For example, according to Xi et al. [17], preferential policies in SEZs lower the entry barrier for firms and attract a larger share of inefficient firms, which has a negative impact on improving the productivity of manufacturing services [17]. Augustyński [18] concluded that the economic effect of job creation due to SEZ creation is much smaller when estimates include the negative effects of reduced government spending on labor policies caused by fiscal incentives in SEZs and the additional unemployment caused by distorted competition and improper distribution of resources [18]. Nel & Rogerson [19] noted that despite the introduced tax incentives, SEZs in Africa are "ineffective" mainly because of poor strategic planning and maintenance, weak management, low levels of investment, poor quality of job provision, low wages, and unsatisfactory development of related social infrastructure. These zones have little prospects for solving the socioeconomic problems of the region and ensuring self-sufficiency in sustainable development [19]. Rothenberg & Temenggung [20] identified an emerging trend in the development of Indonesian SEZs, suggesting that such fiscal policies could ultimately translate into tax incentives for politically connected firms that do not create productivity spillovers [20].

Thus, the studies conducted in the field of SEZ efficiency are contradictory. They indicate that at present there are no universal recipes for solving the problem of choosing between broad (for the entire region) and concentrated (within its limited territories) development incentives. Therefore, it is necessary to search for separate solutions for different types of regional development situations. In this case, we propose a study of the problem of tax incentives for one of these typical situations, when a large region within Russia faces demographic and environmental problems.

Each strategy has its own advantages and disadvantages and works only under specific conditions. For example, broader incentives are usually associated with significant government tax expenditures, based on the assumption that national businesses are sufficiently competitive. While targeted incentives are associated with lower tax expenditures and are more likely to succeed in the institutional realities of an emerging economy, their implementation brings inevitable challenges related to scalability, economic inequality, and other issues. Therefore, it is not possible to determine a priori which strategy is superior.

It is necessary to make arguments that consider the specific circumstances of place and time, as well as the features of the likely behavior of taxpayers under the influence of the incentives proposed by the government. To do this, it is advisable to use methods of economic and mathematical modeling, simulating, among other things, the behavioral reactions of economic entities, since it is extremely difficult to perform counterfactual analysis or conduct field experiments in the territory of the Far Eastern Federal District to identify them.

A flowchart of this study representing the model of tax regulation of economic development in the Far Eastern Federal District is shown in Figure 1



**Figure 1. Flowchart of the study**

This research is structured in the following sections: Section 2 of the research provides a description of the theoretical background for the study. Section 3 describes the data collection procedures and tools of the study. The fourth section presents the findings from the data analysis and discusses the comparison of the results, theoretical and practical implications, and directions for future research. Section 5 offers concluding remarks on the significance of the study.

## 2- Literature Review

When modeling the functioning of the economy under the influence of fiscal policy, it is essential to consider the behavioral reactions of taxpayers in response to the incentives applied by the state, since the expectations of the government may significantly differ from the actual reactions of taxpayers. For this purpose, it is necessary to consider the interaction of a set of individuals making independent decisions (agents) and institutions (rules) that guide their behavior. To address the above-described task and perform calculations, we need to build a mathematical model of the region's economy and conduct computational experiments. When selecting the model type, it is crucial to be aware of two fundamental factors.

First, economic entities respond to incentives based on various factors. However, their actions are ultimately shaped by their individual perspectives on what is beneficial or detrimental to them. As a result, their behavior may not consistently align with the government's expectations. This creates the need to predict their behavioral reactions, which is commonly done using Agent-Based (AB) modeling.

Second, the actions of numerous economic agents result in systemic (macroeconomic) processes with their own patterns of evolution, including those in the field of ecology. To properly account for them, special tools are required, such as system dynamics (SD) modeling.

The agent-based model is a computerized simulation of economic agents' actions in accordance with their assessments of the current situation, the state of the surrounding world, and the rules governing their behavior. Each agent at any moment of time acts in accordance with its internal goals and assessments of the current situation, but is also guided by external rules (institutions) regulating its behavior, and the result of their joint activity is the evolution of the analyzed system as a whole. The agent-based approach allows us to model a multitude of interactions of agents over time and to consider a wider range of complex and nonlinear behavior than traditional equilibrium models. This makes it possible

to study the economy under different policy scenarios and quantify their consequences. Simultaneously, the main problem with this approach is the need to simulate the real behavior of agents and the choice of rules they use to make decisions, which, when solving realistic problems, can lead to a significant complication of modeling processes [21]. Agent-based modeling in the sphere of fiscal policy requires the integration of models of financial interaction with models of production, public expenditures, taxes, investment, and consumer behavior. At the same time, these approaches are actively used to evaluate the effectiveness of various approaches to economic stimulus, such as tax cuts versus government spending. For example, Li et al. [22] focused on finding an optimal taxation scheme that can help reduce air pollution and greenhouse gas emissions while ensuring sustainable economic and environmental development. The authors justify the positive impact of an optimized taxation scheme on energy and industrial structures. Mathieu-Bolh [23] evaluates reforms that offset the loss of government revenues resulting from a lower tax on capital income by increasing the tax on dirty goods or pollutant emissions. The agent-based model of Mattauch et al. [24] justifies that public investment financed by higher capital taxes can reduce property inequality.

Thus, as the research results show, the main advantage of the agent-based approach is that it allows us to look at the problem from the inside—from the particular to the general—and to obtain information about the general quantitative regularities of the model under study, based on the behavioral activity of its constituent elements. Its main disadvantages are potential induction errors (transferring the properties of one class of objects on the basis of observations of its individual instances to the entire class of objects), as well as ignoring those attributes of the system that are not reducible to the properties of its individual elements.

System dynamics, as one of the branches of the systems approach, is a modeling methodology and analysis model that is being actively developed and applied to study the dynamic behavior of complex systems, considering feedback. Using the system dynamics method, Samara et al. [25] evaluated the performance of national innovation systems, including knowledge and human resources, market conditions, financial systems, research activities, technical characteristics, institutional conditions, and subsystems of the innovation process. A system dynamics model that determines the most efficient scenario for achieving green growth in a typical industrial region of the PRC (Liaoning Province), considering energy consumption per unit of GDP, energy consumption pattern, CO<sub>2</sub> emissions per unit of GDP, resource cost, and green GDP per capita, is described in Guo et al. [26]. A dynamic model for evaluating incentives for energy conservation and emission reduction using Fujian Province in the PRC as an example, including fiscal preferences, emissions trading, finance, industry and technology, and political efficiency, substantiates that fiscal policy is the most effective, although the effect is smaller than for a combination of different policies [27]. Meng & Yu [28] built an equilibrium model of the electricity market and a system dynamics model to analyze the effects of different policies in electricity markets, particularly the impact of a carbon tax on the reduction of carbon emissions in the electricity sector. Simultaneously, the conceptual disadvantage of system dynamics is that it is not designed to model the behavior of economic actors and the specifics of their reactions to changing external circumstances, the consideration of which is crucial for determining the consequences of tax policy.

If in the framework of system dynamics, it is possible to model complex systems at a high level of abstraction, considering feedback loops, but without considering individual properties of people and events, then agent-based modeling focuses on individual participants of the system. Thus, these paradigms of system dynamics (SD) and agent-based modeling (AB) represent complementary modeling approaches and have been well established through economic research over the last decade.

Complex adaptive systems usually include a scalable population of agents, i.e., the level of system abstraction in them can be an individual, a group, or an organization. Nonlinearities and feedback can occur at multiple levels, both between individual agents and between groups of agents. Therefore, one of the key factors in the application of hybrid simulation modeling is the ability to represent interdependencies between different levels of hierarchy or scales of the system. Thus, this study employs a synthesis of AB and SD methods, known in the academic literature as hybrid AB-SD modeling [29]. Hybrid AB-SD models, despite the problems and limitations associated with the need to collect a large number of diverse data, the complexity of calibration and validation processes, especially the behavior of economic agents, the difficulty of interpreting the obtained results, have a number of advantages, because they allow not only to analyze the problem in dynamics, but also to capture the relationships (including feedbacks) between the elements under study, i.e. between agents and the external environment, to determine the values of the elements included in the analysis at each moment. Zulkepli & Eldabi [30] argue that hybrid AB-SD modeling provides a broader and better understanding of the real situation because it allows model developers to evaluate the problem under study in different dimensions. Such hybrid modeling is widely applied globally to address diverse economic issues [31-33], including taxation [34, 35]. The rationale for employing the synthesis of system dynamics and agent-based modeling in the context of tax policy aimed at promoting sustainability is presented by Sinenko [36].

Thus, based on the specifics of the subject area of the study, we opted for hybrid AB-SD modeling, which allows us to consider both the behavioral reactions of economic subjects under the influence of tax incentives and the system-dynamic effects of the activities of these subjects. Among the various AB-SD models, Polovyan & Vishnevskaya [37] deal the most closely with the specifics of the task outlined in this article. However, this work does not include

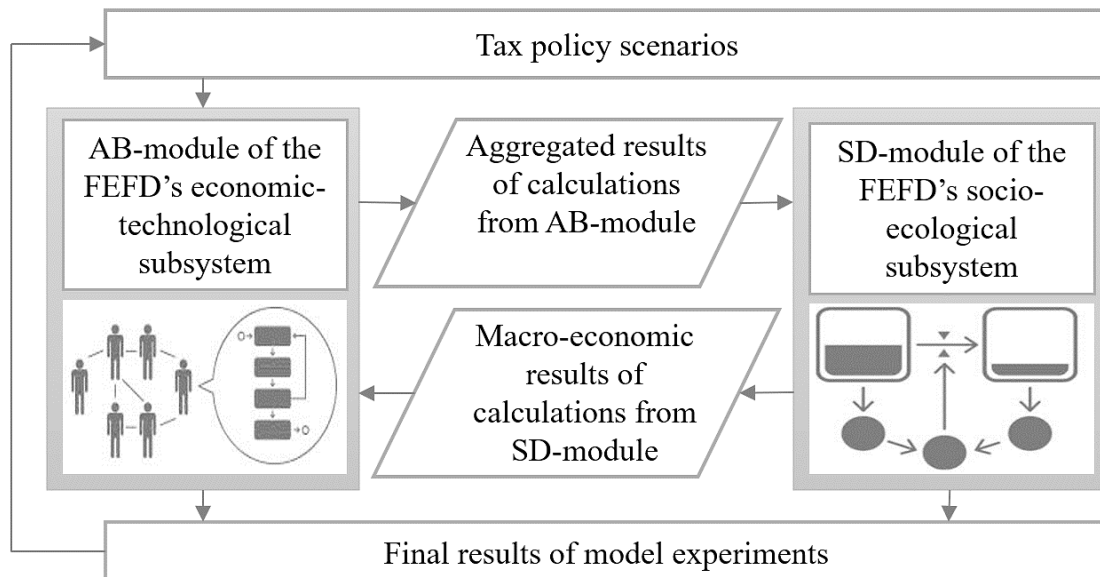
opportunities to specifically analyze tax instruments. Their study focuses on the conditions of an emergent economy, particularly its production and environmental subsystems. We also employ a similar structuring but with consideration for the specifics of the public finance sphere at the regional level as well as a range of additional factors relevant to this analysis (a larger number of economic agent classes, the endogenous nature of R&D, population migration, etc.). Among other things, we proceed from the negative population dynamics in the Russian Far East, which has been a persistent trend in recent decades and imposes significant constraints on a number of technological and economic variables [38, 39].

### 3- Research Methodology

The methodology used in this research to model the dynamics of the region's real economic system is a synthesis of system dynamics, enabling the consideration of environmental and demographic factors of the region's development, and agent-based modeling, which can consider the behavioral reactions of economic entities under the influence of tax incentives.

The proposed mathematical model belongs to the class of integrated models, which are characterized by the presence of feedback between the AB and SD modules and a combination of outputs to represent the desired result as a function of time [29].

The model consists of two subsystems: the economic-technological subsystem, represented by a mass of heterogeneous economic agents (enterprises) whose activities are modeled based on AB principles, and the socio-ecological subsystem, represented by the region's population, which changes under the influence of demographic and ecological factors and is modeled based on SD principles (Figure 2).



**Figure 2. Fundamental scheme of the model for tax regulation of sustainable development in the Far Eastern Federal District**

These subsystems interact through their operational outcomes: the economic-technological subsystem produces goods, generating income for both the population and the government. Simultaneously, the economic-technological subsystem emits pollutants, influencing the socio-ecological subsystem. The income and pollutants entering the subsystem impact the reproduction and migration processes of the population and determine the reverse flows of labor used in the production processes in the economic-technological subsystem [36-39].

Let us now explore the details of the modeling for each subsystem.

#### 3-1-Economic-Technological Subsystem

As mentioned above, the economic-technological subsystem is represented by economic agents—the region's enterprises. In successive production cycles, using labor ( $L$ ) and capital ( $F$ ), these enterprises produce goods ( $Q$ ) while simultaneously emitting pollutants and disposing of them into the surrounding environment.

According to Polovyan & Vishnevskaya [28], output is proposed to be calculated through the fund yield, as it well reflects the results of the factor of new technologies:

$$Q_t^i = \frac{Q_t^i}{F_t^i} \frac{F_t^i}{L_t^i} L_t^i = \varphi_t^i \cdot f_t^i \cdot L_t^i, \quad (1)$$

where  $\varphi_t^i$  is the return on assets of enterprise  $i$  in year  $t$ , and  $f_t^i$  is the asset turnover of enterprise  $i$  in year  $t$  ( $f_t^i = f(t)$ ).  $L_t^i$  is the number of employees at enterprise  $i$  in year  $t$ .

In the production process, in addition to fixed assets, working capital is also required. The latter is not explicitly represented in equation (1) because the money supply for the region’s enterprises is considered unlimited (perfectly elastic) at the market price; that is, we assume that in the production process, there is always access to the necessary working capital for the fixed assets used, and the associated costs are accounted for in the production cost.

Proceeds from the sale of products after taxes are used for investment in expanded reproduction (Figure 3).

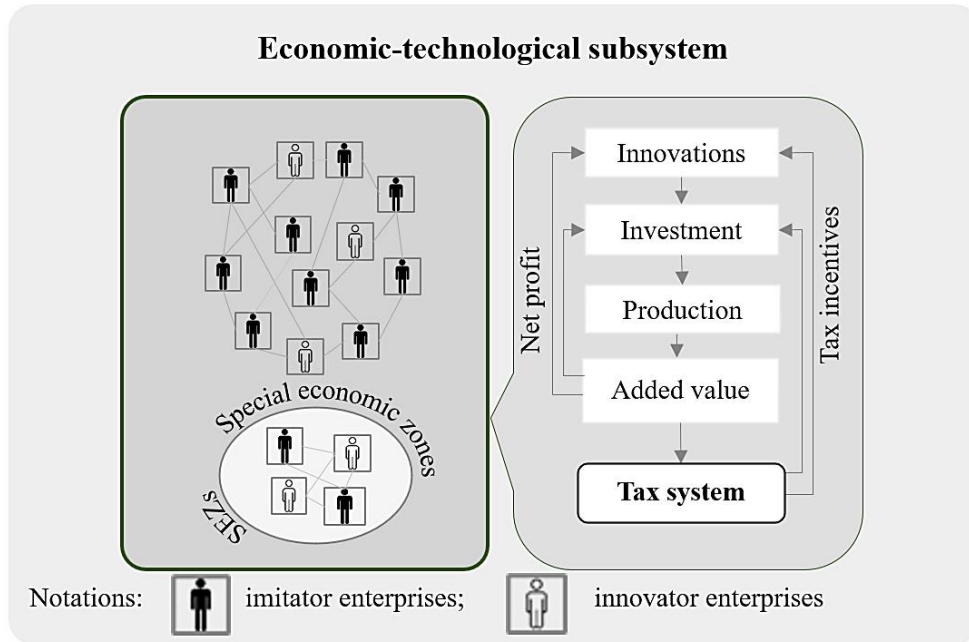


Figure 3. AB module of the model for tax regulation of sustainable development in the FEFD

In this context, all economic agents are divided into innovators  $\{u_{n1}, u_{n2}, u_{n3} \dots u_{nr}\} = U_n$  and imitators  $\{u_{m1}, u_{m2}, u_{m3} \dots u_{mt}\} = U_m$ . Innovator enterprises allocate a portion of their profits to the R&D of production and environmental technologies, which may prove successful or unsuccessful, while imitator enterprises rely solely on already established solutions.

The application of technologies, whether known or newly developed, leads to changes in the return on assets ( $\varphi_t^i$ ), following the logic proposed by Nelson & Winter [40], where new values for each economic agent are generated using a two-stage stochastic process.

In the first stage, independent random variables (1 or 0) are set, determining the fate assigned to the  $i$ -th enterprise: to innovate (1) or not (0). In the second stage, the probabilities of investment success are determined as follows:

$$Pr(dm = 1) = \frac{K_{rm}_t^i - K_{rm}_t^{min}}{K_{rm}_t^{max} - K_{rm}_t^{min}}; \tag{2}$$

$$Pr(dn = 1) = \frac{K_{rn}_t^i - K_{rn}_t^{min}}{K_{rn}_t^{max} - K_{rn}_t^{min}},$$

where  $K_{rm}_t^{max}$ ,  $K_{rm}_t^{min}$  - represent the maximum and minimum costs, respectively, for imitation of an already known technology by regional enterprises in period  $t$ , while  $K_{rn}_t^{max}$ ,  $K_{rn}_t^{min}$  - stand for the maximum and minimum costs, respectively, for the development of a new technology in period  $t$ .

Both imitators and innovators can be residents of territories with a special economic status (SEZ), applying special tax incentives such as benefits related to corporate income tax, property tax, and mandatory social security contributions. These measures increase the likelihood of success for innovative technologies as their implementation grows up production volumes and profitability. In accordance with the principles of evolutionary economics, if the activities of a particular economic agent lead to an increase in its profitability, it tends to reproduce similar entities over time. If not, reproduction does not occur, and enterprises with profitability below average eventually exit the population (get eliminated).

The sizes of industrial investments depend on the profit after tax, considering the tax incentives provided by the government. It is determined as the difference between the exogenous price (assuming that the region’s enterprises do not possess market power) and the production cost, which includes, in addition to labor and capital consumption, property taxes, insurance contributions (wage-related), and environmental payments charged at the respective rates ( $\tau_t^f$ ,  $\tau_t^l$ ,  $\tau_t^e$ ).



This approach to cost breakdown is motivated by the objectives of this study, which, among other things, aims to analytically justify the policy of tax incentives for sustainable regional development, with a focus on the analysis of the opportunities and consequences of fiscal policy.

Taxes paid by enterprises are allocated to the regional budget according to established norms governing the distribution of tax revenues among different levels of the budgetary system. According to Russian legislation, the region’s consolidated budget is funded in full by personal income tax (rate  $\tau_t^h$ ), property taxes, and environmental payments. Additionally, a significant portion (85%) of corporate income tax (rate  $\tau_t^p$ ) contributes to the budget.

According to our approach, the revenues of the regional budget ( $B_t = f^B(Q_t, \tau_t^f, \tau_t^l, \tau_t^e, \tau_t^h, \tau_t^p)$ ) are used to provide public goods, including government financing for social policies, education, and healthcare ( $G_t$ ):

$$G_t = E_t(k_t^S + k_t^E + k_t^M), \tag{3}$$

where  $k_t^S, k_t^E, k_t^M$  signify the share of expenditures on social policy, education, and healthcare, respectively;  $E_t$  is the expenditures of the regional consolidated budget in year  $t$ .

In this case, if in the given year the current revenues of the regional budget exceed its current expenditures ( $B_t > E_t$ ), a budget surplus occurs, and if less ( $B_t < E_t$ ), a deficit ( $D_t = B_t - E_t$ ), which must be covered.

The proposed model assumes that the interest on such financing (at the rate  $r_0$ ) is included in the budget expenditures of the next period:

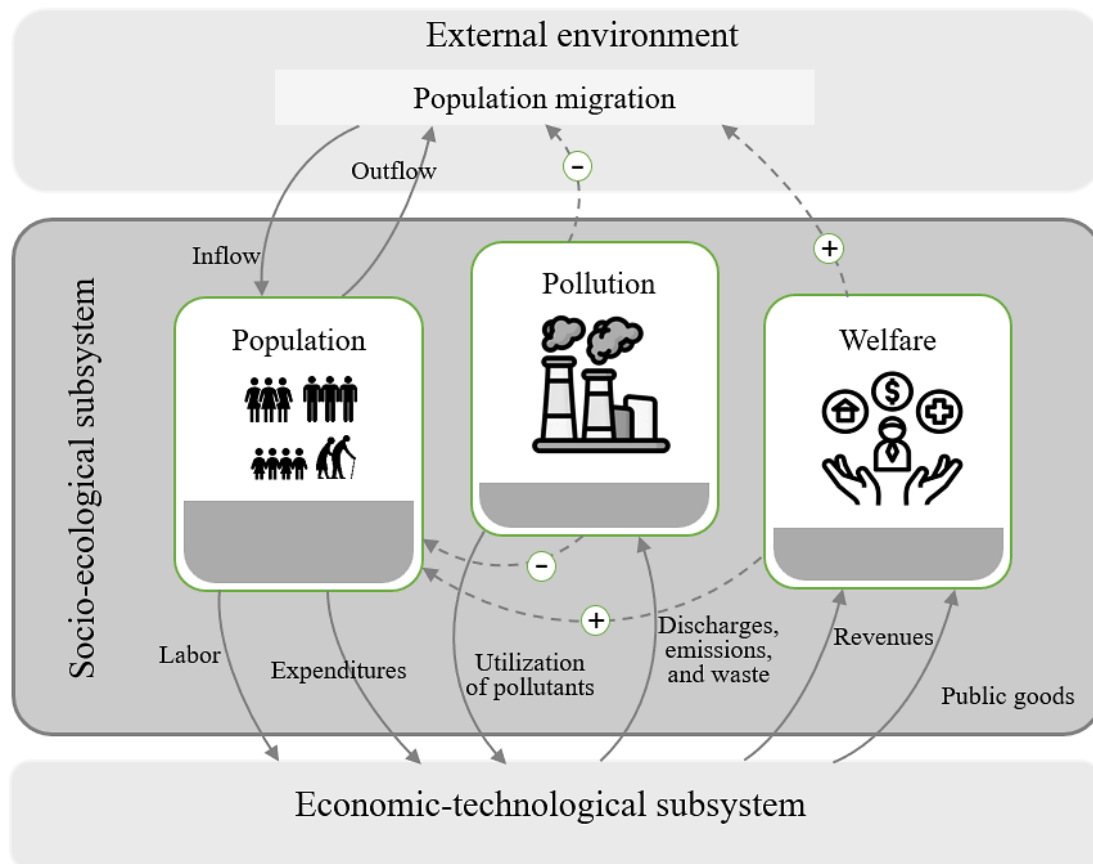
$$E_{t+1} = f^E((G_{t+1} + D_t r_0), G_{t+1}^Z) \tag{4}$$

where  $G_{t+1}^Z$  are the other expenditures of the regional budget.

### 3-2- Socio-Environmental Subsystem

As mentioned earlier, the economic-technological subsystem is represented by the population, which is divided into four age groups (0–14, 15–24, 25–64, and over 64 years), allowing for the identification of the working-age population.

The population dynamics ( $P_t$ ) are determined by the interplay of several factors (see Figure 4).



**Figure 4.** SD module of the model for the tax regulation of sustainable development in the FEFD  
 (Notations: flows ——— ; factors of influence - - - - - )

The birth rate coefficient under normal assumptions, and as proposed in our model, depends on the income level of the population, the quantity of public goods provided by the government, and the state of the environment:

$$b_t = f^b(w_t, G_t, A_t) \quad (5)$$

where  $w_t$  is the average wage level in the region;  $G_t$ , government expenditures on social policy, healthcare, and infrastructure;  $A_t$ , aggregated (i.e., accumulated over the entire calculation period, considering the carryover balance) pollution of the atmospheric air, water bodies, and land with waste.

Similarly, but using separate functions, the mortality rate and population migration balance are determined.

The labor supply depends on the amount of working-age population, we assume ( $\hat{L}_t$ ):

$$\hat{L}_t = f^l(P_t^2 + P_t^3), \quad (6)$$

where  $P_t^2$  and  $P_t^3$  stand for the number of deaths in groups 2 and 3.

The labor supply is considered when calculating the satisfied demand of enterprises for labor. Thus, the actual labor used in the production process  $L_t^i$  (see Figure 1) is determined, in part by considering factor  $\hat{L}_t$ .

Experiments with alternative tax incentive policies are proposed to be conducted using the model described above to calculate the dynamics of a number of economic, technological, environmental, and demographic indicators for the long term.

## 4- Results and Discussion

To build the model, we used actual data reflecting the dynamics and structure of the socio-ecological subsystems in the FEFD between 2010 and 2021. The data include indicators such as population size, migration, birth and death rates; the number of enterprises, including residents of special economic zones (SEZ); production volume; the value and depreciation of fixed assets; investments in fixed capital, including those of environmental significance; the number of workers and their wages; budget revenues and expenditures; atmospheric emissions, wastewater discharges, industrial waste generation, and others. All cost indicators are presented in comparable prices using the GDP deflator.

To verify the model, the entire dataset was divided into two parts: a training sample (2010–2017), used for model tuning, and a control sample (2018–2022), used to assess its quality (see Table 1).

**Table 1. Verification results of the model (on average for 2019-2021).**

Indicator	Fact	Model	Error (MAPE)
Population, mln people	8.13	8.19	+0.7%
Average monthly earnings of employees, ths rbs per person *	35.1	34.8	-0.9%
Production output, bln rbs *	3 126	3 189	+1.9%
Atmosphere emissions, mln tons	1.165	1.111	-4.6%
Budget revenues, bln rbs *	664	678	+2.1%

\*In comparable prices for 2010

The provided metrics suggest that the mathematical model adequately reflects the development of the region's real economic system. The mean absolute percentage error (MAPE), which shows the deviation of the mean values of the series from the mean values of the forecast model, does not exceed 5%.

The model is built in the AnyLogic 8.0 programming environment [41], which supports both agent-based and system dynamics modeling (see Figure 5).

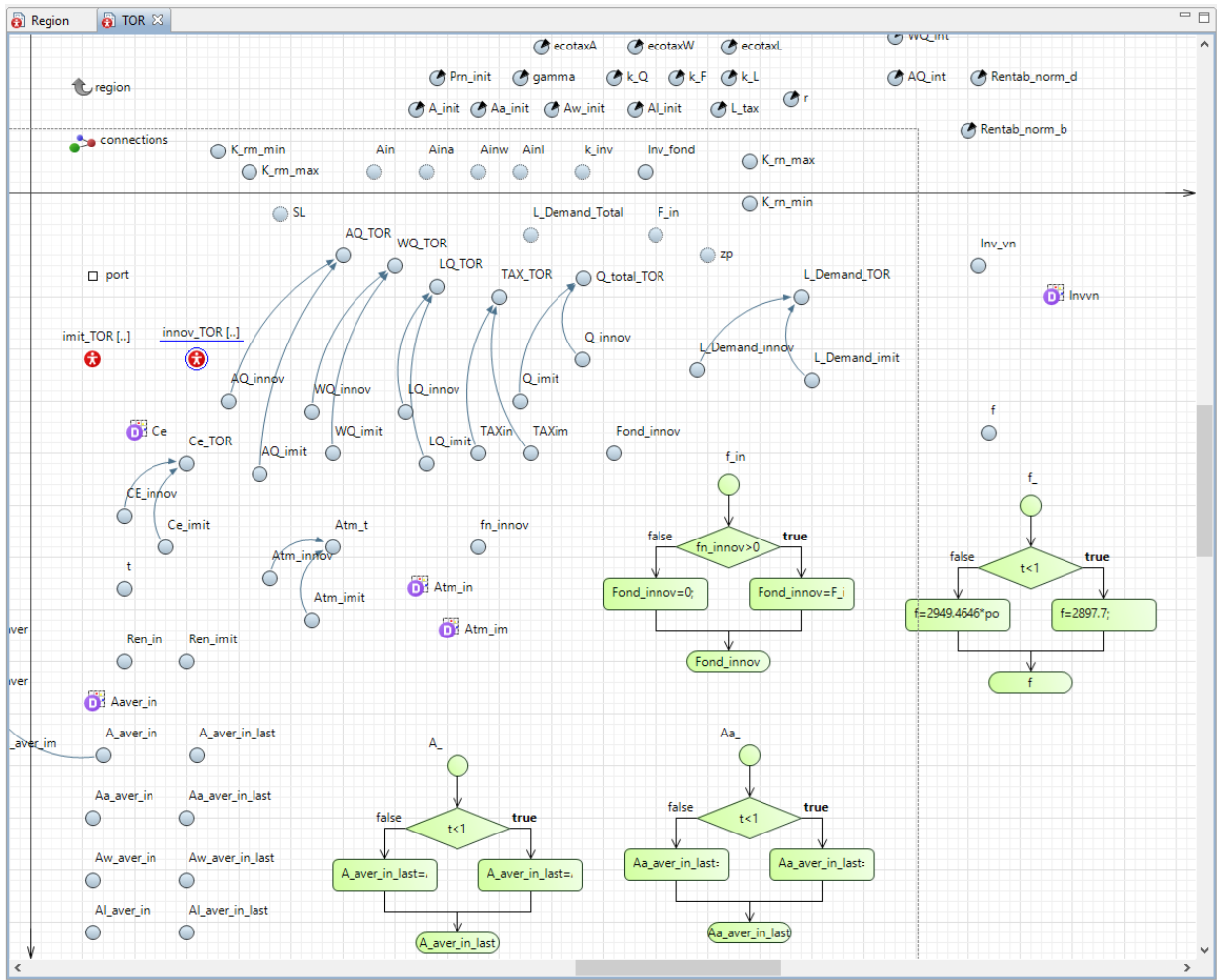
### 4-1- Computational Experiments

#### 4-1-1- Experiment 1. Provision of Broader Tax Incentives

The idea of offering broader tax incentives is widely recognized and intuitively understandable. If there is a disparity between the actual and maximum potential output in an economic system, providing extensive tax incentives to enterprises—effectively reducing tax rates—can help bridge this gap. The reason for this is that tax reduction increases the return on investment for economic agents in human and physical capital, R&D. Higher returns, all else being equal, signify greater accumulation and innovation, and hence higher rates of economic growth.

As shown in the data presented in Table 2, significant tax benefits can indeed make a positive difference in the development of the region compared with the baseline scenario. However, this improvement is only marginal and temporary.





**Figure 5. Fragment of the tax regulation model for a region’s sustainable development, built in the AnyLogic 8.0 simulation modeling environment**

**Table 2. Experiment 1 - providing broad tax incentives (reducing effective rates of the major taxes—corporate income tax, property tax, and mandatory social contributions by 1/4). Increase in the economic indicators compared with the baseline scenario, percentage points.**

Indicators	On average		
	2021–2030	2031–2040	2041–2050
Population growth	0.00	0.00	0.00
Increase in the output volumes	-0.15	+0.25	-0.11
Growth in the average monthly salary	-0.07	+0.05	0.00
Increase in atmospheric emissions	+0.01	0.00	-0.01
Increase in budget deficit (as a percentage of output)	+0.39	+1.05	+1.18

Firstly, if additional funds are allocated to enterprises based on their connection to a specific region, it does not guarantee that the extra profit will be invested in technological progress. The decisions of the enterprise are made independently, guided by its interests, but these decisions depend on the overall conditions that determine the success of R&D in the country and region. Therefore, if the innovation and investment climate in the country and region is not very favorable\*, then broad tax incentives cannot quickly deliver the desired result for the government (successful innovations emerge with a certain probability, but this probability is not high).

Secondly, it should be noted that the critical mass of investments in new equipment and technologies per economic agent matters. When tax incentives are evenly distributed among all entities in a given territory, the additional funds received by each entity may be insufficient to successfully overcome the innovation threshold associated with the “valley of death” problem [42]. This is the stage that separates R&D outcomes from successful innovations. During this stage, it is difficult to evaluate the prospects of new processes and/or products, which is why the risks are high and there is limited access to external financing.

\* In this regard, it should be noted that R&D financing in Russia (approximately 1% of GDP) significantly lags behind not only tech-savvy countries but also the global average. This is explained, in part by the insufficient interest of businesses in conducting R&D.

Thirdly, and quite importantly, the problem lies in the inertia of unfavorable demographic trends in the Russian Far East. In conditions of initially not very high scientific and technological development in the region’s real sector, these trends negatively impact long-term economic growth. Over time, this impact becomes stronger, as evidenced by the slowing pace of growth in the last decade (2041–2050, Table 2). It is not possible to overcome this inertia solely through the tax factor [43].

**4-1-2- Experiment 2. Targeted Stimulation of Economic Development**

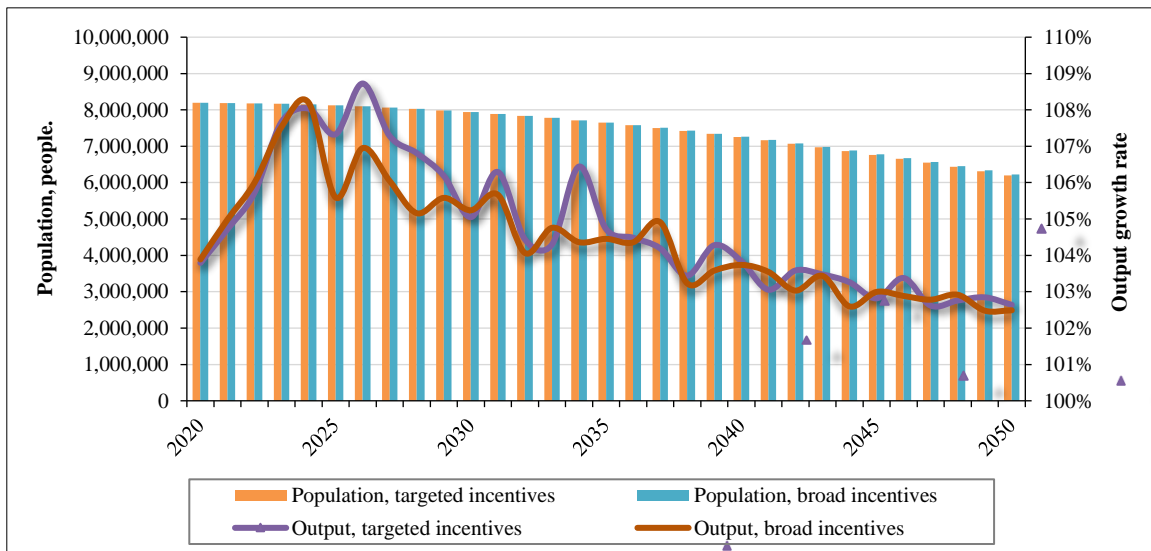
The idea of targeted tax incentives is also well-known and generally understood. Concentrating enterprises on certain “growth poles” allows for a more efficient use of existing infrastructure, human capital, and other resources [44-47]. This leads to increased productivity, facilitates the exchange of ideas and knowledge, stimulate innovation, and creates an overall more favorable environment for R&D. However, it should also be noted that these approaches can also lead to negative outcomes, such as growing disparities between regions and environmental problems.

**Table 3. Experiment 2 - targeted stimulation of economic development (providing residents of SEZs with an investment tax deduction at a rate of 50%\*). Increase in the economic indicators compared with the baseline scenario, percentage points**

Indicators	On average		
	2021–2030	2031–2040	2041–2050
Population growth	0.00	-0.01	-0.04
Increase in the output volumes	+0.21	+0.33	+0.02
Growth in the average monthly salary	+0.19	+0.20	+0.06
Increase in atmospheric emissions	+0.05	+0.13	+0.11
Increase in budget deficit (as a percentage of output)	+0.60	+0.75	+0.62

However, as our computational experiments have shown, provision of strong incentives specifically to enterprises in SEZs fulfilling government objectives— which is a condition to be met to obtain tax deductions—can lead to better results in terms of regional economic growth compared to Experiment 1, even with similar budget deficits. The success of innovative private initiatives in Russia and its regions is closely tied to the participation of enterprises in public-private partnership programs, according to Borkova & Trunin [48]. Russian businesses often lack the opportunities and resources to operate independently in this sector.

If private sector funds are directed toward projects chosen by businesses based on their economic interests, while also considering government priorities and ensuring government participation through tax deductions, and if the funds allocated per enterprise are substantially larger than in Experiment 1, then more favorable outcomes can be expected†. As shown in Figure 6, with comparable population dynamics, the economic growth rates in Experiment 2 are higher than those in Experiment 1 (except at the end of the calculation period when unfavorable demographic trends constrain economic growth in both experiments)‡.



**Figure 6. Comparison of scenarios for demographic development and production output rates in the Russian Far East**

\* The investment tax deduction (at a rate of 25%) has been proposed by the Russian government for implementation starting from 2024. See: Ministry of Economic Development of the Russian Federation [47].

Within the model, a tax deduction at a higher rate (50%) is considered to better demonstrate the potential of targeted stimulation, with comparable (but slightly smaller) budget deficit sizes compared with Experiment 1.

† This, however, does not exclude the issue of state failures related to misguided priority choice, but this question is beyond the framework of this mathematical model.

‡ It should be emphasized that the experiments presented here and their interpretations are not forecasts (predictions of what to expect in the future with a certain probability) but rather foresights. They are intended for critical analysis of development alternatives to justify possible directions for a long-term economic policy.

It is clear that much depends on how quickly and widely new technologies can be disseminated across the entire territory of the region, which, in turn, depends on the overall level of the country's technological development as well as on the solution of issues related to the traditionally accusatory bias in Russian law enforcement practices [49]. Therefore, creating a more favorable environment for investments in R&D in Russia is of paramount importance.

Thus, the main conclusions from economic modeling comparing alternative approaches to tax incentives for economic growth in a region facing demographic and environmental challenges are as follows:

(1) the efficiency of targeted tax incentives may be higher than that of broad ones because they reduce the innovation threshold more strongly; less concentrated broad incentives have a weaker effect on the innovative activity of enterprises in conditions where the overall level in the region is low;

(2) tax incentives themselves (either targeted or broad) may be insufficient to significantly accelerate economic growth and, on this basis, solve the problems of sustainable development in the region. The main reason for this is the inertial negative demographic dynamics, which affects labor supply, productivity, fiscal stability, etc.

This is noticeable from the dynamics of economic indicators shown in Fig. 6: the initial impetus given to the pace of economic growth in the region is fading under the influence of population decline and aging. This conclusion confirms the provisions of numerous studies about the negative impact of population aging (when it reaches a certain level) on economic growth, although the strength of the influence increases as population aging deepens (see, for example, Lee & Shin (2019) [50]).

At the same time, unlike Xi et al. (2021) [17], our computational experiments did not show that targeted tax incentives within special zones of the region can negatively affect productivity, since such incentives reduce the innovation threshold, which becomes lower primarily for innovative enterprises that increase average productivity within the SEZ, than the entry threshold to the preferential territory.

However, when interpreting the results obtained, the main limitation of our approach should be considered, which consists in the postulated nature of the economic agents' behavior, the parameters of which require empirical justification in further research about the latest trends in the development of the Far East.

## 5- Conclusions

Tax incentives for economic entities can be useful tools for addressing regional development issues. Although this tool is quite challenging, its application does not guarantee success. World economic history is replete with cases in which creating preferential conditions for businesses to stimulate innovation and investment ended in failures. However, as the results of the experiments have shown, in the current situation in the Russian Far East, tax incentives can provide an additional impetus to its development.

Firstly, the final result depends on how they are applied. As calculations indicate, when choosing between broad tax incentives granted to economic entities in the region (i.e., unconditionally reducing effective tax rates based on territorial criteria) and targeted stimulation of specific growth poles (residents of SEZs), the latter approach may yield slightly better results. This does not mean that it is inherently superior but is influenced by the specifics of the Russian institutional environment, which is characterized by the traditionally strong influence of the state on all aspects of public life. Moreover, it should be noted that this conclusion (about the advantage of special incentives over a simple reduction in tax rates) is consistent with international experience\*, which can be explained by the objective strengthening of the role of the state in many countries around the world at the initial stage of a new industrial revolution.

This is the theoretical significance of the analysis. However, the limitations of our approach should be considered, namely, the postulated nature of the behavior of economic agents, the parameters of which require further empirical substantiation considering the recent trends in the development of the Far East.

Secondly, tax incentives for economic entities are not a panacea. When the economy faces serious, long-term, and hence inertial demographic (as well as environmental) challenges, which are especially pronounced in the Far East of Russia, they serve as a natural ceiling that largely mitigates the efforts of the government and businesses to accelerate technological development and increase the pace of economic growth. In this sense, path dependence is important.

The practical significance of this work lies in the fact that it substantiates the expected consequences of the implementation of various options of the policy of tax stimulation of economic growth in the Far East, the analysis of which can be the basis for making managerial decisions.

In particular, among the considered tax instruments, the strongest is concentrated tax incentives for growth poles on the territory of the region, built on the principle of partnership between the government and technological innovators (co-financing of scientific and technological projects). As the results of computational experiments have shown, such

\* Research on the corporate income tax in OECD countries has shown that, for stimulating investments, it is not so much the reduction of its main rate that matters but rather the use of targeted instruments for investment incentives [2].

incentives can contribute to a significant improvement in regional development by accelerating and scaling innovation, but they do not automatically ensure its sustainability. Therefore, strategic fiscal policy should provide for the joint use—with mutual support and reinforcement—of innovative tax incentives and environmental incentives, which can raise this "ceiling" over time.

In the case of the FEFD, the use of the AB-SD synthesis method has shown that there is no simple fiscal solution to the complex problems of sustainable development in the region. Fiscal policy by itself, including various combinations of tax instruments, does not guarantee the transition to a trajectory of stable growth of the region's economy and human population. For this purpose, in addition to the positive impact of taxes, it is necessary to consistently improve the basic structural and dynamic characteristics of the economic and environmental system of the region, including by increasing the level of investment in science, infrastructure, and human capital, as well as cultivating new patterns of behavior of economic agents that better correspond to new opportunities and challenges.

Therefore, further research in this field is advisable to explore ways of systemic tax and budget regulation to address both economic and simultaneous social-demographic and environmental issues of the region, and empirical substantiation of the parameters of economic agents' behavior under the influence of tax incentives in specific circumstances of place and time.

## 6- Declarations

### 6-1-Data Availability Statement

The data presented in this study are available in the present article.

### 6-2-Funding

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### 6-3-Institutional Review Board Statement

Not applicable.

### 6-4-Informed Consent Statement

Not applicable.

### 6-5-Conflicts of Interest

The author declares that there is no conflict of interest regarding the publication of this manuscript. In addition, the ethical issues, including plagiarism, informed consent, misconduct, data fabrication and/or falsification, double publication and/or submission, and redundancies have been completely observed by the author.

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