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Article

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Energy Security of Territories as a Factor of Sustainable Development under the Conditions of Economic Changes

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ABSTRACT

Territorial security implies the possibility of providing a continuous process of development and functioning in a particular locality. Taking into account that fact that the main focus is now made on the complex development of territories, the continuous improvement of the mechanisms ensuring the process is constantly being improved. The article discusses how it is possible to use the method of mathematical modeling and statistical evaluation in order to answer the question whether there are enough resources in the territory in order the development to be continuous. The urgency of the research is determined by the fact that the most important element of development is the possibility of consuming energy resources and, accordingly, the possibility of their production in conditions of economic change. The novelty of the research is determined by the fact that for the first time the question is raised about the structure of the energy security of the territory. The authors consider the issue of compliance with the structure of energy consumption as an object of research and propose to calculate the level of energy security by the extent possible to provide the territory independently, if necessary, at the expense of alternative energy sources. The practical direction of the research is determined by the fact that the possibility of independent development of territories is projected without external influence from agents of economic development. The paper analyzes not only the existing system of today, but also the forecasting model.

Keywords: Development, Power Industry (Energetics), Security, Territory
JEL Classifications: O10, O13, N7

1. INTRODUCTION

Today, the security issue reverberates and the reason for its appearance is very transparent - the growing threat to humanity and its multi-vectority. Among threats there are the following: Destabilization of the system of international economic relations, high degree of uncertainty of the participants' actions in the economic space, disintegration tendencies, escalation of international tension, permanent occurrence of global and local crises, limited world resources and their high cost. Recently, the security of the state, the security of the territory and the security of the individual are not considered separately - they are interconnected and interdependent. If any objective or subjective reason (for example, war) represents a threat to national security, it represents a threat both to the enterprise and to the private individual. All this determines the relevance of the study of world experience in solving complex problems of economic security of any subject of management and its institutionalization (the historical process of transition from the phenomenon, which is self-governing and self-organized to managed and organized). For example, international institutions are governed by global economic security and generate international economic law, which is an important means of supporting it, while state institutions control national economic security and are the main retransmitters of the norms and laws that provide it (Skorupskaite and Junevicius, 2017; Volkov and Melnikiene, 2017; Vidickiene, 2017; Wójcik and Wąsowicz, 2017).

New challenges are increasingly stimulating scientific thinking to search for answers in the field of economic security. Using the method of historical and logical unity makes it possible to establish the essence of the concept of "economic security of the territory," but first it is necessary to understand how and when the term "economic security" appears and how it complicates economic relations and acquires an economic color (VoLodzkienė, 2018; Laurinavičius, 2018; Boltochko, 2018; Jablonskis et al., 2018).

The integrity and sustainability of the state historically depends not only on the effective functioning of the triad of its main systems: Political, military and economic, but also from the security system, which unites international, regional, public and state institutions (organizations, structures, authorities) and economic entities, which protect the state from the negative influence of internal and external threats on the basis of the development of norms and laws to ensure the vital interests of citizens, as well as exclusion of the possibility of causing damage to the economy. Metaphorically, the security of the state can be compared with the immune system of the body. So, human health depends not only on the coordinated operation of the systems, but also on the immune system, which unites organs and cells that are able to perform protective functions on the basis of constantly acting and "emergency" mechanisms for cleansing the body. In connection with this, the need to determine the principles of economic security of the territory in the implementation of development programs is developing. In particular, we can talk about various branches of security, in particular the energy sector and energy security.

2. LITERATURE REVIEW

The influence of political, economic, ecological and spiritual crises, the lack of resources and ideas, and the arbitrary nature of aggressive processes necessitate a revision of existing approaches to the issue of ensuring economic security of the country (Hameiri and Jones, 2015; Kupatadze and Kizilöz, 2016). Since the regions are the locomotives of the economy of any state, of course they feel this influence (Kosai and Unesaki, 2016). Therefore, the cornerstone of the question is the development of the theoretical and methodological foundations of the synergetic management of economic security in particular of regions or other forms of territories in general (Bialasiewicz et al., 2005).

There are several reasons, which, in fact, concern not so much the general understanding of the economic security of the territory, but it just as a control object, which makes it possible to assume that such specificity exists (Levy, 2009; Chechel and Konoplyov, 2013). In particular, such reasons include, firstly, the need to clarify the understanding of the territory as an object of management, and, secondly, as an object which, striving to achieve a certain level of economic security, requires the choice of methodological foundations and a special toolkit for managing such security (Bonin, 2014).

Therefore, before examining the economic security of the territory as a managed system, it is necessary to study its subject field, that is, territories in terms of a systematic approach (Kononov and Kononov, 2016).

Ludwig Bertalanffi developed the general theory of systems, which determined the system as a set of elements that are in a certain relationship with each other and with the medium (King and Gulledge, 2014). There are many definitions of the system, among which by definition of the ISO 9000:2000 system is a set of interconnected and interacting elements (Mohapatra, 2017). Studying the general theory of the organization, they synthesize many concepts in the general conceptual construct and postulate: The system is an object that solves actual contradictions in the given conditions of the environment due to the functional orientation of its dynamics and structure, formed by organizational processes (Wohlstetter, 1977).

According to the terms of the general theory of systems (systemology), any territory is a system in which the set of inputs into production resources - labor costs (labor items, labor means, labor fources) are transformed into finished products and services (Feng, 2016; Karazijienė and Jurgelevicius, 2017). And the territory also operates within a large system - the foreign policy, economic, social and technical environment with which it constantly has complex relationship (Russett, 1979).

In cybernetics the territory can be represented as the intersection of two higher-level systems: The supersystem "society" and the supersystem "resources" (Ivanov, 2016).

According to the terms of cybernetics, the founder, the sociotechnical system consists of two subsystems: Managed and managing (Treu, 2018). A managed system or managed object is determinant, since it is a set of elements for which control relationships arise (Lappalainen, 2007). That is, the managed system of territory includes elements that provide the process of creating material and spiritual goods or services (Penny, 2007). The management system or control object is a set of elements that purposefully affect the managed system (Özpek, 2013). That is, the management system of the territory relates to its organizational management structure (Fischhendler and Katz, 2013).

Economic security of the territory as a managed system inherited almost all the properties of the system, as well as its inherent systemic principles: Openness, nonlinearity, dynamism, dissipativeness, emergence, homeostaticity, attraction, bifurcation, fractality (Matůš, 2015). In it, processes of self-organization and self-deorganization with such characteristics (according to the scientific content of the synergetics), described by G. Hacken, namely (Froestad and Shearing, 2017), can take place:

1. Intensive exchange of energy, information or other resources of the system with the environment, and it is completely chaotic
2. The behavior of the system is characterized by spontaneity and is described by several values - parameters of order and control parameters (information overload of the system disappears)
3. The presence of a critical value of the control parameter (associated with the arrival of energy, information, knowledge

or other resources), in which the system is able to lose the state of stable equilibrium (homeostasis); the quantitative accumulation of certain deformations of vital parameters leads to qualitative changes

4. The new state is due to the harmonious (coherent) behavior of the elements of the system
5. A new state exists only with a continuous nonstop flow of energy, information, knowledge or other resources (in the presence of internal and external sources of oscillations (fluctuations) of the system). The increase in the intensity of the exchange leads to the critical transitions of the system, resulting in its structure becoming complicated up to the occurrence of turbulent chaos (Akhmetshin et al., 2018a; Akhmetshin et al., 2018b).

3. MATERIALS AND METHODS

A significant overlapping of scientific works forms the fundamental basis for understanding the economic security of the territory as a controlled system (Kazantsev, 2012; Sakulyeva and Kseniia, 2019). But often it is considered unsystematically, which determines the relevance of its research from the standpoint of a systematic approach, namely, an in-depth study of its structure, functions, processes, and goals with the help of iterative analysis.

The article uses methods of comparative statistical analysis, which determines the possibility of analyzing the energy structure of states and individual territories. In the framework of the analysis, the statistical method is used for obtaining unprocessed statistics, as well as making up coefficients derived from the actual values that determine the levels of achievement of the criteria. The criterion evaluation method is used primarily to form a scale that assesses the sufficiency of the applied efforts and forms the general structure of understanding how the progress in achieving socio-economic parameters is determined (Prodanova et al., 2017; Asan et al., 2016).

It should be noted separately that the method of mathematical modeling used to make up a model for forecasting the sustainable development of territories is applied in a local format, since the model does not take into account the context of globalization (Vorobyov et al., 2018; Rudneva et al., 2016).

4. RESULTS AND DISCUSSION

On the basis of the analysis of the current state and trends of alternative energy development, the criteria were defined for assessing the interaction of the market environment indicators, state regulation of investment and innovation activities, which will reflect the complete set of interdependencies for assessing the development of renewable energy in the countries (Voronkova et al., 2019; Mažylis and Pikšrytė, 2013; Portella et al., 2017).

For further research and calculations, a sample of 18 countries has been formed that represent and as a whole characterize most regions of the world, including the USA and Canada, China, India and Brazil, the most developed countries of Europe - France, Norway, Italy, Spain, Germany, Great Britain, countries Eastern Europe - Hungary, Poland, Czech Republic, Slovenia and Slovakia, as well as the Baltic countries - Lithuania and Latvia.

The sample obtained represents 32% of world GDP and 21% of the world population; therefore it is sufficiently indicative of the quantitative and qualitative composition in the context of the analysis of the development of renewable energy. It has been decided to collect data for the last 10 years, that is, for 2008-2017.

As a result of the statistical data collection, 14 tables with initial values of indicators for the further analysis and calculation of the integral indicator of the effectiveness of the alternative energy development have been formed.

Data for the analysis of state support are based on the quantitative assessment of incentives for the development of alternative energy in the state through the following factors:

- Special “green” tariff
- Investment or tax privileges
- Reduction of income taxes, energy taxes, VAT, etc.
- Subsidies for electricity producers
- Public investment, loans, grants, capital subsidies.

If a country uses one of the given incentives, we assign it a value of 1, if it does not use - 0. In the end, the corresponding parameter will be from 0 to 5, where zero will characterize the lack of state support, and five - maximum state support.

The expert estimation method has assigned weight coefficients to the lower-level parameters in such a way that, within each of the criteria, the sum of the coefficients equals one (Table 1).

By analogy, we define the corresponding values for the second level indicators. We determine that the estimation of the market environment will have a coefficient of 0.45, that is, the most will affect the value of the final integral indicator, the state regulation - 0.3 and the investment and innovation environment - 0.25.

According to the results of the calculations we have the dynamics of the integral values of the market environment criteria, state regulation of the investment and innovation environment of renewable energy sources (Table 2).

We see that according to the integral estimation of the market environment (Figure 1) Norway has the best characteristics, and the corresponding dynamics is maintained throughout the analyzed period, the values fluctuate within the range of 0.45-0.47. The overall dynamics of development is indicative, as the positive dynamics for the period 2008-2017 is observed in relation to absolutely all the countries being analyzed, which indicates the global tendencies of growth of qualitative market characteristics of the renewable energy sources development (Strielkowski and Lisin, 2016). The leaders are also Spain, Germany, Italy, Latvia, Brazil and the United Kingdom. As it could have been predicted, the Czech Republic, Slovakia and Slovenia have the worst performance, ranging from 0.007 to 0.025, which is more than 15 times less than in Norway. It should be noted that in the

Table 1: Figures of weight coefficients of parameters

	Efficiency index for RES development												
	Market environment			State regulation						Investment and innovation environment			
	0.45			0.3						0.25			
Efficiency index for RES development	Production of electricity from RES, excluding hydropower, % from total	Consumption of energy produced from RES, % from total final energy consumption	Employment in the field, thsd. of people	State support	Income tax, % of commercial income	The time required to connect to the power grid, days	Procedures required to start a business, units	The time necessary to register the property, days	Corruption percept on index	Avoidance of CO_2 emissions as a result of substitution of traditional types of energy with RES, mln tons of CO_2	Patents number in the industry of RES, units	Average interest rate on loans, %	Rating of the business leading easiness
0.25	0.4	0.2	0.15	0.1	0.1	0.2	0.2	0.2	0.2	0.15	0.3	0.25	0.3

period from 2008 to 2014, the Czech Republic had the lowest rating, but starting from 2015, the integrated assessment of the market environment outstripped the respective values of Slovakia and Slovenia.

Figure 1 shows that Canada has the best integrated assessment of government regulation, showing a value >0.8 within the entire analyzed period. Leaders are also Norway, Great Britain, Germany, the USA and Lithuania. The dynamics of Poland and Slovakia are interesting as they showed the greatest increase of the corresponding estimate for 2008-2017, as well as Slovenia, although it is characterized by the lowest values within the range of 0.28-0.48, also had a significant growth, coming up close to 0.5 in 2017 (Figure 2).

According to the calculation of the integral indicator which characterizes the investment and innovation activity in the country (Figure 3), we have two obvious leaders - the USA and China, with the United States characterized by rather stable dynamics at the level of values of 0.68-0.77, while for the analyzed 10 years, the PRC has significantly improved its position by increasing the volume of patents in the field of RES, as well as by reducing the amount of CO_2 emissions into the atmosphere. Among the lowest values, we have indicators of such countries as Brazil, Czech Republic, India, Slovakia and Slovenia. Most of the sample is in the middle range, characterizing the investment and innovation environment of the integral estimate from 0.4 to 0.6.

On the basis of the integral estimation of the three relevant components of the economic development of the industry, one integral index of the effectiveness of the economic support for the development of alternative energy countries has been derived (Table 3)

So, according to the results of the integrated assessment of the economic support for the development of alternative energy (Figure 4), Norway is of paramount importance, while the lowest is the Czech Republic, Slovakia and Slovenia. Also, Canada, Germany and the USA have a high level of RES output. China has one of the fastest paces of renewable energy development, which at the beginning of the analyzed period had an integral estimate of 0.32 and increased it by almost 60% - up to the leaders of the sample (0.52). In general, we have a global positive dynamics in the period 2008-2017 in the field of alternative energy and stimulating its development through state regulation of the industry and improving the investment and innovation climate of the states as a whole, therefore, we can conclude that in the near future trends will be maintained. Particular attention should be paid to India and China, since, according to many forecasts, these two countries will show the highest growth rates of renewable energy use, as they have significant potential (Patriota et al., 2016).

Analysis of current global trends in low-carbon economy shows a positive trend in the use of renewable energy of all kinds: Growth in generation, consumption of electrical energy based on renewable energy, which is explained by countries' desire to improve energy efficiency and economy ecologization, use energy-efficient technologies, improve environmental safety

Table 2: Integral values of the economic support criteria for the development of alternative energy of the countries in 2008-2017

Country	Category/Year	2008	2009	2010	2011	2012	2013	2014	2015	2016	2017
Czech Republik	Market environment	0.007	0.007	0.007	0.007	0.011	0.017	0.021	0.024	0.024	0.025
	State regulation	0.289	0.281	0.284	0.294	0.382	0.438	0.461	0.504	0.482	0.481
	Investment and innovation environment	0.197	0.17	0.201	0.193	0.167	0.206	0.25	0.263	0.302	0.322
USA	Market environment	0.084	0.096	0.104	0.117	0.132	0.145	0.154	0.161	0.168	0.173
	State regulation	0.754	0.76	0.748	0.748	0.754	0.75	0.753	0.758	0.753	0.756
	Investment and innovation environment	0.682	0.732	0.761	0.769	0.757	0.741	0.742	0.741	0.742	0.74
Canada	Market environment	0.181	0.19	0.196	0.198	0.204	0.215	0.226	0.245	0.247	0.248
	State regulation	0.816	0.818	0.847	0.843	0.855	0.848	0.847	0.857	0.854	0.854
	Investment and innovation environment	0.581	0.595	0.595	0.596	0.581	0.571	0.567	0.575	0.58	0.563
China	Market environment	0.1	0.111	0.12	0.131	0.147	0.174	0.196	0.219	0.236	0.259
	State regulation	0.458	0.46	0.475	0.478	0.499	0.61	0.627	0.629	0.666	0.669
	Investment and innovation environment	0.559	0.617	0.669	0.728	0.75	0.745	0.756	0.781	0.804	0.817
India	Market environment	0.192	0.19	0.188	0.194	0.201	0.204	0.204	0.209	0.21	0.211
	State regulation	0.499	0.504	0.517	0.514	0.528	0.55	0.55	0.577	0.607	0.627
	Investment and innovation environment	0.267	0.268	0.266	0.258	0.264	0.264	0.261	0.247	0.274	0.274
Brazil	Market environment	0.258	0.274	0.286	0.283	0.287	0.296	0.318	0.333	0.331	0.331
	State regulation	0.458	0.496	0.509	0.513	0.525	0.578	0.59	0.574	0.574	0.565
	Investment and innovation environment	0.134	0.146	0.162	0.151	0.182	0.213	0.218	0.155	0.124	0.135
France	Market environment	0.071	0.082	0.09	0.099	0.115	0.123	0.131	0.146	0.15	0.153
	State regulation	0.707	0.707	0.745	0.751	0.755	0.755	0.76	0.77	0.766	0.769
	Investment and innovation environment	0.48	0.485	0.49	0.496	0.489	0.481	0.475	0.495	0.505	0.502
Norway	Market environment	0.458	0.45	0.448	0.452	0.461	0.466	0.464	0.466	0.467	0.47
	State regulation	0.766	0.786	0.786	0.798	0.783	0.786	0.801	0.808	0.799	0.801
	Investment and innovation environment	0.52	0.534	0.533	0.536	0.542	0.54	0.535	0.541	0.535	0.541
Italy	Market environment	0.112	0.142	0.167	0.218	0.29	0.344	0.369	0.381	0.387	0.391
	State regulation	0.653	0.63	0.619	0.619	0.628	0.643	0.658	0.661	0.673	0.712
	Investment and innovation environment	0.43	0.419	0.397	0.391	0.373	0.402	0.42	0.443	0.469	0.461
Spain	Market environment	0.216	0.276	0.314	0.329	0.374	0.428	0.422	0.406	0.409	0.412
	State regulation	0.618	0.608	0.608	0.634	0.629	0.6	0.66	0.683	0.694	0.693
	Investment and innovation environment	0.459	0.442	0.426	0.44	0.444	0.442	0.426	0.468	0.469	0.474
Germany	Market environment	0.188	0.214	0.229	0.291	0.325	0.341	0.382	0.446	0.451	0.459
	State regulation	0.756	0.776	0.756	0.763	0.76	0.753	0.756	0.762	0.762	0.762
	Investment and innovation environment	0.541	0.539	0.537	0.544	0.542	0.532	0.533	0.55	0.549	0.547
Great Britain	Market environment	0.059	0.075	0.084	0.117	0.146	0.2	0.257	0.333	0.336	0.343
	State regulation	0.744	0.757	0.753	0.758	0.751	0.784	0.791	0.83	0.831	0.834
	Investment and innovation environment	0.537	0.556	0.562	0.563	0.556	0.554	0.551	0.554	0.559	0.557
Slovenia	Market environment	0.019	0.02	0.019	0.019	0.02	0.022	0.021	0.021	0.021	0.021
	State regulation	0.313	0.325	0.324	0.333	0.334	0.515	0.54	0.56	0.63	0.633
	Investment and innovation environment	0.296	0.28	0.301	0.295	0.3	0.315	0.312	0.394	0.426	0.448
Slovakia	Market environment	0.014	0.017	0.018	0.02	0.02	0.02	0.019	0.02	0.021	0.021
	State regulation	0.471	0.515	0.521	0.523	0.554	0.624	0.63	0.646	0.675	0.686
	Investment and innovation environment	0.296	0.331	0.397	0.356	0.325	0.349	0.341	0.356	0.4	0.437
Poland	Market environment	0.057	0.076	0.09	0.114	0.15	0.149	0.179	0.201	0.204	0.206
	State regulation	0.355	0.422	0.48	0.486	0.597	0.658	0.662	0.683	0.689	0.683
	Investment and innovation environment	0.37	0.371	0.382	0.388	0.403	0.423	0.445	0.477	0.491	0.494
Hungary	Market environment	0.084	0.117	0.137	0.133	0.14	0.162	0.172	0.172	0.177	0.178
	State regulation	0.549	0.549	0.53	0.529	0.544	0.541	0.541	0.532	0.516	0.507
	Investment and innovation environment	0.42	0.424	0.428	0.427	0.413	0.42	0.429	0.436	0.465	0.469
Lithuania	Market environment	0.084	0.117	0.137	0.133	0.14	0.162	0.172	0.172	0.177	0.178
	State regulation	0.632	0.643	0.659	0.657	0.66	0.683	0.709	0.757	0.764	0.764
	Investment and innovation environment	0.452	0.448	0.457	0.451	0.432	0.413	0.413	0.442	0.454	0.451
Latvia	Market environment	0.164	0.179	0.161	0.188	0.25	0.293	0.368	0.374	0.373	0.374
	State regulation	0.585	0.576	0.574	0.65	0.672	0.683	0.689	0.691	0.694	0.697
	Investment and innovation environment	0.475	0.386	0.404	0.376	0.412	0.382	0.415	0.424	0.427	0.453

and reduce harmful emissions into atmosphere to prevent global environmental and climate change (Villa et al., 2017; Intima, 2017; Ponçano, 2017; Ponçano and Silva, 2017; Marder et al., 2017; Ramirez and Wolff, 2017; Moura et al., 2018; Nosova et al., 2018; Satelles et al., 2018; Salvo et al., 2018). In the context of low-carbon measures, the development of national strategies for the development of renewable energy in the short and long-term perspectives, the formation of an action plan to increase the share of renewable sources in the total structure of energy production and final consumption are observed (Malysheva et al., 2016). The success of the global decarbonization policy in the coming years will largely depend on the behavior of the twenty most influential countries in the world (G-20). And this is at the same time the countries that carry the greatest carbon emissions into the atmosphere and produce the largest GDP. The weak point in such a policy today is the awareness of the responsibility and coherence

Figure 1: Integral figures of the market environment criteria

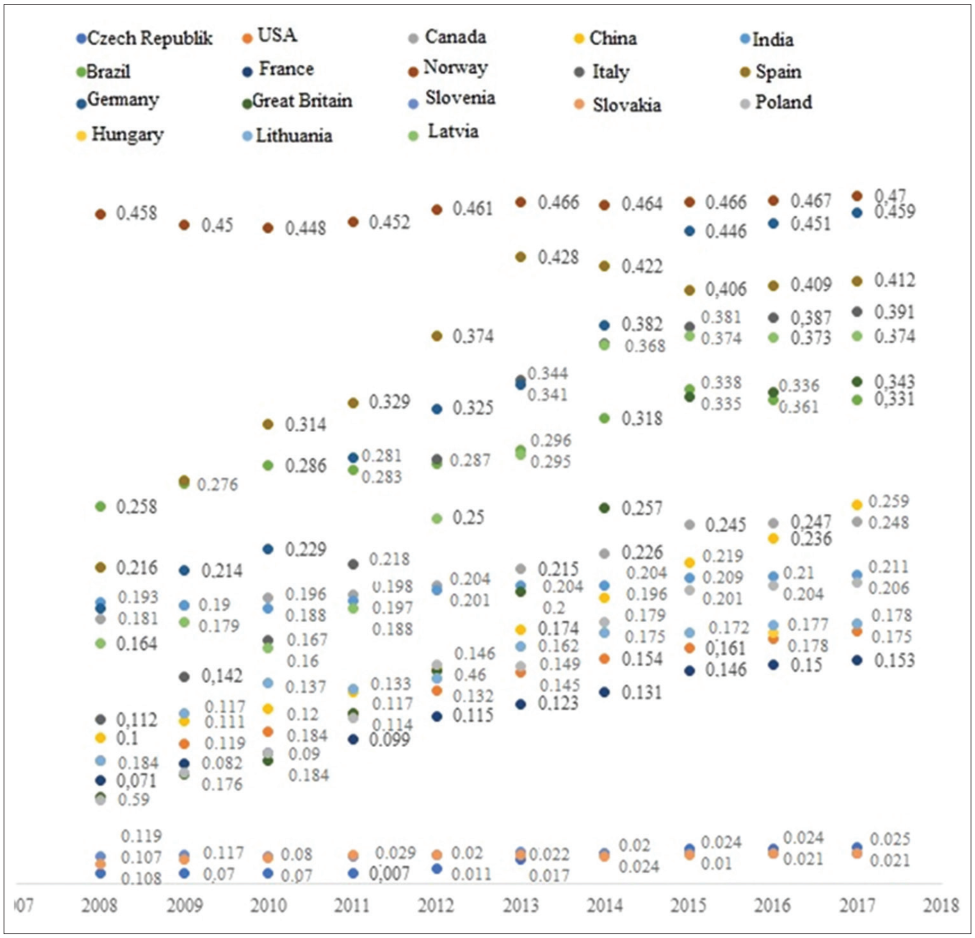


Figure 2: Integral figures of the state regulation criteria

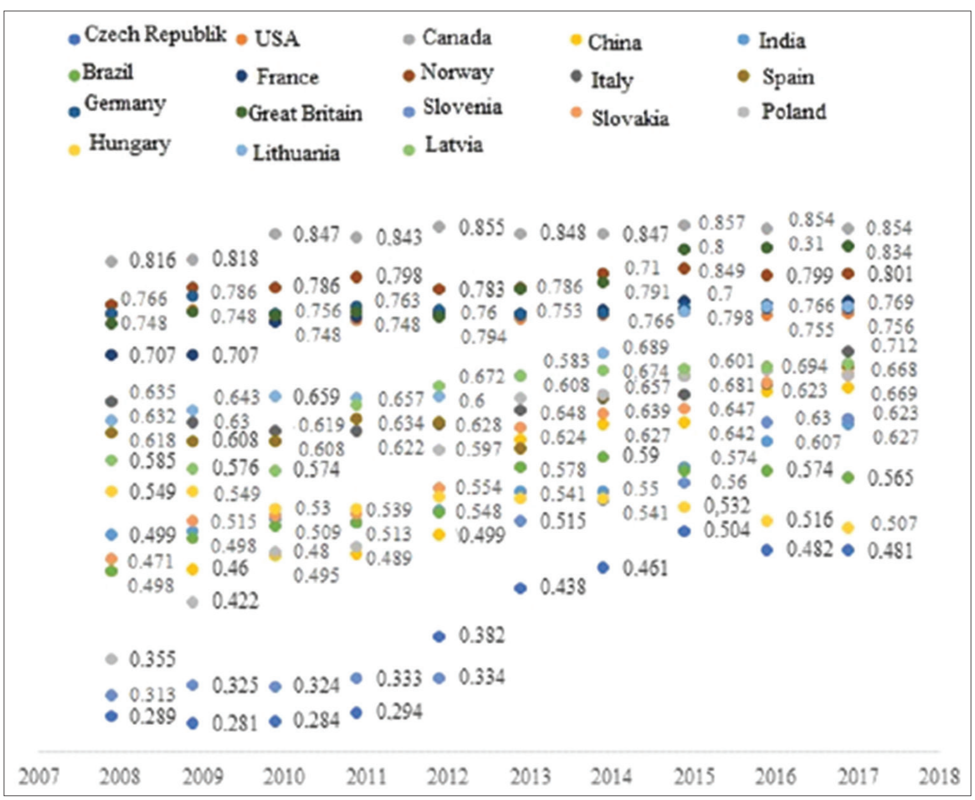
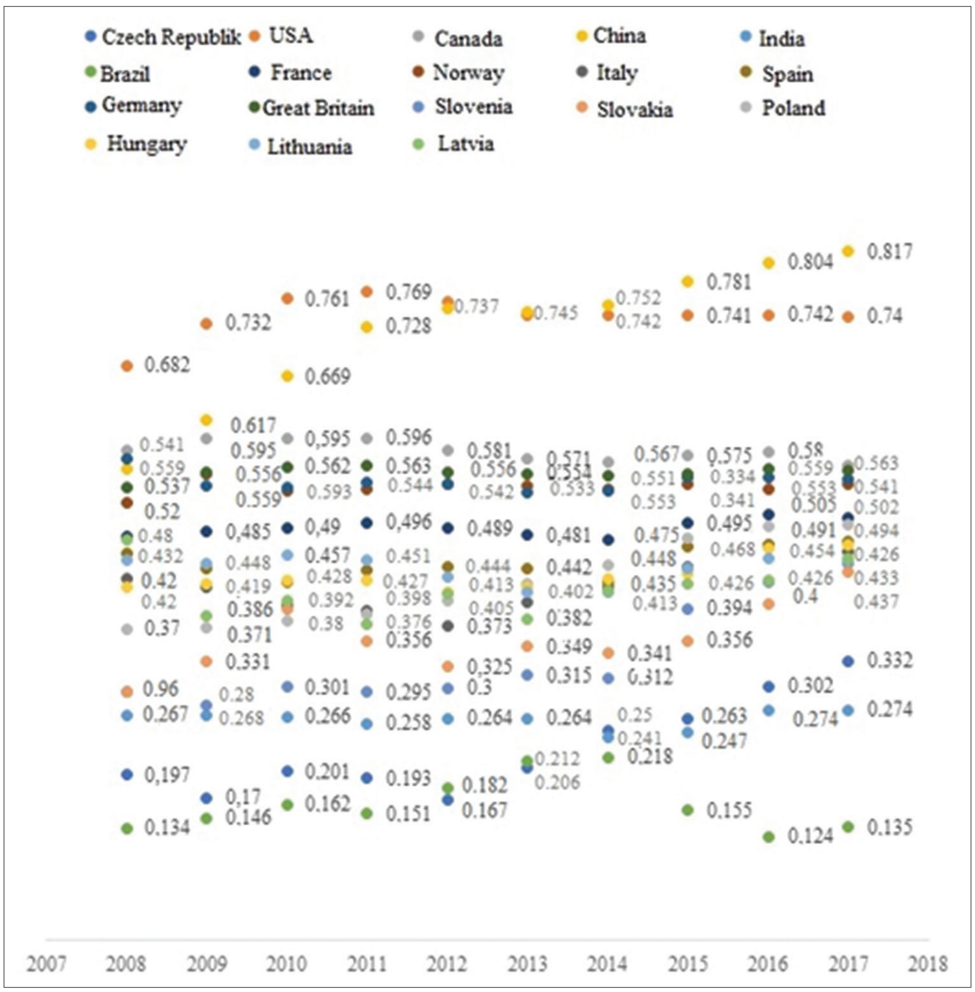


Table 3: Value of the economic support index for alternative energy development in selected countries

Country/Year	2008	2009	2010	2011	2012	2013	2014	2015	2016	2017
Czech Republic	0.139	0.13	0.139	0.139	0.161	0.191	0.21	0.228	0.231	0.236
USA	0.434	0.454	0.462	0.47	0.475	0.475	0.481	0.485	0.487	0.49
Canada	0.472	0.48	0.491	0.491	0.493	0.494	0.498	0.511	0.512	0.509
China	0.322	0.342	0.364	0.384	0.404	0.448	0.465	0.483	0.507	0.521
India	0.303	0.304	0.306	0.306	0.315	0.323	0.322	0.329	0.345	0.352
Brazil	0.287	0.308	0.322	0.319	0.332	0.36	0.374	0.361	0.352	0.352
France	0.364	0.37	0.387	0.394	0.401	0.402	0.406	0.42	0.424	0.425
Norway	0.566	0.572	0.571	0.577	0.578	0.581	0.583	0.587	0.583	0.587
Italy	0.354	0.358	0.36	0.382	0.412	0.448	0.468	0.48	0.493	0.505
Spain	0.397	0.417	0.43	0.448	0.468	0.483	0.494	0.505	0.509	0.512
Germany	0.447	0.464	0.464	0.496	0.51	0.512	0.532	0.566	0.569	0.572
Great Britain	0.384	0.4	0.404	0.421	0.43	0.464	0.491	0.537	0.54	0.544
Slovakia	0.177	0.177	0.181	0.182	0.184	0.243	0.249	0.276	0.305	0.312
Slovenia	0.222	0.244	0.264	0.255	0.257	0.284	0.283	0.292	0.312	0.325
Poland	0.224	0.254	0.28	0.294	0.347	0.371	0.39	0.415	0.421	0.421
Hungary	0.307	0.323	0.328	0.325	0.33	0.34	0.347	0.346	0.35	0.35
Lithuania	0.34	0.357	0.373	0.37	0.369	0.381	0.393	0.415	0.422	0.422
Latvia	0.368	0.35	0.345	0.374	0.417	0.432	0.476	0.481	0.483	0.491

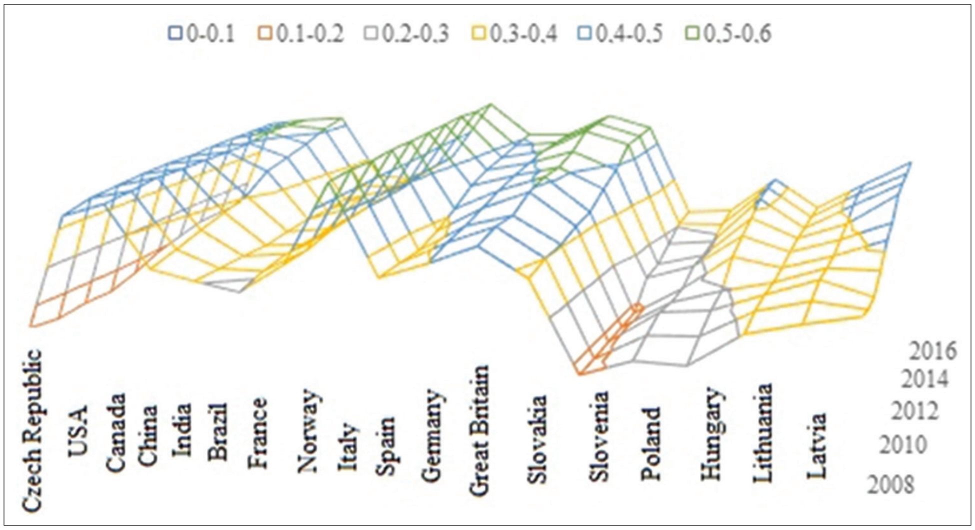
Figure 3: Integral figures of the investment and innovation criteria



of the actions of the United States, China and the countries of the European Union.

The study of economic support for the development of alternative energy as part of the energy security of the territory makes it possible to single out the following points: Over the past few years the dynamics of generation and consumption of energy from renewable sources have been steadily growing, the share of alternative energy sources has been increasing, among which water energy dominates and the proportion of solar energy has also been rapidly increasing. At the highest state level, an action plan is being developed to improve the energy efficiency of the economy,

Figure 4: Value of the economic support effectiveness index for the development of RES in 2008-2017



in particular, strategies for the development of renewable energy have been developed, and a bilateral dialogue is underway with international agencies on the development of alternative energy, in particular the International Renewable Energy Agency. Also, one of the highest "green" tariffs is currently in force, which remains a powerful incentive for the development of domestic renewable energy, but at the same time there is an imperfection of the legislative base regarding some aspects of its use, in particular, by households.

Evaluation of the effectiveness of the alternative energy development based on the calculation of the integral index has showed that the world leaders in the industry are Norway, USA, Canada, Germany and China, and the Czech Republic with the characteristics of the market environment, government regulation of the investment and innovation environment ranks last, even behind Slovakia and Slovenia. At the same time, China has one of the fastest rates of building renewable energy potential.

In conditions of increasing turbulence of the external environment, it is important to predict the state of stable equilibrium of the territory. Predicting the dynamics of events and ownership of the development scenario makes it possible to effectively manage the economic security of a territory, which requires the development of an adequate mathematical model that would be based on fundamental laws and a priori knowledge of the processes of the system, taking into account causality of influence factors.

In 2004, for the first time, a synergetic model of the stability of an average firm was offered, in which the important role of the control parameters that they play while choosing the path to one or another steady state was revealed. We adapted the model to the financial reporting of the territory, developed an information base for calculating the model and tested it on the example of an average city in the EU, which is an industry average in terms of staff and capital. The most important thing for the synergetic management of economic security is the understanding of which control parameters influence the state of stable equilibrium of a territory.

Synergetic modeling of economic processes and phenomena is based on two main points:

1. The choice of order parameters, that is, macroscopic variables, quantitatively characterizing the main connections in the system and control parameters, that is, external conditions in which the system cannot change, and therefore, has to adjust to them
2. Making up the main proportions, which states that the rate of change of the order parameters with the influence of time is proportional to their growth minus their loss. The ratio of proportions is formed on the basis of experience.

Mathematical modeling of the territory sustainability provides the ability to predict the state of stable equilibrium, which allows us to develop appropriate measures to manage the economic security of the territory. The sustainability of the industrial activity of a territory is determined by such parameters as: The number of highly organized personnel, the availability of equity capital and the volume of investments (credit). That is, in this case, the concept of sustainability of a territory is essentially equivalent to the concept of sustainability of a company, since with sustainable development of a territory; there is a consolidation of social and economic policies and a process of structuring the economy of a territory as a corporate structure. The mathematical model of the stability of the territory is presented in the form of a system of three differential equations (Eq. 1):

$$\begin{cases} \dot{Y}_1 = -\gamma Y_1 + \alpha Y_2 + \alpha Y_2 Y_3 \equiv f_1(Y_1, Y_2, Y_3) \\ \dot{Y}_2 = \mu Y_2 - \beta Y_1 + \mu Y_3 - \beta Y_1 Y_3 \equiv f_2(Y_1, Y_2, Y_3), \\ \dot{Y}_3 = -\omega Y_3 + \delta Y_2 \equiv (Y_1, Y_2, Y_3) \end{cases} \quad (1)$$

Where $Y_1 = Y_1(t)$ - the number of employees at the time, people

$Y_2 = Y_2(t)$ - the amount of personal capital at the time t, rub

$Y_3 = Y_3(t)$ - the amount of borrowed capital, i.e. the loan at the time, rub

$\dot{Y}_1, \dot{Y}_2, \dot{Y}_3$ - derivatives with respect to the independent variable t.

The values of the coefficients are as follows:
α is the proportionality coefficient, showing how much of its capital a territory can allocate to attract new employees. Namely, promotional costs (including the internet), informing about the prospects for expanding the scope of activity of the territory, about the well-organized work of employees, about the cohesion of the team, as well as the respectability of external and internal design offices. In short, these are the costs to form a reputation on the labor market. However, from a mathematical point of view, this coefficient does not greatly influence the type of sustainability of the system: It is important that it is not close to zero.

γ - proportionality coefficient, which summarizes the various reasons as a result of which an employee may be dismissed or he/she quits himself/herself. Employees' turnover threatens to lose accumulated experience, skills, and competencies, which in turn affects the increase in the cost of finding, selecting and training new employees with lower productivity.

μ - proportionality coefficient, which shows the effectiveness of capital investments in the territory (taking into account the influence of various taxes, payments, fees - they carry a dissipative effect on the "energy" of the territory and threaten with a decrease in profitability).

β is the proportionality coefficient characterizing the amount of territory expenses per employee. This includes the costs of wages, deductions for social events and the cost of the territory for the maintenance of labor; except for those included in the wage fund (these include expenses of the territory for social security of workers, their cultural and everyday services, for their housing, on vocational training and other labor costs).

δ - proportionality coefficient, which affects the availability of equity capital. Its sufficient share testifies to a high level of financial health of the territory, solvency in the long term. If the share of own capital is low, then the company faces bankruptcy.

ω - proportionality ratio indicating the difficulty to obtain a loan. For example, a high interest loan increases the risk of non-repayment, which threatens with bankruptcy.

For an average firm, the coefficients α and β should be relatively large, since both relate to expenses for employees, and the coefficient μ and γ, on the contrary, should not be large because, firstly (in the case of μ), the profit from operations on the market is not too high, otherwise the company would be big, not medium; and secondly (in the case of γ), in a civilized society in the territory, the employee turnover rate is low.

In the model Y_1, Y_2, Y_3, variable factors or in the synergetics thesaurus they are called order parameters; $\alpha, \gamma, \mu, \beta, \delta, \omega$ are constant factors (proportionality coefficients) or control parameters.

We clarified the model of sustainability of the territory as a social structure. The second and third components of the right side of the first equation of the mathematical model (1) indicate that the increase in new employees is proportional to the availability of equity capital and the use of credit for its intended purpose (capital meeting $-\alpha Y_2, Y_3$) (people prefer working in a large company, which, in turn, more invests in the formation of its attractive image), and the first member indicates a reduction in the number of employees in the enterprise, mainly due to the lack of funding and due to other, less important reasons.

The members of the right-hand side of the second equation of the mathematical model (2) indicate that the rate of growth of equity is determined in proportion to its value, which is obtained by investing the amount of capital and credit (terms) minus the costs associated with salaries and loan maintenance (summands $\mu Y_2 u \mu Y_3$). The coefficients μ and β of the equation reflect the share of the use of equity and credit for the salary of employees and credit resources.

The third equation of system (2) reflects the fact that the rate of $\dot{Y}_3$ turnover of the credit volume (the possibility of additional lending) is positively affected by the availability of equity capital (the larger the capital of the territory is, the more willingly they are given a loan) and in a negative way - already existing credit obligations (δY_2).

We have also proposed "soft modeling" or a technique for qualitative analysis of a mathematical model (1) first, stationary relation is found, and equating the derivatives to zero, namely, a nonlinear system of algebraic equations (Eq. 2) is considered:

$$\begin{cases} -\gamma Y_1 + \alpha Y_2 + \alpha Y_2 Y_3 = 0 \\ \mu Y_2 + \mu Y_3 - \beta Y_1 - \beta Y_1 Y_3 = 0, \\ \delta Y_2 - \omega Y_3 = 0 \end{cases} \tag{2}$$

From the third equation it follows: $Y_2 = \frac{\omega}{\delta} Y_3$, while from the first - $Y_1 = \frac{1}{\gamma}\left(\frac{\alpha\omega}{\delta} Y_3 + \frac{\alpha\omega}{\delta} Y_3^2\right)$

By substituting these expressions into the second equation of an algebraic system, we get (Eq. 3):

$$Y_3\left[Y_3^2 + 2Y_3 + \left(1 - \frac{\mu\gamma}{\beta\alpha} - \frac{\mu\gamma\delta}{\beta\alpha\omega}\right)\right] = 0 \tag{3}$$

after obvious transformations. So, the first radical is $Y_3^{(1)} = 0$ and we have a trivial singular point (0, 0, 0). Two other radicals are written as follows (Eq. 4):

$$Y_3^{(2,3)} = -1 \pm \sqrt{\frac{\mu\gamma}{\beta\alpha} + \frac{\mu\gamma\delta}{\beta\alpha\omega}} \tag{4}$$

Since the desired stationary outcomes must be in the first quadrant, the relations between the coefficients of the mathematical model (2) are easily established, namely:

$$\mu\gamma > \beta\alpha \tag{5}$$

At the same moment the numerical parameters ω and δ acquire arbitrary positive values, following the economic content:

$$\frac{\mu\gamma}{\beta\alpha}\frac{\omega}{\omega+\delta}>1 \tag{6}$$

Equities (5 and 6) are derived from the requirement that one of the radicals $Y_s^{(2,3)}$ must be positive, that is not limited only with the trivial stationery solution. For this purpose the condition $\frac{\mu\gamma}{\beta\alpha}\left(1+\frac{\delta}{\omega}\right)>1$ must be met, the realization of which can be in two ways.

The stability of stationary solutions is estimated knowing the radicals of the characteristic equation (Eq. 7).

$$\begin{bmatrix} \left(\frac{\partial f_1(*)}{\partial Y_1}-\lambda\right) & \frac{\partial f_1(*)}{\partial Y_2} & \frac{\partial f_1(*)}{\partial Y_3} \\ \frac{\partial f_2(*)}{\partial Y_1} & \left(\frac{\partial f_2(*)}{\partial Y_2}-\lambda\right) & \frac{\partial f_2(*)}{\partial Y_3} \\ \frac{\partial f_3(*)}{\partial Y_1} & \frac{\partial f_3(*)}{\partial Y_2} & \left(\frac{\partial f_3(*)}{\partial Y_3}-\lambda\right) \end{bmatrix}_{\substack{Y_1=Y_{1s}\\Y_2=Y_{2s}\\Y_3=Y_{3s}}} = 0 \tag{7}$$

Where (Eq. 8):

$$\lambda^3+\alpha_1\lambda^2+\alpha_2\lambda+\alpha_3=0 \tag{8}$$

Or (Eq. 9, 10, 11):

$$\alpha_1=-\left(\frac{\partial f_1(*)}{\partial Y_1}+\frac{\partial f_2(*)}{\partial Y_2}+\frac{\partial f_3(*)}{\partial Y_3}\right) \tag{9}$$

$$\alpha_2=\begin{vmatrix} \frac{\partial f_1(*)}{\partial Y_1} & \frac{\partial f_1(*)}{\partial Y_2} \\ \frac{\partial f_2(*)}{\partial Y_1} & \frac{\partial f_2(*)}{\partial Y_2} \end{vmatrix} + \begin{vmatrix} \frac{\partial f_1(*)}{\partial Y_1} & \frac{\partial f_1(*)}{\partial Y_3} \\ \frac{\partial f_3(*)}{\partial Y_1} & \frac{\partial f_3(*)}{\partial Y_3} \end{vmatrix} + \begin{vmatrix} \frac{\partial f_2(*)}{\partial Y_2} & \frac{\partial f_2(*)}{\partial Y_3} \\ \frac{\partial f_3(*)}{\partial Y_2} & \frac{\partial f_3(*)}{\partial Y_3} \end{vmatrix} \tag{10}$$

$$\alpha_3=-\begin{bmatrix} \frac{\partial f_1(*)}{\partial Y_1} & \frac{\partial f_1(*)}{\partial Y_2} & \frac{\partial f_1(*)}{\partial Y_3} \\ \frac{\partial f_2(*)}{\partial Y_1} & \frac{\partial f_2(*)}{\partial Y_2} & \frac{\partial f_2(*)}{\partial Y_3} \\ \frac{\partial f_3(*)}{\partial Y_1} & \frac{\partial f_3(*)}{\partial Y_2} & \frac{\partial f_3(*)}{\partial Y_3} \end{bmatrix} \tag{11}$$

Where equations $\frac{\partial\ (\ )}{\partial} i\ j,\ \ 1,2,3\ f\left(L\right)$ - correspondingly the right parts of the equation of the mathematical model (1), representing partial derivatives; designation |·| corresponds to the second order determinant in finding the coefficient α_2 and the third order determinant in the case of the coefficient α_3.

If $\lambda_1,\lambda_2,\lambda_3$ are the required radicals of the equation (6), then the following equation is satisfied (Eq. 12):

$$\alpha_1=-\left(\lambda_1+\lambda_2+\lambda_3\right);\alpha_2=\lambda_1\lambda_2+\lambda_2\lambda_3;\alpha_3=\lambda_1\lambda_2\lambda_3 \tag{12}$$

Specifically, in our case, the determinant (7) takes the form (Eq. 13):

$$\begin{bmatrix} (-\gamma-\lambda) & \alpha & \alpha Y_2 \\ -\beta-\beta Y_3 & \mu-\lambda & \mu-\beta Y_1 \\ 0 & \delta & -\omega-\lambda \end{bmatrix}=0 \tag{13}$$

This is calculated at the stationary point.

It should be noted that the radicals of the characteristic equation can be: Real (negative and positive), complex (with negative real parts and positive real parts), and also pure imaginary.

To study the nature of the equation radicals (6) and their signs, the discriminant of the equation is used (Eq. 14):

$$D_3=-4\left(\alpha_3-\frac{1}{3}\alpha_1^2\right)^3-27\left(\alpha_3-\frac{1}{3}\alpha_1\,\alpha_2+\frac{2}{27}\alpha_1^3\right)^2 \tag{14}$$

Hurwitz conditions $-\alpha_1>0,\alpha_3>0,\alpha_1\alpha_2-\alpha_3>0$; descartes' theorem: The number of positive rsdicals of an algebraic equation is equal or less by an even number of the number of sign changes in the sequence of coefficients $1,\alpha_1,\alpha_2,\alpha_3$.

The same theorem is applied to the number of negative radicals of the equation and changes in the signs of the sequence, that is, to the radicals of the equation (Eq. 15):

$$-\lambda^3+\alpha_1\lambda^2-\alpha_2\lambda+\alpha_3=0 \tag{15}$$

Specifically for the trivial singular point of the mathematical model (2), the determinant is written (Eq. 16):

$$\begin{bmatrix} (-\gamma+\lambda) & \lambda & 0 \\ -\beta & \mu-\lambda & \mu \\ 0 & \delta & -(\omega+\lambda) \end{bmatrix}=0 \tag{16}$$

And characteristic (Eq. 17):

$$\begin{gathered}\lambda^3+\left(\gamma-\mu+\omega\right)\lambda^2+\left(-\mu\gamma+\omega\gamma-\mu\omega-\delta\mu+\beta\alpha\right)\\ \lambda-\gamma\mu\omega-\delta\mu\gamma+\beta\alpha\omega=0.\end{gathered} \tag{17}$$

Based on the developed mathematical model of the control object behavior, it becomes possible to predict the state of stable equilibrium of the territory. There are several types of prediction that requires an understanding of the laws of development:

1. Inertial forecasting or extrapolation is that the process continues the trajectory that was before it began, that is, the future parameters of the system are determined on the basis of previous development trends

2. Scenario design is to determine the likelihood of possible alternatives for development or the desired state in the future turbulent macroenvironment. Scripts depend on the resources invested in the future
3. Design management is to predict the impact of decisions. It refers to the structuralist approach, in which there is no dynamic prehistory. The researcher does not have information about the inertia of the process, but knows the instantaneous “snapshot” of certain parameters affecting development. The scientific challenge lays in the fact that knowledge of the instantaneous distribution of the parameters of a complex socio-economic system and their connection in the future allows us to obtain a forecast time sweep of what will happen. In the future, this type of forecasting is applied. As noted above, nonlinear dynamics studies the properties of dynamic systems, which are systems that describe a process in time, namely, the transition from a state of stable equilibrium to unstable and vice versa.

The main tasks are: First, the search and classification of a particular equilibrium point, and secondly, the identification of sets that either attract (attractors) or repel (repellers).

5. CONCLUSION

For the qualitative analysis of the dynamic system, which is the territory, the phase space method is used. It is based on the geometry of time and allows you to visualize the behavior of the territory. A significant simplification of the description of the dynamic system state belongs to the advantages.

The phase system space is an abstract multidimensional space in which the change in the coordinates of a point (that is, its movement) forms curves (phase trajectories) over time, which vividly describes the evolution of a non-linear, “chaotic” system in a geometric form (phase portrait). The main characteristic of space is its dimension, i.e. the number of parameters that must be set to determine the state of the system.

A phase portrait is a collection of all phase paths describing all possible modes. On its basis, it is possible to determine the particular equilibrium point of the system as a guideline to which it will come with time.

A special point of the phase space is the equilibrium point at which the process is established and the order parameters do not change, therefore, the derivatives are equal to zero. At this point, different phase trajectories attract or repel (diverge) (solutions can branch out). In the first case, an attractor is formed, in the second, a repeller. The singular point of the phase space is a mathematical category, and within the framework of the economy it has been offere to call it a state of stable equilibrium.

In the economic context, the phase trajectories are the trajectories of the economic development of a business entity, or the trajectories of individual business processes (core and supportive) and interests of stakeholders. If all of them are in the area of attraction of the attractor, then there is no need to make quick management decisions to change the situation. On the contrary, if they are not within the domain of attractor’s attraction, then there is a need to make quick management decisions.

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