

KAIZEN TECHNOLOGIES IN NATURAL AND ECONOMIC SYSTEMS MANAGEMENT: APPROACHES TO ECONOMIC AND MATHEMATICAL MODELING

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Introduction. Intergovernmental fiscal relations reforms are the driving force for the local communities' transition to self-sufficiency and more rational planning of their resources, which in future financial periods will make territorial communities economically self-sufficient and financially capable. Decentralization of power relations in the state foregrounds the study the research of complex socio-economic systems, which operate based on collective decision-making and collective action. This requires the study of the preconditions for the effective management of public resources at the local level and the formation of the methodological framework to improve the territorial organization of the state through, first, the formation of self-sufficient territorial communities.

A comprehensive vision of the reforms required by the Ukrainian society is presented in the «Strategy for Sustainable Development of Ukraine-2020» approved by the Decree of the President of Ukraine [1]. Among the priorities of the Strategy are decentralization and reformation of national social and economic system, restructuring of business entities' territorial organization giving maximum geographical considerations. In accordance with the goals of Sustainable Development, adapted for Ukraine (during 2015 – 2030s) [2], the goal 11 concerning sustainable development of cities and communities is directly related to the process of decentralization. Nowadays the problem of strong united territorial communities (UTCs) formation in the context of administrative and territorial reform implementation based on the principles of decentralization becomes especially acute.

Analysis of recent researches and publications. Pavliuk Y.P., Oliynyk D.I., Batalov O.A., Dashko O.I., Murkovych L.L., Molodozhen Y.B. and other scholars studied current aspects of territorial communities' and local self-government's development problems solution [3-6]. Own findings concerning the problem are presented in [7-15].

The aim of research. The new administrative and territorial system should become the basis for constructing a new model of territorial administration, based on the principles of decentralization, subsidiarity, balance of national interests with regional and territorial communities' interests representation, local self-governance widespread, territorial communities' power and autonomy, coherence with natural geographical capacity. That is why the problem of UTCs resource management and their sustainable development conditions deserves special attention. Objective necessity and urgency of building territorial communities self-financing models as the basis of their dynamic development is determined by the fact of current territorial organization management and administrative-territorial structure reforms, which require the formation of new models for territorial communities development management on the principles of decentralization. That is why there is the need to find out new technologies of territorial communities'

resources management on the principles of territories self-financing.

The main material. According to the Law of Ukraine «On Local Self-Government in Ukraine» (statutory wording of 02.08.2017), «the territorial community is presented by residents permanently residing within a village, settlement, city, which is an autonomous administrative and territorial division, or a voluntary association of residents of several villages having a single administrative center» [16].

Management of interconnections between internal capabilities and external impact creates conditions for UTCs sustainable development. The main infrastructural components of UTCs sustainable development are economic, environmental and social.

System harmonization and the balance of these three components form enormously complex challenge. Its result is reflected in the «Methodology for the formation of communities capacity» [17]: a powerful territorial community is a territorial community of villages (settlements, cities), which, as a result of a voluntary association, can independently or through appropriate local self-government bodies provide an adequate level of service provision, in particular in the sphere of education, culture, health care, social protection, housing and utilities infrastructure, taking into account human resources, financial support and infrastructure development of the corresponding administrative division.

Thus, at first glance, one may consider that conditions for decentralization of power and territorial community's increased role and significance to ensure the effective functioning of territories and state as a whole at the legislative level have already been created. On the other hand, our studies revealed that there is the need to build a new model of territorial organization of power and administrative-territorial system, since, as we have proved earlier, there is a volatile three-level system of territorial management, therefore, territorial communities' management tools should be improved.

The new model of management should be based on the fact that the main link that ensures the effective functioning of the country's economic system is the territorial community, since it is impossible to provide economic development with only the regulatory influence from the top down. It is necessary to create conditions for the territorial communities dynamic develop. It is quite possible that higher than community levels in the three-level system of territorial management will have to ensure the coordination of the entire system functioning. To solve the problem of the whole country's dynamic development implementation it is necessary to form the conditions of communities' stability and efficiency.

In our opinion, to form the effective management system at the stage of territorial community organizing, it is advisable to use a well-known I closed economy model, that is, to model the parameters of the model functioning using only internal capabilities without interaction with the external environment. This model has limitations, as there are no closed economies, as well as territorial communities cannot be socially isolated. However the proposed assumption allows us to assess own, internal capabilities of a territorial community, along with its potential of self-financing and the break-even point. Thus, the autarky of a complex system, i.e. territorial community, enables the assessment of its internal factors and capacities to self-sufficient functioning by means of efficient utilization of own resources and allows to identify the system's possibility to reach dynamic equilibrium.

Evidently, the state of dynamic equilibrium is formed on the basis of the interaction of two opposite trends – the growth of production and consumption. The quantitative measurement of equilibrium is economic efficiency – Pareto-efficiency, which requires optimal resources distribution among market participants for production purposes. We assume the scarcity of resources, limited goods with their unlimited consumption.

Accordingly, we modeled the autarky system conditions, namely the lack of external resources provision (resources limited by the internal territorial community's capabilities) and the need to sustain territory residents (without any consumption restrictions) at current level of well-being.

In our opinion, to describe the case mathematically we may use the input-output model with certain limitations. Clearly, this model is used in economic planning at the regional and national level, if there is the need to determine the volume of output, which provides the residents' demand and production needs for these goods with a well-known technology. This problem with the assumption of linear technology (direct proportionality between the volume of output and the resources cost volume) is mathematically formalized in W. Leontief «Input-Output» model.

In the multi-sectoral model for the territorial community, we will assume that the elements of this complex system are the main factors of production, namely: land, labour, capital, entrepreneurial skills and information. National production is undertaken with the help of these factor inputs in a specific separate territory.

«Land» firstly refers to the land as the type of natural resources. «Labour» refers to active individuals

who live in the territory, characterized by permanent residence within the village, settlement, city borders, which are independent administrative-territorial units. «Capital» is a communal property and financial resources of a territorial community. These factors of production use are the basis of territorial community's economic functioning.

Undoubtedly, different nature-resource potential of territories cause the development of different areas of economic activity. This results in specialization of the regional production sphere, i.e. manufacturing, agriculture, services sector, etc. However the study objective is to model the case of self-financing disregarding the territory's specialization. This means the formation of a territorial community's management system, which sustains self-financing and the development by the available resources of indifferent specifics.

Effective management of a territorial community's inner potential provides assessment of the internal economic security level based on the autonomy and self-sufficiency. Of course, this approach is a certain assumption. A territorial community does not function as a «closed system», but the approach allows to measure the inner potential of its functioning and, consequently, to assess the possibilities of self-financing and the break-even point.

In this regard, the input-output model for the territorial community becomes:

$$x(t) = Ax(t) + y(t), \quad (1)$$

where $x(t)$ – gross product, produced inside the territorial community;

A – matrix of direct cost, which does not depend on the time period.

Formula (1), which takes into account investments, may be written as:

$$x(t) = Ax(t) + z(t) + \hat{y}(t), \quad (2)$$

So, final products made inside a territorial community includes net final products $\hat{y}(t)$ and production costs of fixed assets $z(t)$.

Let $\zeta(t)$ be the vector of the spheres of economic activity facilities presented in a territorial community at the point t (beginning of the year). If there is no fixed assets disposal, the investments are absent, the facilities in it are not changed, the construction of new facilities takes place immediately, then the expression of the fixed assets cost function becomes:

$$z(t) = B(\zeta(t) - \zeta(t-1)), \quad (3)$$

where B – specified matrix (matrix of capital-output ratio growth).

Matrix coefficient $B(b_{ij})$ indicates services (products) costs of the i -industry to increase facilities of the j -industry per unit.

If the services output equals the available facilities in the beginning of the year, that is $x(t) = \zeta(t)$, the correlation (1) is:

$$x(t) = Ax(t) + B(x(t) - x(t-1)) + \hat{y}(t). \quad (4)$$

With the fixed quantity $t - 1$, the balance illustrates the correlation between net final product $\hat{y}(t)$ and corresponding gross output $x(t)$. To assess the parameters of a territorial communities development in a dynamic perspective on the basis of net final product (services), we examine the dynamics of changes $\hat{y}(t)$, where $t = 1, \dots, T$.

Taking into consideration, that the modeling main objective is to find the terms of territorial communities' autonomy and self-sufficiency, we provide the following model limitations:

a) In relation to gross outputs of the territory's economic activities fields, related to the scarcity of fixed assets (there is need in certain quantity of fixed assets to satisfy needs of the limited number of consumers). The number of consumers is measured for different goods or services by the number of territorial community's households, or by the quantity of territorial housing:

$$x(t) \leq (\zeta(t)). \quad (5)$$

b) In relation to labour resources:

$$(d_2, x(t)) \leq L(t), \text{ where } t = 1, \dots, T. \quad (6)$$

Models (2), (3), (4) and (6) describe the main correlations of the dynamic «Input-Output» model, which unlike in the (1) is controlled, as it enables to trade-off the control actions. They include the volumes of gross outputs in different economic activities fields $x(t)$ and the fixed assets construction $\zeta(t+1) - \zeta(t)$ in the models (2), (3), (4) and (5).

Hence, it is possible to place limitations on control actions.

c) In relation to control actions:

$$x(t) \geq 0, \zeta(t+1) - \zeta(t) \geq 0, \text{ where } t = 1, \dots, T. \quad (7)$$

d) No trade outside a territorial community's boundaries (what is usually regarded as the external trade). This limitation is explained by the initial modeling condition to determine autonomy, i.e. goods and services are manufactured to satisfy needs of territorial community residents. As a result, there is a limitation on the net final product:

$$\hat{y}(t) \geq 0, \text{ where } t = 1, \dots, T. \quad (8)$$

e) A territorial community does not stockpile, so the vector $\hat{y}(t)$ describes final consumption of a territory's residents, which we denote as $w(t)$, so we may specify the limitation (8):

$$w(t) \geq \hat{w}(t), \text{ where } t = 1, \dots, T; \quad (9)$$

$\hat{w}(t)$ – specified time function, which describes the minimum acceptable consumption level (it is determined by physiological needs of a person to ensure normal functioning).

f) We considered models with the simplified idea of capital investment. Taking into account that capital investment is being utilized much longer than others, construction can continue for a long time. Therefore, it is advisable to introduce such a concept as facilities reserve, that is, the facilities, which construction is not completed (construction in progress).

Let in a territorial community (i-community) the volume of facilities reserve which construction was started in year t is $Q(t)$. Let new construction be rhythmical and takes τ^m_i years (construction lag). Then the amount of community's facilities is:

$$\zeta(t+1) = \zeta(t) + Q(t - \tau^m_i), t = 1, \dots, T; Q(t) \geq 0. \quad (10)$$

Now the formula (3) can be specified including the volume $b_{ij}(\tau)$, which illustrates the amount of resource expenditures in the i - area of economic activity used to form a unit of facilities in j area in τ -th year of construction, and written the following way:

$$z_i(t) = \sum_{j=0}^n \sum_{\tau=0}^{\tau_i^m} b_{ij}(\tau) Q_j(t - \tau), i = 1, \dots, n; t = 1, \dots, T. \quad (11)$$

The proposed model can be used to assess the impact, which the key studied parameters including limitations on relation to autarky of economic system have on the overall performance of a territorial community. Thus, this model allows to evaluate the territorial community's capacities considering self-financing and break-even point, that is, to achieve the Pareto-efficiency state.

To ensure the system's economic development, its sustainability has to be kept within certain limitations. The state of maximum sustainability of the dynamic equilibrium is the system's equilibrium state characterized by the maximum efficiency (Pareto-efficiency) [18].

The process of the economic system's efficiency accumulation has its limitations; it is finished with crisis. The dynamic equilibrium state between marginal maximum and minimum values is sustainable.

J. Schumpeter, founder of the economic development theory argued that if economic system moves to disequilibrium, it never comes back [19]. It moves to another stationary equilibrium state at the qualitatively new development level. The new ways of combining efficient methods of available resources application aimed to produce capital and non-capital goods represent the transition mechanism. J. Schumpeter considered crisis period as the environment to implement innovative ideas of entrepreneurs, because it is more difficult to provide them in other business cycle phases. Innovation in a crisis is provoked by the necessity to use scarce resources more efficiently, i.e. factors of production. It is worth paying attention to the fact that during crisis, the importance of people group interaction concerning the use of limited resources is scaled up. This is the synergistic effect manifestation. Its implementation mechanism is self-organization. Hence, self-organization is the tool to overcome crisis. J. Schumpeter paid attention to the fact that the formation of new resources combinations occurs not by command pattern, but due to competition. New resources combinations are more efficient, compete with previous (outdated). In general, this leads to the growth of total resources utilization efficiency in the society.

Consequently, within a complex system, i.e. a territorial community, it is necessary to support constantly the process of self-development and improvement, because in the absence of them the system goes into a state and can be destroyed. In our concern, it makes sense to use the kaizen-strategy to keep the development process, as it provides continuous improvement, because it combines modern tools for managing the constant development of complex economic systems, including the territorial community.

Kaizen is the improvement consumer-biased strategy. The management goal is to strive constantly for the production of better goods (services) at lower prices. Kaizen strategy provides a systematic approach and problem-solving tools to achieve the ultimate goal.

Another important facet of the kaizen strategy is the formation of the way of thinking focused on the process (process thinking), building of the management system which supports the process participants towards excellence and identification of their efforts. This sufficiently distinguishes kaizen from western management practices.

Thus, almost all elements of the kaizen «umbrella» can be used in the process of territorial communities' management reforms, i.e. in the process of setting conditions of their further development based on self-financing.

Taking into account that it is impossible to ensure a territorial community's functioning separate of other communities and external environment, it is reasonable in further research, to remove limitations concerning territorial community's economic system autarky.

Conclusion. The mathematical model of territorial community management using the multi-sectoral model of national economy and the kaizen strategy has been constructed.

It is proved that application of the kaizen strategies will allow to organize, control and manage actions, in the most effective way, of a complex system which is a territorial community amid its dynamic development.

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Математична модель технології кайдзен в управлінні природно-господарськими системами. Реформування міжбюджетних відносин є рушійною силою для переходу місцевих громад на самозабезпечення та більш раціональне планування своїх ресурсів, що у майбутні фінансові періоди дозволять зробити територіальні громади економічно самодостатніми й фінансово спроможними. В умовах децентралізації владних відносин у державі актуальними стають дослідження складних соціально-економічних систем, які функціонують на основі прийняття колективних рішень і виконання колективних дій. Це вимагає вивчення передумов здійснення ефективного управління суспільними ресурсами на місцевому рівні та формування методологічної бази вдосконалення територіальної організації влади шляхом, насамперед формування самодостатніх територіальних громад. Побудовано математичну модель управління територіальною громадою з використанням багатогалузевої моделі національного господарства та Кайдзен-стратегії. Моделювання здійснено за умови, що об'єднана територіальна громада вважалася «закритою системою», з метою визначення

внутрішнього потенціалу функціонування, що дозволяє оцінити можливості самофінансування і беззбитковості. У багатогалузевій моделі для територіальної громади вважали, що елементами цієї складної системи є основні фактори виробництва, а саме: земля, праця, капітал, підприємницькі здібності та інформація. Установлено, що ефективне управління внутрішнім потенціалом територіальної громади дозволить оцінити рівень її внутрішньої економічної безпеки, основою якого є автономія і самодостатність. Доведено, що застосування Кайдзен-стратегій дозволить ефективно організувати, контролювати та здійснювати управляючий вплив на складну систему, якою є територіальна громада в умовах її динамічного розвитку.

Ключові слова: об'єднана територіальна громада, сталий розвиток, інноваційні технології, природно-господарські системи, управління.

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Horoshkova Lidiia, Doctor of Economic Sciences, Associate Professor. **Volkov Vladimir**, Doctor of Technical Sciences, Professor. Zaporizhzhia National University. **Khlobystov Ievhen**, Doctor of Economic Sciences, Professor. National University of «Kyiv-Mohyla Academy». **Viktor Kutyk**, Zaporizhzhya National University. **Kaizen technologies in natural and economic systems management: approaches to economic and mathematical modeling.** The mathematical model of a territorial community management based on a multi-sectoral model of a national economy and Kaizen strategy has been built. According to the modelling a united territorial community is a "closed system". This allows to determine the internal functioning potential to assess the possibilities of self-financing and break-even point. In the multi-sectoral model for a territorial community, we assume that the elements of this complex system are the basic factors of production, namely, land, labour, capital, entrepreneurial skills and information. It has been found out that effective management of territorial community's internal potential allows to assess its internal economic security rate based on autonomy and self-sufficiency. It has been proved that Kaizen strategies cause effective organization, control and managerial influence on a complex system like a territorial community in the context of its dynamic development.

Key words: united territorial community, sustainable development, innovative technologies, natural and economic systems, management.

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Горошкова Лидия Анатольевна, доктор экономических наук, доцент. **Волков Владимир Петрович**, доктор технических наук. Запорожский национальный университет. **Хлобыстов Евгений Владимирович**, доктор экономических наук, профессор. Национальный университет «Киево-Могилянская академия». **Кутык Виктор**, аспирант. Запорожский национальный университет. **Математическая модель технологии кайдзен в управлении природно-хозяйственными системами.** Построена математическая модель управления территориальной общиной с использованием многоотраслевой модели национального хозяйства и Кайдзен-стратегии. Моделирование осуществлено при условии, что объединенная территориальная община считалась «закрытой системой», с целью определения внутреннего потенциала функционирования, что позволяет оценить возможности самофинансирования и безубыточности. В многоотраслевой модели для территориальной общины считали, что элементами этой сложной системы являются основные факторы производства, а именно: земля, работа, капитал, предпринимательские способности и информация. Установлено, что эффективное управление внутренним потенциалом территориальной общины дает возможность оценить уровень ее внутренней экономической безопасности, основой которой является автономия и самодостаточность. Доказано, что применение Кайдзен-стратегий позволяет эффективно организовывать, контролировать и осуществлять управляющее влияние на сложную систему – территориальную общину в условиях ее динамического развития.

Ключевые слова: объединенная территориальная община, устойчивое развитие, инновационные технологии, природно-хозяйственные системы, управление.