ESPACIOS
REVISTA

Application of Mathematical Tools for Decision-Making in Management of Heat Supply Enterprises in Depressed Areas

Aplicación del modelamiento matemático de toma de decisiones a la gestión de empresas de calefacción centralizada en áreas deprimidas

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ABSTRACT:

The task to increase management efficiency is particularly relevant for the heat supply infrastructure of the Donetsk region, the functioning of which is hampered by the system-wide concerns as well as the external challenges. The structural model of effective management of heat supply enterprises in depressed areas has been developed in the research. This model developed through application of the adaptive mathematical methods is based on both systematic and cybernetic approaches and incorporates a range of the authorial approaches, models and methods.
Keywords: heat supply enterprises; cybernetic; depressed areas

RESUMEN:

La tarea de mejorar la eficiencia de gestión es particularmente relevante para las empresas de calefacción centralizada en la región de Donetsk, cuya operación se ve obstaculizada por una serie de problemas en todo el sistema, así como por la presencia de unos desafíos externos. El estudio desarrolló un modelo estructural para la gestión eficaz de empresas de calefacción centralizada en áreas deprimidas. Este modelo se basa en el uso de métodos matemáticos adaptativos, se basa en un enfoque sistémico y cibernético y combina varios enfoques, modelos y métodos del autor.
Palabras clave: empresas de calefacción centralizada; cibernética; áreas deprimidas

1. Introduction

Modern developments in the area of applying mathematical tools in the heat supply enterprise management system (HSEMS) are focused on handling the specific tasks emerging in the course of management. The effectiveness of the tariff setting system, updating of equipment, and investment activities, etc. are among them. At the same time,

the complexity and the specific character of the heat supply activity predetermines the need to use an integrated approach to management of enterprises, which takes into account all significant direct and feedback links. The expediency of applying the integrated system approach to management of heat supply enterprises (HSE) is greatly enhanced by the non-standard external challenges in depressed areas.

One of the most striking examples of the areas characterized by the obvious depression signs on the borders of the modern post-Soviet territory is the Donetsk region. The social and economic system of the Donetsk region developed steadily until the middle of 2014 and provided about 20% of the industrial production of Ukraine (with a ten percent population). Donetsk traditionally ranked first in the ranking of the socio-economic development of the cities in the country with a significant lead. With the onset of hostilities in the Donetsk region area, the state of its socio-economic system has deteriorated drastically, which affected primarily the results of HSE operation. Specifically, 20,101 private houses, 4,507 apartment buildings and the adjacent community infrastructure were damaged in this area as a result of the military operations as of 2017[3].

The population outflow from the region and an abrupt decline in its living standard resulted in an increase in debt for the housing and communal services. In just a few months of hostilities the debt increased by 28.2% as of 01.01.2015[4].

At the same time, the HSE services in the Donetsk region are of the paramount importance in its economic and social system. The market of the housing and utilities services, including the heat supply services, is one of the largest in its economy. Thus, the housing and utility sector of the region provides for the needs of about 2.5 million people, as well as more than 180 large-scale enterprises in all branches of the national economy. More than 8% of the working population is employed in provision of the housing and utilities services[5].

In the context of the above, it can be concluded that development of the decision support tools aimed at efficiency improvement for management of heat supply enterprises in a depressed area (using the example of the Donetsk region) is an urgent task with great practical significance.

The purpose of the research is to develop a mathematical decision-making apparatus, its verification and incorporation into the tools aimed at improving the efficiency of managing heat supply enterprises in depressed areas (using the example of the Donetsk region).

2. Methodology

The methodological framework of the study consists of the researchers' works aimed at solving the problems of developing tools for economic and mathematical modeling in order to improve management efficiency in the housing and utilities sector. Among them are the works of such authors as B.G. Aivazian [6], V.G. Gurlev [7], N.L. Evdokimenko [8], N.E. Egorova [9], E.N. Efomov [10], N.V. Koroleva [11], S.P. Kosarin [12], T.I. Lebedeva [13], I.V. Milkina [14], M.I. Mitrofanova [15], A.A. Ofitserov [16], O.M. Poponina [17], N.A. Khodanova [18], T.S. Khomiakova [19], A.M. Shein [20]. These authors' works are dedicated to solving a wide range of problems in the field of application of the mathematical apparatus in management of the housing and utilities sector at the regional and municipal levels. At the same time, the problems of modeling and applying instrumental procedures to increase validity of the decisions made at the level of individual enterprises of the housing and utilities sector, including HSE, as well as enterprises operating in depressed areas, are the least developed and poorly covered in the scientific literature.

In this regard, development and verification of the decision support economic and mathematical tools, aimed at improving the management efficiency of housing and public utilities enterprises in depressed areas, gain ground.

The instrumental and methodological research apparatus includes the statistical, retrospective, and terminological analysis methods, expert assessments, the systemic approach methodology, the cybernetic approach methodology, and the scientific generalization method.

The mathematical and instrumental methods used in the work are represented by the

following tools: optimization methods, viable system model, forecasting methods, correlation and regression analyses, interpolation and trend approximation methods, system-dynamic modeling method, scenario analysis, simulation modeling method, computer experiment theory and practice, and methods for developing decision support systems.

3. Results

Study of the scientific literature allowed for the conclusion that the authors of the research in this area focused their efforts on development of the methods, tools and approaches, as well as the mathematical apparatus, aimed at solving certain specific problems, such as tariff policy regulation in the housing and utility infrastructure system, assessment and prediction of the housing stock state and others. The authors systemized the tools for improving efficiency of the heat supply enterprise management system and reflected in the reference (Myznikova, Timokhin, 2016, pp. 146-148).

Emphasizing the above authors' great importance and significant contribution to solving these issues, we might mention that the complexity of the HSE problems in depressed areas requires expansion of the mathematical apparatus and decision support tools that take into account the behavior of market participants.

Based on the goals of expanding the mathematical apparatus for HSE integrated management, it is of interest to consider HSE as a system. At the same time, it is worth emphasizing that a particularly important task of HSE management, like management of many other systems, in the modern conditions of the Donetsk region is to achieve the ability of the system to maintain its autonomous functioning for as long as possible.

This property of the system was called 'viability' and described in the works of S. Beer (Beer, 2005), as well as a wide range of scientists within the framework of the cybernetic approach.

The authors' structural model for HSE effective management in depressed areas oriented on application of the adaptive mathematical models and methods is based on the cybernetic approach, but it has fundamental differences (Fig. 1).

The authors' structural model differs from the one proposed by S. Beer (Beer, 2005) in that it formalizes the logical and informational links between the authorial mathematical models and methods, combining them into a single methodology.

The management system, as in the model worked out by S. Beer, is presented in the form of a number of separate subsystems endowed with specific functions: the system for making strategic decisions (system 5); the information system (system 4); the scarce resource allocation system (system 3); the internal audit system (system 3*); the current problem solving system (system 2).

Figure 1
The structural model of effective management of heat supply enterprises in depressed areas based on application of the adaptive mathematical models and methods
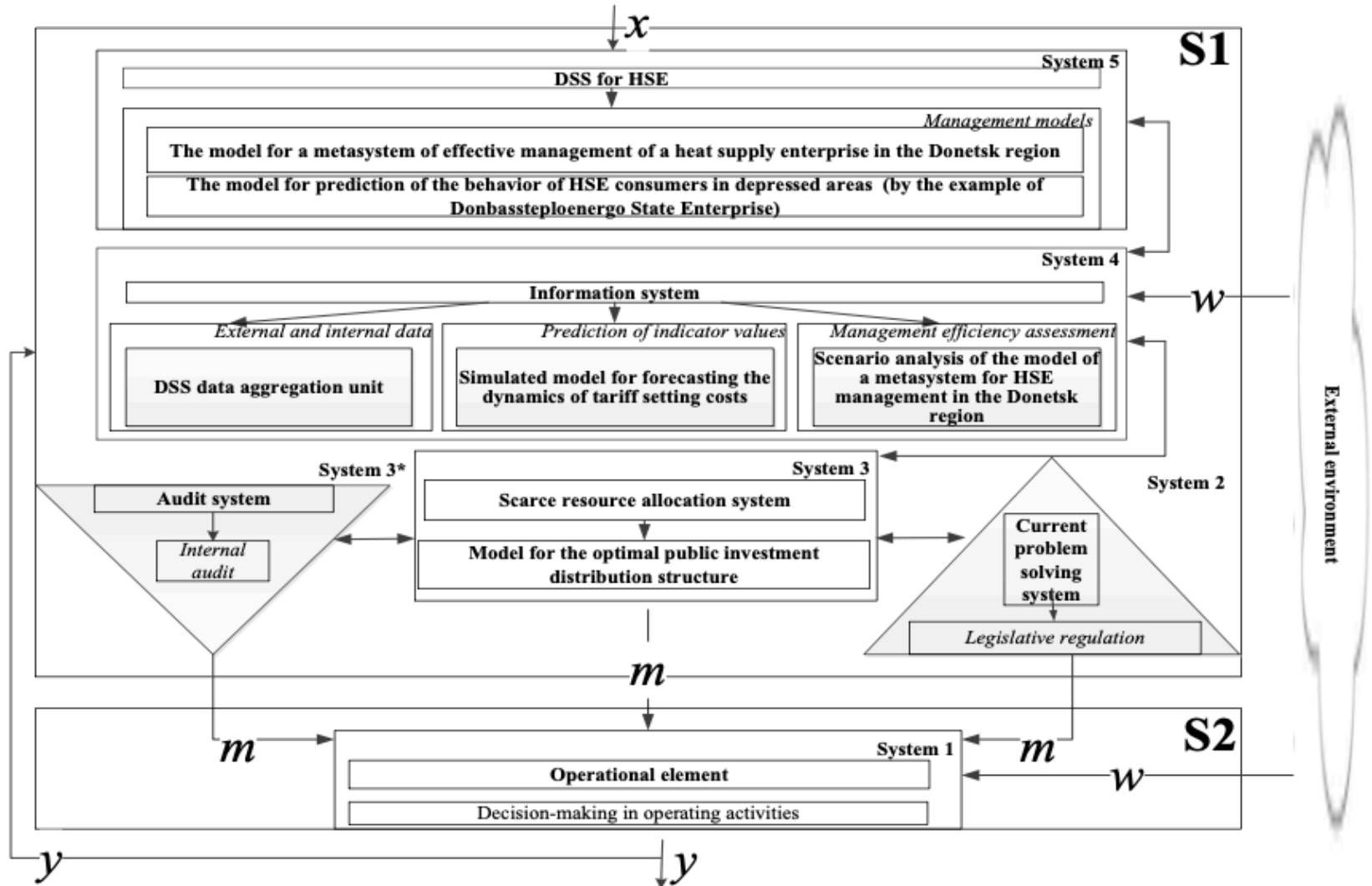
Proceeding from the structural model construction according to VSM modeling methodology, which assumes adherence to the recursion principle, it (as well as all models and methods that are included in its structure) can be used both by the lower level (individual production units; individual departments) and the higher level (sectoral ministry) viable systems.

The universality of the approach behind the structural model allows its adaptation for description of the functional relationships of the models for managing complex socio-economic systems of any nature, and the mathematical models included in it - for the systems of management of water supply, wastewater disposal, gas supply, energy supply, and other enterprises.

Hence, the structural model developed through application of the adaptive mathematical models and methods and based on the system and cybernetic approaches and combining a number of the authorial approaches, models and methods, is universal for the management systems of the population life support enterprises in depressed areas at all levels of management and is aimed at improving their effectiveness.

The aforesaid makes it possible to form a unified methodology, the use of which enables to take reasonable managerial decisions at the strategic, tactical and operational levels of HSE management in the Donetsk region.

Implementation of the described structural model and expansion of the methodological framework of a heat supply enterprise management by adding the tools incorporated in the authors' structural scheme contributed to improved effectiveness of the taken managerial decisions. Introduction of the authors' tools in the practice of heat supply enterprise management in the Donetsk region will ensure achievement of the economic effect presented in Table 1.

Table 1
The sources of achieving economic effect

Time, quarter	The sources of achieving economic effect (rubles)			
	Reduction in the share of closed personal accounts	Reduction in the accounts receivable	Reduction in other expenses	Change in financial results

I	215,564.28	21,186.11	41,389.68	256,953.96
II	595,791.18	17,132.93	41,578.71	637,369.89
III	226,906.22	19,231.14	42,091.2	268,997.42
IV	491,592.4	18,926.44	42,520.49	534,112.89

The total effect from implementation of a set of measures amounted to 278,140.07 rubles in one quarter. The sources of the achieved economic effect became savings in other costs, as well as increase in the number of active consumers, which resulted in reduction in the share of closed personal accounts and decrease in receivables.

4. Conclusions

In order to improve management efficiency, the structural model was proposed for the effective management of heat supply enterprises in depressed areas by applying the mathematical models and methods. The model is based on the approach to construction of viable systems and allows for an integrated approach to solving managerial problems. The authors' structural model differs from the one incorporated in the cybernetic approach in that it formalizes the logical and informational links between the authors' mathematical models and methods, integrating them into a single methodology. The developed structural model makes it possible to take adequate managerial decisions at all heat supply enterprise management levels in depressed areas to improve the management system efficiency.

Implementation of the research results provides HSE promoted viability by improving efficiency and validity of management decisions. The main results of the research have been implemented in the practice of managing Teplo Donbassa State Enterprise. The economic effect that has been confirmed by the report amounts to 278,140.07 rubles in one quarter.

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