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**MODELS OF FINANCIAL CRISIS PREVENTION AT ENTERPRISES
OF HOUSING AND COMMUNAL SERVICES**

A methodical approach to assessment, analysis and prevention of financial crisis at the enterprises of housing and communal services is proposed in this article. Adaptive models of forecasting the financial indicators, models for financial situations classification and neuro-fuzzy models of crisis class identification are developed. Forecasted class of crisis at enterprises of housing and communal services is determined considering the risk of changes in tariff policy.

Keywords: enterprises of housing and communal services; financial crisis; insolvency; adaptive forecasting models; neuro-fuzzy models.

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**МОДЕЛІ ПОПЕРЕДЖЕННЯ ФІНАНСОВИХ КРИЗ
НА ПІДПРИЄМСТВАХ ЖИТЛОВО-КОМУНАЛЬНОГО
ГОСПОДАРСТВА**

У статті запропоновано методичний підхід до оцінювання, аналізу та попередження фінансових криз на підприємствах житлово-комунального господарства. Розроблено адаптивні моделі прогнозування фінансових індикаторів, моделі класифікації фінансових ситуацій, нейро-нечіткі моделі ідентифікації класу кризи. Визначено прогнозований клас кризи підприємств житлово-комунального господарства з урахуванням ризику зміни тарифної політики.

Ключові слова: підприємства житлово-комунального господарства; фінансова криза; неплатоспроможність; адаптивні моделі прогнозування; нейро-нечіткі моделі.

Рис. 4. Табл. 6. Лит. 21.

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**МОДЕЛИ ПРЕДУПРЕЖДЕНИЯ ФИНАНСОВЫХ КРИЗИСОВ
НА ПРЕДПРИЯТИЯХ ЖИЛИЩНО-КОММУНАЛЬНОГО
ХОЗЯЙСТВА**

В статье предложен методический подход к оценке, анализу и предупреждению финансовых кризисов на предприятиях жилищно-коммунального хозяйства. Разработаны адаптивные модели прогнозирования финансовых индикаторов, модели классификации финансовых ситуаций, нейро-нечеткие модели идентификации класса кризиса. Определен прогнозируемый класс кризиса предприятий жилищно-коммунального хозяйства с учетом риска изменения тарифной политики.

Ключевые слова: предприятия жилищно-коммунального хозяйства; финансовый кризис; неплатежеспособность; адаптивные модели прогнозирования; нейро-нечеткие модели.

Problem statement. In today's transformational economy Ukrainian enterprises including housing and community services (housing & utilities) are functioning under risks and much uncertainty. Outdated management and absence of new information technologies lead to crisis situations at enterprises, especially in their financial activity. Lack of appropriate crisis leveling methods may cause great financial costs and, ultimately, leads to bankruptcy.

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According to the Moratorium on bankruptcy of housing and utilities enterprises which has the function of meeting immediate people's needs (water supply, drainage, heat and gas supply) and have more than 50% of state ownership share cannot be liquidated. That's why bankruptcy of housing and utilities has a number of unique features. This requires the implementation of new approaches to crisis management among which the most promising one is preventive management. Applying the preventive approach to the complexity of the related problems cause the necessity of using advanced economic and mathematical tools for support and substantiation of management decisions aimed at preventing crises in financial and economic activities.

Literature review. Analysis of relevant literature shows that the problem of crisis assessment has been considered by many scientists. To date, economic mathematical methods are successfully used for specific tasks of enterprises' crisis assessment. The researches of such domestic scientists should be mentioned here: M.Y. Adamiv and O.Y. Kuzmin (2013), Y. Daradkeh et al. (2012), R. Drumnik et al. (2014), I.G. Lukyanenko (2004), A.V. Matviychuk (2013), R.O. Rudenskyi (2009). Moreover, it is important to mention such foreign scientists as W.H. Beaver (1966), S.M. Berneti (2011), J. Minussi et al. (2007), J.A. Ohlson (1980), R.J. Taffler (1982). However, it should be also noted that most of the works on the assessment of enterprise crisis are aimed at assessing the onset of bankruptcy, which is the final stage of crisis at an enterprise, while they have not reflected the preventive aspect of such assessment which should be carried out at the stage of potential or latent crisis. For the enterprises of housing and communal services, due to the mentioned above Moratorium on bankruptcy, development of tools for preventive financial control is of particular importance. All of this causes the topicality of the proposed research.

Key results. Nowadays Ukrainian housing & utilities are characterized by volatile trends (Klebanova and Rudachenko, 2015), which subsequently could lead to financial crisis. This is due to large depreciation of networks, of fixed assets, to the lack of state funding, unprofitableness, high staff turnover, rising costs of raw materials, shortage of own current assets, lack of advanced methods in management of these enterprises etc. It should be also noted here that dramatic rise of housing and utility charges (particularly for water and heat supply) under low average wages leads to social tensions in many regions and in country as a whole. Regarding this, at the majority of housing & utilities enterprises accounts receivable increase and accumulate primarily.

The proposed methodical approach to crisis assessment at housing & utilities is based on the principles of efficiency and preventive management. It allows determining the crisis class of the analyzed and forecast periods at enterprises. The main stages of this approach include: selection of diagnostic indicators which characterize the financial situation; determination of the current financial crisis class; determination of the forecasted financial crisis class.

General scheme of such research objectives as assessment, analysis and prevention of crisis class at housing & utilities is presented in Figure 1.

The first stage is to determine the groups of indicators which characterize housing & utilities' financial situation. The results of this stage realization allow revealing crisis situation at these enterprises. The first stage implementation allows reaching

such research objectives forming the initial list of financial indicators, determining the representants in groups of financial indicators, forming the final list of financial indicators.

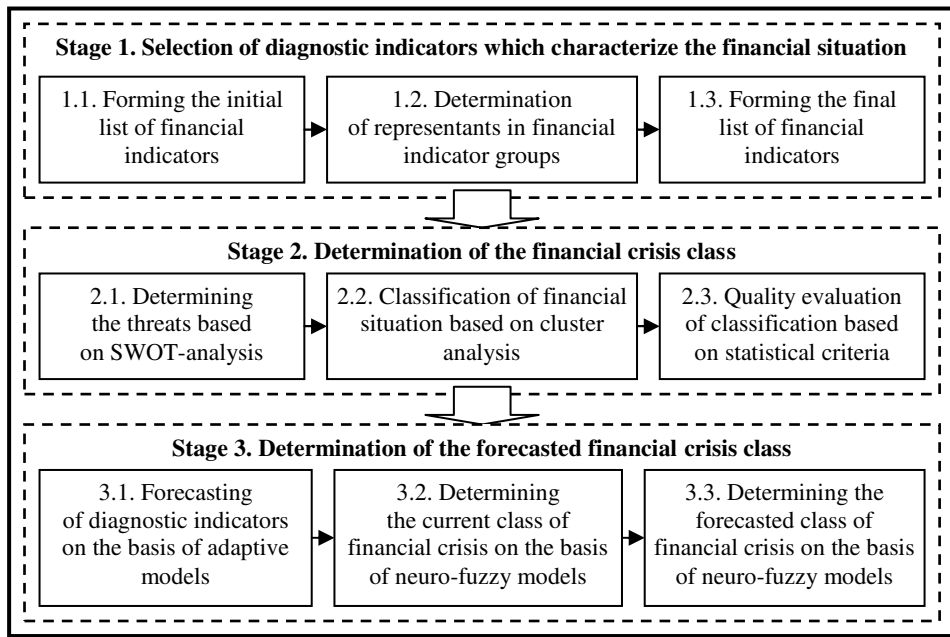


Figure 1. General scheme of assessment, analysis and prevention of crisis class at housing & utilities, authors'

The second stage is to determine the financial crisis class at housing & utilities. The main objectives of this stage are: determination of threats, classification of financial situation based on cluster analysis, quality evaluation of classification.

The third and the final stage covers forecasting the diagnostic indicators which characterize housing & utilities' financial situation that make it possible to prevent possible changes in crisis class in the short term.

Implementation of the proposed methodical approach largely depends on the quality of the first stage realization. One of the components is selection of diagnostic indicators that allows assessing the financial situation in the current and forecasted periods. Analysis of the related publications shows substantial differences in opinions as for indicator groups and number of indicators in each group (Blank, 2003; Klebanova et al., 2003; Moroz and Shvarts, 2006; Pliuta, 1980; Ponomarenko et al., 2013).

The Guidelines on Identifying the Signs of Insolvency approved by the Ministry of Economy of Ukraine propose to analyze the financial situation of enterprises by 5 groups which contain 13 indicators. To reduce the number of indicators on the basis of "gravity center" method the representant indicators for each group are selected. These indicators are used for diagnosis and prevention of enterprises financial crisis. Among the diagnostic indicators are: quick ratio; financial independence ratio; the share of funds in production; asset turnover ratio; ROE (return on equity).

SWOT-analysis based on the selected diagnostic indicators allows determining the list of financial crisis threats for housing & utilities sector. It has been proved that increase in accounts receivable is one of the strongest threats arising from population's inability to pay for public utility services (Rudachenko, 2014; Klebanova and Rudachenko, 2015).

The result of the analysis show that over 95% of overall housing & utilities infrastructure is occupied by two largest sub-sectors: 1) water supply and sewage networks; 2) heat-power engineering. This is caused by high demand for these services and high energy capacity. So, the main stages in implementation of the proposed methodological approach was tested at these very enterprises.

Classification of financial situation of "Novovodolazke pidpriemstvo teplovykh merezh" (Heating Networks Enterprise in Nova Vodolaha) was implemented on the basis of cluster analysis, particularly Ward's method. The enterprise provides district heating for Kharkiv regional consumers. The results of classification are illustrated in Figure 2.

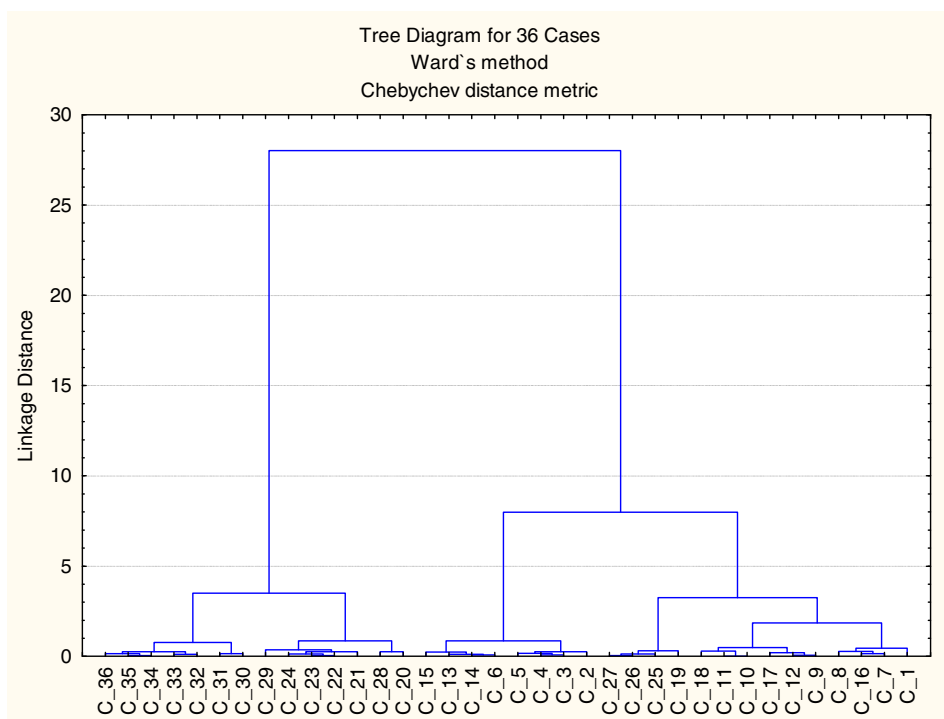


Figure 2. Tree diagram for Ward's method classification, authors' construction in "Statistica 6"

The analysis of the results shows that the first cluster contains crisis financial situations, the second cluster contains unstable financial situations, and the third – stable financial situations. Table 1 provides the interpretation of these classes.

For proving the hypothesis about the three clusters, obtained by means of Ward method, clustering was held on the basis of K-means.

Table 1. Interpretation of the financial crisis classes, authors'

Cluster number	Interpretation	Description
1	Crisis financial situation	Enterprises of this class have low liquidity, financial stability and profitability. Representant indicators defining liquidity and financial independence were lower than the standard. This indicates poor financial solvency and unsatisfactory financial stability. The most problematic aspects of these enterprises are significant receivables and payables leading to losses
2	Unstable financial situation	Enterprises of this class don't have high liquidity, financial stability, profitability and business activity. This indicates low quality of their financial management
3	Stable financial situation	Enterprises of this class have a slight increase in representant indicators for each group: property rates; liquidity; financial stability; business activity; profitability

Figure 3 illustrates the plot of diagnostic indicators means for each cluster obtained by K-means method. The diagnostic indicators means indicate a considerable difference between the classes. This again confirms high quality of the resulting classification. Similar clustering of financial situations at several other housing & utilities also resulted in 3 classes of crisis financial situations.

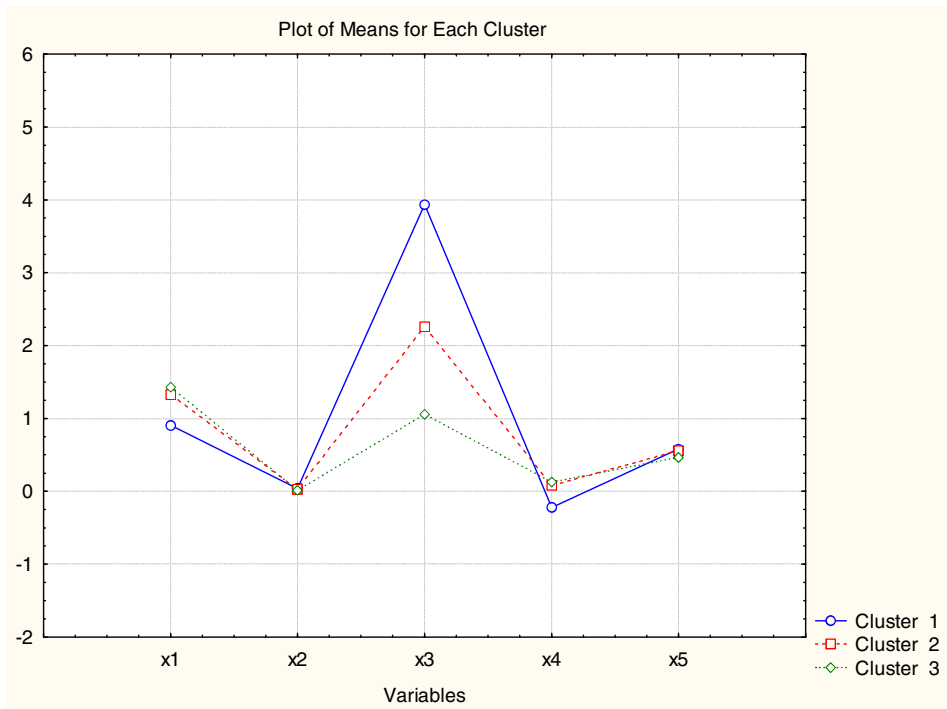


Figure 3. Plot of diagnostic indicators means for each cluster, authors' construction in "Statistica 6"

One of the proposed approach objectives is forecasting the diagnostic indicators on the basis of trend and adaptive models. However, the results of this forecasting has an error far more than 10%. This confirms the irrationality of these models implementation. Therefore, adaptive models were used for further research. Minimum of mean absolute percentage error (m.a.p.e) was used as a criteria of optimality for adaptation parameter selection in forecasting (Rudachenko, 2014).

The results of the research helped us define the model with the smallest percentage error for each diagnostic indicator of financial activity of the enterprises in question (Table 2).

Table 2. Selection of forecasting adaptive models for diagnostic indicators of financial activity of the enterprises, authors'

Indicator	Model	M.a.p.e., %
Novovodolazke pidpriemstvo teplovykh merezh (Heating Networks Enterprise in Nova Vodolaha)		
Quick ratio	Fading trend	4.233
Proportion of funds in production	Fading trend	6.998
Asset turnover ratio	Exponential trend	7.043
ROE	Fading trend	6.201
Financial independence ratio	Fading trend	6.600
Novovodolazke vodoprovodno-kanalizatsiine pidpriemstvo (Water and Sewage Enterprise in Nova Vodolaha)		
Quick ratio	Fading trend	8.542
Proportion of funds in production	Fading trend	7.755
Asset turnover ratio	Fading trend	7.599
ROE	Fading trend	8.015
Financial independence ratio	Fading trend	7.699

The financial crisis class of the current and forecasted periods was determined on the basis of neuro-fuzzy models, which are the generalization of classical set theory and classical formal logic (Leonenkov, 2005; Matviychuk, 2013; Shtovba, 2007). The structure of neuro-fuzzy network corresponds to the main blocks of fuzzy system. The main difference between neural network and other techniques is that neural models can be built on the proposed information. That is the reason of widespread use of neural network in developing of unformalized objectives under hard algorithmization. Input indicators of neuro-fuzzy model are 5 diagnostic indicators, and output indicator determines the financial crisis class (Table 3).

Table 3. Range of financial crisis class values, authors'

Cluster number	Range of values	Class interpretation
1	0–1	Crisis financial situation
2	1–2	Unstable financial situation
3	2–3	Stable financial situation

The structure of fuzzy neural network which is based on 2012–2014 statistics of "Novovodolazke pidpriemstvo teplovykh merezh" is presented in Figure 4. Verification of neuro-fuzzy models based on mean absolute percentage error shows an excellent quality of crisis classes recognition. The residual is about 0.068%.

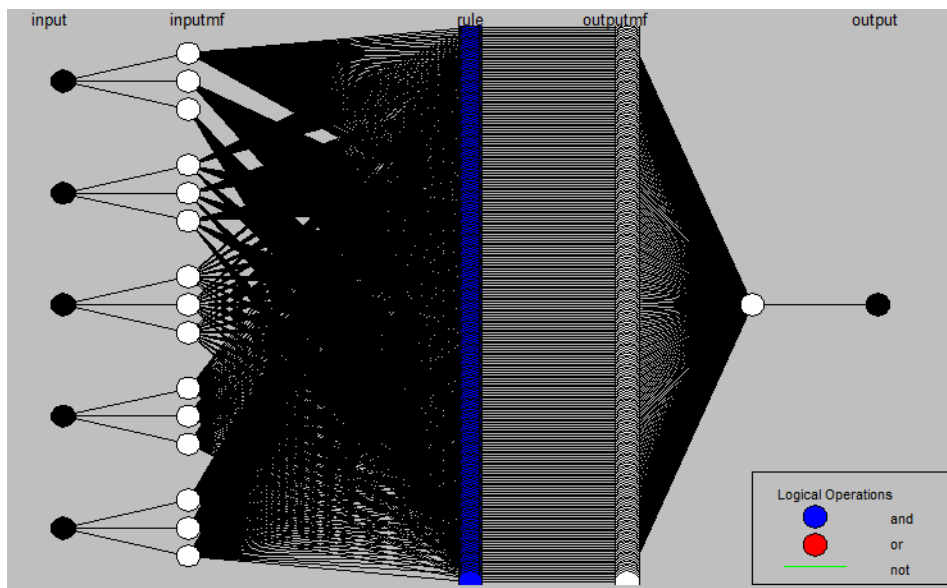


Figure 4. The structure of the fuzzy neural network, authors' construction in "Statistica Neural Networks"

Determining the current financial crisis class on the basis of fuzzy neural network led us to the following conclusions: from the first quarter of 2012 to the second quarter of 2013 the financial condition of "Novovodolazke pidpriemstvo teplovykh merezh" was identified as stable financial situation, in 2014 it became worse.

The proposed model was also approbated on several other housing & utilities enterprises of Kharkiv region. The results of determining the financial crisis at these enterprises are demonstrated in Table 4.

According to Table 4 Kharkiv housing & utilities' financial conditions can be overall classified as unstable.

The following Table 5 presents the forecast of financial crisis class on the basis of diagnostic indicators of financial activity at housing & utilities in Nova Vodolaha.

Forecasted financial situation of "Novovodolazke pidpriemstvo teplovykh merezh" shows a possible change in the crisis class because in this period the output value is 1.061. Forecasting results indicate that management should implement anti-crisis measures.

Threats determination is one of the important objectives of the proposed methodological approach (Figure 1) for housing & utilities. Based on the analysis it has been determined that receivables growth is one of the strongest threats for housing & utilities. Receivables accumulation demonstrates the population's inability to pay charges for these services.

The complex of models assessing the impact of receivables growth on financial crisis formation is developed. Diagnostic indicators of housing & utilities' financial activity, enterprises' receivables and the income of the same region population were forecasted to determine the increasing enterprises' receivables. The results were used for forecasting the financial crisis class on the basis of neuro-fuzzy models.

Table 4. **Financial crisis classes at housing & utilities of Kharkiv region, authors' calculation based on enterprises financial reporting and authors' neuro-fuzzy model implementation**

Enterprise	Proportion of funds in production	Quick ratio	Financial independence ratio	Asset turnover ratio	ROE	Crisis class
2012						
Kharkivvodokanal (Kharkiv water utility)	0.070	1.335	0.586	0.558	-0.156	2.1452
Kharkivski teplovi merezhi (Kharkiv heating networks)	0.031	0.633	0.024	0.071	-0.535	1.9586
Kharkivzelenbud (Local urban landscaping enterprise)	0.284	0.804	0.912	0.273	0.027	2.0521
Zhovtneve tramvaine depo (Tram depot in Zhovtneve town)	0.398	0.493	0.620	2.250	0.104	0.8852
2013						
Kharkivvodokanal	0.069	1.149	0.533	0.558	-0.189	2.1120
Kharkivski teplovi merezhi	0.024	0.449	0.135	0.710	-0.453	1.9002
Kharkivzelenbud	0.399	0.598	0.919	0.217	0.040	1.9450
Zhovtneve tramvaine depo	0.012	1.006	0.136	1.457	0.091	0.9131
2014						
Kharkivvodokanal	0.035	0.586	0.272	0.285	-0.096	2.0245
Kharkivski teplovi merezhi	0.025	0.092	0.028	0.441	-0.305	1.8745
Kharkivzelenbud	0.282	0.498	0.949	0.148	0.035	2.1634
Zhovtneve tramvaine depo	0.010	0.953	0.078	0.316	0.071	0.8836

Table 5. **Forecasted financial crisis class of Kharkiv region housing & utilities, authors' calculation based on enterprises' financial reporting and own neuro-fuzzy model**

Period	Quick ratio	Proportion of funds in production	Asset turnover ratio	ROE	Financial independence ratio	Crisis class
Novovodolazke pidprijemstvo teplovykh merezh						
June 2015	0.841	0.040	5.059	- 0.466	0.761	1.061
Novovodolazke vodoprovodno-kanalizatsiine pidprijemstvo						
June 2015	0.247	0.131	0.803	- 0.015	0.173	2.995

The complex of models was tested at "Novovodolazke vodoprovodno-kanalizatsiine pidprijemstvo" data. The results are presented in Table 6.

Table 6. **Determining the forecast financial crisis class considering the risk of changing tariff policy, authors' calculation based on enterprises' financial reporting and own neuro-fuzzy model**

Period	Quick ratio	Proportion of funds in production	Asset turnover ratio	ROE	Financial independence ratio	Crisis class
June 2015	0.006	0.49	0.45	-0.002	0.068	2

Table 6 shows the forecasted indicators have been deteriorated as a result of housing and communal service charges rapidly growing. This caused the deterioration of the financial crises class.

Increased government tariffs for population have lead to a number of negative trends related to insolvency of population. Particularly that leads to accumulation and increasing of receivable and payable accounts, to deterioration of profitability and other financial indicators and eventually, to enterprises losses that turn into deterioration of the financial crises class.

Conclusions. Implementation of crisis assessment models enables the following. First of all, the abridged system of diagnostic indicators used in operative assessment of enterprises' crisis was developed. Secondly, classification of financial crisis at housing & utilities was formed that made it possible to track the trend of industry development. Thirdly, enterprises' financial crisis assessment depending on the dominant threats of current and forecast periods was carried out. This assessment allows preventing the financial crisis emergence and timely development of preventive measures to minimize losses in the housing & utilities sector.

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