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PROBLEM ASSESSMENT OF ENERGY SECURITY IN THE COUNTRY

PROBLEMY OCENY BEZPIECZEŃSTWA ENERGETYCZNEGO KRAJ

ПРОБЛЕМЫ ОЦЕНИВАНИЯ ЭНЕРГЕТИЧЕСКОЙ БЕЗОПАСНОСТИ СТРАНЫ

Abstracts

The article noted the calculation of energy resources in the economy and its fundamental impact on the calculation of energy security. Analyzes different methods of calculation of energy security. Discovered flaw in the calculation of energy security, which is not directly examine the effect of energy technologies.

***Keywords**: energy security, calculation of energy security, indicator approach automated computing power calculation of energy security, energy trilemma Index of energy independence.*

Streszczenie

W artykule opisano metodologię obliczania zasobów energetycznych w gospodarce i jej zasadniczy wpływ na określanie poziomu bezpieczeństwa energetycznego. W artykule przeprowadzono analizę różnych metod szacowania poziomu bezpieczeństwa energetycznego. W trakcie przeprowadzanej analizy wykryto błąd w metodologii formuły szacowania bezpieczeństwa energetycznego, ponieważ nie w pełni bezpośrednio uwzględnia wpływ zmieniających się dominujących technologii energetycznych.

***Słowa kluczowe:** bezpieczeństwo energetyczne, określanie poziomu bezpieczeństwa energetycznego, zautomatyzowane podejście wskaźnikiem mocy obliczeniowej szacowania bezpieczeństwa energetycznego, trilemma energii, główna niezależności energetycznej.*

Аннотация

В статье отмечено расчет энергоносителей в экономике и его фундаментальное влияние на вычисления энергетической безопасности. Проанализированы различные методики расчета уровня энергетической безопасности. Выявлено недостаток врасчете энергетической безопасности страны, непосредственно не определяет влияние технологии в энергетике.

***Ключевые слова**: энергетическая безопасность, расчет энергетической безопасности, индикативный подход, автоматизированное электро вычислительное вычисления уровня энергетической безопасности, энергетическая проблема, индекс энергетической независимости.*

Introduction. Energy security has become a phenomenon not only theoretical scientific problem, but the practical aspects of 21st century both developed countries and developing countries. Because modern processes of social production based on the hydrocarbon sector, which is a prerequisite for the production of electric current.Despite the urgency of this problem and diversity of research at present is not established single universally a comprehensive theory of energy security. The current research are focused on specific aspects of energy security, so we should focus on methods of calculation.

Analysis of recent research and publications. At the time many scientists are exploring the problem of assessing energy security: E. V. Bykov, Bondar-Pidhurska O. V., Vasyukov A. R, Voloshin V. S., Garayev Z. I., Dzyadykevych U. V., Duca G. G., Kuklina A. A., Loiko V. V., Myzina A. L., Mikhalevich A. A., Podolets R. Z., Postolatiy V. M., Prokip A. V., Pyatkova N. I., Salikhov T. P., Senchahova V. K., Stogniy O. V. etc. The main areas of research are to assess the energy security of the position of number energy resources.

Bold unsolved aspects of the problem. The number of publications indicates the actuality of this theme. Although extensive research methodology of calculation of energy security adopted unified theory is not recognized. This requires the creation of a unified methodological basis of calculation.

The purpose of research is a critical analysis of modern approaches to calculating the quantitative and qualitative assessment of energy security.

1. Transforming attitudes evaluating energy security. Considering assessment of energy security, it is advisable to explore the transformation of the basic principles in shaping its calculation of mathematical tools. Basic provisions of calculation Energy Security was founded by G. Hotelling, who in April 1931 published work «The economic theory of exhaustible resources» [1]. Despite the fact that this work was not covered entity category of «economic security», the paper focuses on the problem of non-renewable energy resources (table 1).

Table 1. Features of the use exhaustible energy resources

Features	Characteristic
The impact of government policy	state policy in the field of mining should be based on the tax system as opposed to an administrative prohibition extraction of minerals
The character of the impact of monopoly on the production and pricing of these resources	the volume of production and the price is directly tied to market interest rates. Maximizing revenue monopoly of natural resources in the extraction and sale of these resources is determined by equality of marginal revenue monopoly and its costs
The trend of exhaustive extraction of natural energy resources	at the initial stage exhaustible extraction of energy resources production volumes are relatively low, and prices relatively high. In the final stages of production - on the contrary, low prices and high volumes
Rule of extraction exhaustible energy resource	optimal resource extraction reproduction is achieved provided that the net price per unit of resource (selling price less costs to production) is increasing rapidly, according to the current interest rate
Rent exhaustible energy resource	excess of income over current production costs as a reward for savings for future generations resources

Source: compiled by authors from [1]

As you can see, comprehensive energy resources have the economic characteristics:

1. Stocks of exhaustible natural resources are clearly defined.
2. Property rights are also enshrined.
3. Property for sale in the market of free competition, which provides an accurate prediction of future prices for this resource.
4. The real interest rate and the constant demand for resource over time.

The oil crisis of 1970 put forward a general scientific explanation of the need for the state of the energy market and pricing issues for oil and oil products, the resolution of which is subject to consideration identify economic features exhaustive study of the energy resource.

The current pricing of oil and natural gas also takes into account these features through the incorporation of rent, which also called G. Hotelling model. Hotelling Rent - is the difference between the marginal cost of production of non-renewable resources and their market value in terms of limiting production. In other words, it is the difference between current revenues and production costs gas distributors resources and supports compensation for the loss of non-renewable energy resources. Thus, in 2015, this rent extraction of oil was $52,4 a barrel, while in 2000 it consist $28,3 [2].

In November 1975 in France (Rambouillet) held its first meeting «Big Six» (USA, France, UK, Italy, Germany, Japan), in which adopted a declaration on priority to ensure the economy of western countries' energy sufficient.

The term «energy security» is defined as the European Bank for confidence that the energy will be in stock and available in the quantity and quality needed in these economic conditions [3].

According to guarantee energy security in Europe took declarative. Subsequently, the corresponding declaration to take effect agreed there were «White Paper» [4] «Green Paper» [5] and «Energy Charter» [6].

While most economically developed countries use no more than 5-6 basic macroeconomic indices and index derivatives to determine the level of energy security, but a clear and unambiguous model for calculating energy security has not been formed. In other countries, used by tens to hundreds of indicators. This diversity of performance degrades significantly comparative calculation of energy security. As a practical assessment of energy security mainly realized indicator approach, despite the fact that proposals by assessing the level of security on a single indicator - the proportion of their energy resources in total consumption.

The technique of energy security based indicator approach includes the following steps [7]:

1. Definition and classification of threats to energy security;
2. Definition monitored energy security;
3. Formation of aggregate indicators necessary for monitoring energy security;
4. Building blocks indicative diagnostics threats to energy security;
5. Formation of aggregate indicators necessary for monitoring energy security;
6. Formation of aggregate indicators necessary for monitoring of crisis energy security;
7. Assessment of the situation on the indicator blocks;
8. Assessment of the situation on the state of energy security as a whole;
9. Develop measures to eliminate, neutralize and weaken threats to energy security action.

Indicator approach of definition of energy security is based on the calculation of certain indicators. However, this set of indicators for theassessment is varied in different countries and at the same time determined by the quality of natural energy resources. Therefore, the IEA (International Energy Agency) building on developed energy resources provides guidance on forming the country's energy balance [8]. This specific methods and tables that serves the energy statistics in physical units in the form of food supplies to the balance of the consumption of energy products. This balance ensures control of completeness and provides simple ways to collect basic statistical data on each product. Overall energy balance allows you to fully track the performance of energy conversion and relative ability to supply various fuels. The essential foundation serving food energy balance.

The European approach to forming energy balance based on scientific research G. M. Kryzhanovskiy, which allowed the Soviet Union to move to full electrification of the country.

Uzbek scientists [9] improve the methodology for calculating the index of energy security (1):

$$I_{bi} = \frac{(I_{hdi} + I_{si})}{2} \times I_{eei} \quad (1)$$

where: I_{bi} - energy security index; I_{hdi}- human development index, including life expectancy, literacy rate of the adult population and GDP per capita; I_{si}- index of provision with energy, defined as the ratio in volume of production and consumption of primary energy; I_{eei} - index of performance is derived from the costs of different types of energy in their production, processing, transportation and distribution. The indicator is calculated according to the energy balance as the ratio of final consumption to total consumption of primary energy.

According to this methodology was defined energy security indicator of 131 countries. In 2015 first place occupied Norway, while Ukraine ranked 54 place. Assessment results show that the highest level of energy security guaranteed primarily providing their own energy, human potential and the cost of energy in the system energy efficiency. To evaluate the energy security of the country, Moldovan team of researchers has compiled and submitted for classification units [10]: Heating block; 2. Production of electrical and thermal energy block; 3. Energy transmission and distribution block; 4. Block of electricity imports; 5. Environmental block; 6.Conception block; 7. Administration and Finance Block.

In fact, the classification of indicators follows a comprehensive assessment, but in the wide open in the form. The development of software and automation allow Indicator calculation method of energy security to become a dominant and a series of automated electrical computing models.

One of them is developed by the World Energy Council [11], The Energy Trilemma Index ranks countries in terms of their likely ability to provide sustainable energy policies through the 3 dimensions of the energy trilemma.

Energy security: the effective management of primary energy supply from domestic and external sources, the reliability of energy infrastructure, and the ability of participating energy companies to meet current and future demand.

Energy equity: the accessibility and affordability of energy supply across the population.

Environmental sustainability: the achievement of supply and demand-side energy efficiencies and the development of energy supply from renewable and other low-carbon sources.

The Index rank measures overall performance and the balance score highlights how well a country manages the trade-offs between the three competing dimensions: energy security, energy equity, and environmental sustainability. The best score ‘A’ is given for a very high performance.

Countries with good results are awarded with the score ‘B’. High performers receive the score ‘AAA’ while countries that do not yet perform well receive a ‘DDD’ score.

A watch list has been created for countries that are in the process of transitioning their energy systems, or where recent or unscheduled events that are not yet reflected in the data may lead to a change in Index performance in the near future.

Countries on watch include: Germany, Japan, Italy, Mexico, South Africa, Serbia, the UAE, the US and the UK.

A country’s overall rank in the sustainability index consists of two indicator types: energyperformance and contextual performance, weighted with a 3:1 ratio.

Each of the two broad indicator types is redivided into three, equally-weighted subdimensions, with equally-weight edindicators.

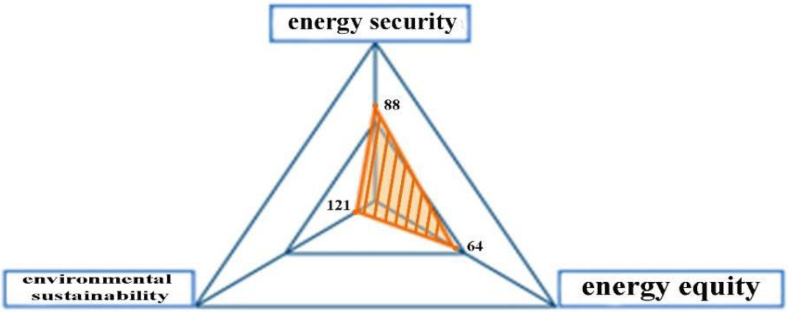
Each indicator and the average of the dimension result are normalized (0-10, where 10 is the max). To calculate the energy and contextual performance, and the overall result, the individual dimension results are then weighted (25% or 8.3%) and added up. In addition, the World Energy Council pro- vides a thorough description of the energy system of each country. Thus, according to calculations, in 2015 Ukraine ranked 110, pointing to a high dependence on expensive imports of fossil fuels (oil and gas) and insufficient infrastructure (table 2).

Table 2. The Energy Trilemma Index in Ukraine

Years	The components of Energy TrilemmaIndex			The Energy TrilemmaIndex
	Energy security	Energy equity	Environmental sustainability	
2011	54	70	114	95
2012	60	73	114	99
2013	59	73	114	97
2014	54	74	116	94
2015	88	64	121	110

Source: compiled by authors from [11]

Overall, energy trilemma for Ukraine is as follows: the low level of energy security - position 88 in the world ranking, low energy equity - 64 position, and low environmental sustainability - 121 position (figure 1).



Source: compiled by authors from [11]

Figure 1.1.The Energy Trilemma Index in Ukraine

Energy trilemma is not balanced because there are many risks for both energy security and environmental sustainability. Another approach to the definition of energy security is risk assessment. International Index of risks [12] calculates risk assessment for 25 countries that make up the group of the largest consumers of energy. It includes the main groups of indicators: the impact of the global risk of fuel import fuel, energy costs, prices and market volatility, energy, power generation sector, the transport sector environment. Points (indices) for these countries are related to the benchmark index, which is taken as the average for member countries of the Organization for Economic Cooperation and Development (OECD 1980rotsi (adopted 1000).

2. Modern approaches to energy security assessment. Modern economic thought marks the conceptual approaches to assessing energy security. The first approach is to define energy security focuses on the use of domestic energy resources of the country and in accordance with the contribution of each energy source the total energy consumption of the country. This approach made the calculation of energy security in the countries that provided energy to a sufficient level. In particular this applies to the United States, Russia, Saudi Arabia, Norway, Sweden, Canada and others.

Another approach focuses on the assessment of energy consumption through the use of imported energy resources. Under this approach, the calculated energy security in the

Table 3. Comparison of methods for assessing energy security

Method	Indicators	The components of indicators	The position of Ukraine in 2015	Number of positions
Energy Balance	**1.Human development index**	1.1. Expected life expectancy 1.2. A adult literacy rate 1.3. GDP per capita	54	131
	2.The index of energy provision	2.1 The availability of own sources of primary energy 2.2 The ability to provide domestic energy consumption due to additional supplies from outside the country 2.3. The capacity of national staff to effectively operate the complex energy system 2.4. Effective functioning of the national energy supply system		
	3.Effectiveness Index	3.1.Spending levels different types of primary energy in their extraction, processing, transportation and distribution		
Energy Trilemma	**1.Energy security**	1.1. Consumption growth relative to GDP growth 1.2. Ratio energy production to consumption 1.3.Distribution losses as % of generation 1.4.Diversity of electricity generation 1.5. Days of oil and products stocks 1.6a.Exporters Fuel exports as % of GDP 1.6b.Importers Fuel imports as % of GDP	110	130
	2. Energy justice	2.1.Affordability of retail gasoline 2.2. Affordability & quality of electricity relative to access		
	3. Environmental sustainability	3.1.Total primary energy intensity 3.2.CO2 intensity 3.3. Effects on air and water 3.4.CO_2 emissions from electricity generation		
International Risk Index	**1. Global Fuels**	1.1. Security of World Oil Reserves 1.2. Security of World Oil Production 1.3. Security of World Natural Gas Reserves 1.4. Security of World Natural Gas Production 1.5. Security of World Coal Reserves 1.6. Security of World Coal Production	25	25
	2. Fuel Imports	2.1. Petroleum Import Exposure 2.2. Natural Gas Import Exposure 2.3. Coal Import Exposure 2.4. Total Energy Import Exposure 2.5. Fossil Fuel Import Expenditures per GDP		
	3. Energy Expenditures	3.1. Energy Expenditure Intensity 3.2. Energy Expenditures per Capita 3.3. Retail Electricity Prices 3.4. Crude Oil Prices		
	4. Price & Market Volatility	4.1. Crude Oil Price Volatility 4.2. Energy Expenditure Volatility 4.3. World Oil Refinery Utilization 4.4. GDP per Capita		
	5. Energy Use Intensity	5.1. Energy Consumption per Capita 5.2. Energy Intensity 5.3. Petroleum Intensity		
	6. Electric Power Sector	6.1. Electricity Diversity 6.2. Non-CO2 Emitting Share of Electricity Generation		
	7. Transportation Sector	7.1. Transportation Energy per Capita 7.2. Transportation Energy Intensity		
	8. Environmental	8.1. CO2 Emissions Trend 8.2. Energy-Related Carbon Dioxide Emissions per Capita 8.3. Energy-Related Carbon Dioxide Emissions Intensity		

Source: compiled by authors from [7, 11, 12]

EU, China and Japan. This approach specific calculation that he founded two hypotheses. The first - the energy security comes at reducing the number of imported energy suppli- es. The second - the level of energy dependence on a particular supplier is determined by its share in the total use of a particular resource. Therefore, the level of dependence on: energy suppliers described function:

$$Z = z(X), \quad (2)$$

$X = (x_1, x_2, ..., x_n)$ - vector describing the structure of energy imports; x_1 - share of total energy consumption , which provides supply and the first vendor. This methodology proposed by A. Prokop and is based on determining the level of competition (Herfindahl index). It revealed the mathematical energy security dependence on particular suppliers of energy resources [13]:

$$Z_j = \sum_{i=1}^{n} x_i^2 = \sum_{i-1}^{n} \left(\frac{x_{ij}}{X_j} \cdot 100 \right)^2, \quad (3)$$

where: Z_j - level of country's energy dependence on j- order energy source; x_{ij} – the amount of the j-th energy source supplied and- order supplier; X_j - the total demand of the country in the j- th power resources. Given the numerical diversity of modern energy formed integral index of energy security, which ultimately served as general formula of the energy dependence of the country:

$$Z_T = \prod_{j=1, Zj \neq 0}^{m} Z_j^w = \prod_{j=1, Zj \neq 0}^{m} \left[\sum_{i=1}^{n_j} \left(\frac{x_{ij}}{X_j} \cdot 100 \right)^2 \right]^{W_j}, \quad (4)$$

where: Z_T - the energy dependence of the country; m - the amount of primary energy used by country; n_j - the number of energy suppliers; W_j - importance of j-th resources in the energy balance of the country; x_{ij} - the imports of j-th energy that comes from i-the resource; X_j - the volume of j-th energy imports. Therefore, according to this methodological approach to determine the level of energy dependence on energy suppliers could definitely use two approaches (2) and (4). The overall level of energy security, with no energy (or have, but in insufficient quantities) should rely on (3). However, these methods of calculating energy dependence should be used only on a certain date. This is due to the fact that under these conditions a sharp change in world energy prices occurs. For the short term should be used this technique, but taking into account the risk of changes in energy prices. Therefore, the formula takes the following form [13]:

$$Z_j^S = \sum_{i=1}^{n^j} \frac{1}{r_i} \cdot \left(\frac{x_{ij}\left(p_{ij}^T + C_{ij}\right)}{\sum_{i=1}^{n^i} \left[x_{ij}\left(p_{ij}^T + C_{ij}\right) \right] + p_{vj} \cdot x_{vj}} \cdot 100 \right)^2, \quad (5)$$

where: C_{ij} - the expected price change j- energy resource, supplied i country; p_{ij}^T - price per unit j energy resource supplied i country in time T; p_{vj} and x_{vj} - volume and price per unit j energy resources, providing opportunities through internal; r_i - foreign political indicator of risk for i country.

The modern theory and practice of assessing the level of energy security based on the normative and quantitative analysis. Normative analysis is based on the consideration of individual particles supplier (exporter) energy. It is recommended that the total share volume of imports of a particular imported energy in the country does not exceed 30%. For natural gas has introduced an additional condition that the level of use of gas facilities in the country should not exceed 85%. This analysis is widely used in European countries which aim to adhere to these standards. However, the scientific vision of this technique does not allow for comparative analysis of changes in energy security over time and assess the effectiveness of measures for its improvement.

That is why quantitative analysis empowers regulatory analysis, and assesses components of the energy system in certain units. The disadvantage of this analysis is impossible to describe all the links in national energy statistics due to malfunctioning labor and descriptions of existing relationships. In addition, quantitative analysis does not allow to take into account territorial characteristics and the time difference of different countries.

To address the shortcomings quantitative approach was proposed a comprehensive approach to assessing the level of energy security [14, 15, 16]. Its specificity - take account of technical, financial, economic, social and environmental aspects of energy security. Comprehensive assessment of energy security is a basic concept for the energy security of Belarus. This approach is based on an analysis of 46 indicators that are combined into ten blocks. The method of scalarization determine the level of impact of each indicator in the corresponding block, thus is the most important indicator for a particular algorithm. From the mathematical approach using these indicators calculated integral energy security [15]

$$X_{num} = \sum\left(\sum X_{ij} / n_j\right) / N_i \qquad (6)$$

where: X_{num}- overall integrated evaluation (score) of the entire system of scalarization indicators; X_{ij} – j-indicator of i-block; n_j – number of indicators in the block; N_i - the number of blocks.

This technique helps to adjust measures to guarantee energy security through the provision of the most appropriate areas for investment of the energy sector.

Conclusions. The study showed that modern methods of calculating energy security are primarily based on the ratio of world energy prices and the import share of energy in a particular country. At the same time, dominant in Western Europe is the level of environmental safety, which is quite decisive in assessing the priority of energy security.

At present energy security is based on the fol lowing approaches: indicator, energy balance, energy security risks. However, the evaluation results are not comparable with each other. These methods and techniques reflect the achieved state power. Their main drawback - the lack of energy security characteristics depending on the technological components of the energy.

Indicator of energy security should be based on the concept of cheap, high-quality, affordable and unlimited in the number of electricity consumption.

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MODELING OF GRAIN PRODUCTION PROFITABILITY BY FUZZY LOGIC

MODELOWANIE RENTOWNOŚCI PRODUKCJI ZBOŻA Z WYKORZYSTANIEM LOGIKI ROZMYTEJ

МОДЕЛИРОВАНИЕ РЕНТАБЕЛЬНОСТИ ЗЕРНОПРОИЗВОДСТВА С ИСПОЛЬЗОВАНИЕМ НЕЧЕТКОЙ ЛОГИКИ

Abstracts

Ukraine is an agrarian state. One of the most important brunches of agriculture sector is grain production. High yield of grain is a basis of Ukrainian food security. Therefore the task of developing a reliable mathematical model forecasting the grain production profitability is actually. Regression analysis and fuzzy simulation principles have been used for building of the grain production profitability depending model. The values profitability forecasting for 2015 obtained by three different methods are convergent to each other.

Keywords: *mathematical modeling, grain production, statistic model, regression analysis, profitability, yield, crop production, fuzzy logic, membership function.*

Streszczenie

Podstawą bezpieczeństwa żywnościowego Ukrainy są wysokie plony zbóż. W związku z tym szczególnie istotną kwestią jest opracowanie niezawodnego modelu matematycznego prognozowania produkcji zboża. Opracowano model szacowania rentowności produkcji zboża z wykorzystaniem analizy regresji i zasady logiki rozmytej. Przeprowadzona została prognoza rentowności produkcji zboża dla roku 2015 w oparciu o trzy różne formuły matematyczne, natomiast uzyskane wyniki predykcji były bardzo zbieżne.

Słowa kluczowe: *modelowanie matematyczne, produkcja zboża, modelu statystycznego, analiza regresji, rentowność, produktywność, logika rozmyta, funkcja.*

Аннотация

Основой продовольственной безопасности Украины являются высокие уро-

жаи зерновых культур. Поэтому задача разработки надежной математической модели прогнозирования зернопроизводства является актуальной. С использованием корреляционно-регрессионного анализа и принципов нечеткого моделирования нами построена модель рентабельности производства зерна. Выполнено прогнозирование значения рентабельности производства зерна на 2015 год тремя различными методами, результаты прогнозирования близки между собой.

Ключевые слова: *математическое моделирование, зернопроизводство, статистическая модель, регрессионный анализ, рентабельность, урожайность, нечеткая логика, функция принадлежности.*

Введение. Украина является аграрным государством и имеет значительный потенциал для дальнейшего развития аграрного сектора. Выращивание сельскохозяйственной продукции, в основном, сориентировано на зерновые культуры. Зерно дает возможность обеспечить животноводство зернофура-жом, а население не только хлебом и хлебопродуктами, но и сырьем для промышленной переработки. Зерно является не только источником продовольственной безопасности государства, но и через способность к длительному хранению и высокую транспортабельность чрезвычайно выгодно для экспортирования. За последние годы Украина уверенно вошла в группу стран – крупнейших экспортеров зерна в мире. Так, за итогами 2013-2014 и 2014-2015 маркетинговых годов Украина занимает третье место в мире по экспорту зерна на внешние рынки. Несмотря на заметный технологический прогресс последних лет, зерновая отрасль сохраняет зависимость от природно-климатических условий. Значительные колебания объемов производства зерна приводят к последующим ценовым колебаниям, и, как следствие, к экономической нестабиль-ности отрасли. Высокий урожай зерновых согласно закону зависимости цены от предложения вызывает спад цены на зерно и рентабельности производства и наоборот. Поэтому актуальной является задача разработки надежной математической модели для прогнозирования рентабельности производства зерна. Изучением роли факторов, влияющих на повышение рентабельности, а также математическим моделированием эффективности производства зерна занимались такие ученые как И.Б. Загайтов, В.В. Витлинский, П.М. Грицюк. Несмотря на значительные усилия, которые прилагаются для изучения данной проблемы, исследование динамики зернопроизводства и рисков, с которыми оно сопряжено, сохраняет свою актуальность благодаря изменениям климата и разнообразию климатических условий в различных регионах мира. Так, исследование динамики зернопроизводства в провинции Манитоба (Канада) проводилось с учетом погодной неопределенности и риска [B.T. Coyle, R.Wei, J. Rude, 2008]. Разработке системы принятия решений для оптимизации урожая кукурузы с учетом стохастических изменений климата посвящена диссертация Ж.В.Мэлде [J.W. Mjelde, 1985].

1.Статистическая модель рентабельности зернопроизводства. В системе зернопроизводства переплетаются разнообразные факторы: экономические, политические, хозяйственные, естественные. Как и в любой другой сложной системе, ее функционирование сопряжено с неопределенностью состояния внешней среды. Наличие неопределенности обусловливает возникновение рисков зернопроизводства.

При оценке рисков зернопроизводства рентабельность R является более объективным критерием, чем цена C. Выражение для рентабельности зернопроизводства имеет вид

$$R = P / Z - 1 = Y \cdot C / Z - 1. \quad (1)$$

Здесь P - доход (грн/га); Y - урожайность (ц/га); Z - затраты (грн/га); C внутренняя