



RESEARCH ARTICLE

Econometric analysis of grain yields (using the example of the Republic of Azerbaijan)

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Abstract

This article is an econometric analysis of the influence of factors affecting the yield of grain crops in the Republic of Azerbaijan. In the course of the work, the dependence of yield on climatic, economic and agrotechnical factors was assessed based on correlation and regression analysis. The results of statistical modeling were formed, which allows identifying the most important determinants, such as the number of meteorological workers, the level of mechanization of production at the enterprise, the average annual number of crops, the use of mineral fertilizers, and government funding. The data obtained can be used to develop detailed recommendations for increasing the efficiency of grain crop production, as well as developing forecast models to improve planning in agriculture.

Keywords: Productivity, Crops, Econometric analysis, Agriculture, Statistical modeling.

Introduction

Studying the productivity of grain products is an important element of agricultural science and practical achievements. The relevance of the mentioned topic is due to the fact that grain production plays a key role in ensuring food security, energy stability and economic development of many countries. From this point of view, it is considered necessary to note the relevance and importance of studying the productivity of grain products.

The priorities of the state's economic security transform over time in accordance with the historical stages of development of the state and global changes. Economic security is an important component that ensures the stability and sustainable development of the national economy, and its priorities must be updated in accordance with changes

in the internal and external environment. For example, for a state that has gained independence, the initial priorities are the formation of the national economy, the management of strategic resources and ensuring economic sovereignty. At this stage, the stability of the national currency, energy independence and the creation of basic infrastructure are of particular importance.

Later, in the phase of global economic integration, priorities are focused on expanding access to international trade, attracting foreign investment, and developing competitive economic sectors. Global trends such as technological changes taking place in the world, digitalization, and climate change also determine new priorities for the state's economic security.

In the modern era, food security, sustainable management of energy resources, ensuring cybersecurity, and developing an innovation-based economy occupy a special place among the priorities for economic security. Events such as pandemics and global crises show states the need to ensure internal economic stability and the sustainability of critical sectors.

Thus, the priorities of the state's economic security policy should be flexibly and proactively adjusted in accordance with changing realities, and a balance should be established between domestic needs and global challenges. This approach, while preserving the economic sovereignty of the state, creates a solid foundation for sustainable development and well-being.

Food security is one of the most important elements of socio-economic development as a basic indicator of human

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How to cite this article: Jamal, A.S., Shakir, A.S., Heydar, M.E., Bakir, M.E., Adalat, N.D. (2025). Econometric analysis of grain yields (using the example of the Republic of Azerbaijan). The Scientific Temper, 16(2):3693-3697.

Doi: 10.58414/SCIENTIFICTEMPER.2025.16.2.01

Source of support: Nil

Conflict of interest: None.

existence. Physical and economic accessibility of people to food products is the basis of their health, productivity and well-being. Ensuring food security is not limited only to improving the quality of life of people at the individual level, but also supports the overall social stability and economic development of society.

Without food security, other areas of development cannot be successfully implemented. Good and sufficient nutrition ensures the physical and mental development of a person, which increases labor capacity and directly affects the efficiency of the economy. At the same time, the lack of access to food products can lead to an increase in poverty, increased social discontent and even mass migration processes.

Food security on a global scale is also of strategic importance in terms of geopolitical stability and international cooperation. Global problems such as climate change, depletion of water resources and soil erosion further increase the challenges related to food security. Therefore, ensuring food security has become a priority direction of national strategies and international efforts.

In general, since food security is the fundamental basis for ensuring human existence and the sustainable development of society, the implementation of sustainable policies in this area should be one of the main tasks of every state and the international community.

The lack of full and rational use of the potential of the agro-industrial complex is one of the main problems that negatively affects the provision of food security. The fact that the volume of production in various sectors of agriculture only partially meets the domestic consumption needs of the population leads to the fact that a large part of the need for food products is met through imports. This creates a number of risks.

First of all, dependence on imports increases the risk of food shortages during price fluctuations in global markets and disruptions in supply chains. Secondly, this situation negatively affects the competitiveness of local producers and slows down the development of the agricultural sector. As a result, the existing resources and potential for the development of the agro-industrial complex are not fully realized.

To solve this problem, comprehensive measures should be implemented to increase production and improve productivity in all areas of the agro-industrial complex. For example, the introduction of modern technologies, support for local farmers, promotion of innovative irrigation and fertilization methods, as well as improvement of infrastructure for storage and processing of products would increase the efficiency of this sector.

By fully utilizing the potential of the agro-industrial complex, satisfying domestic consumption through local production can reduce import dependence and create

conditions for ensuring a higher level of food security. This approach would also increase economic sustainability and support the long-term development of the agricultural sector.

Food security is directly related to the threat of food shortages and is of strategic importance for preventing this threat. Food security refers to the continuous provision of people with quality, nutritious and accessible food products. Failure to ensure this can lead to serious socio-economic problems, increased poverty, food crises and even mass migration.

Food insecurity is caused by various reasons:

- Climate change and natural disasters: Climate change negatively affects food production through impacts such as drought, flooding and soil erosion.
- Scarcity of production resources: Limited water, fertile land and other natural resources reduce production potential.
- Import dependence: Insufficient development of domestic production forces countries to import food products from foreign markets, which increases vulnerability to problems in global supply chains.
- Financial and social inequality: Low-income groups have limited access to food products, which deepens nutrition problems.

To ensure food security, states should implement strategic measures:

- Increasing domestic production and improving productivity;
- Providing financial support to the agricultural sector and increasing farmers' knowledge;
- Creating modern infrastructure for the storage and processing of food products;
- Developing flexible response strategies to changes in global food markets.

Food security issues are one of the main elements not only of domestic economic development but also of national security. Therefore, the implementation of an effective and sustainable policy in this area is necessary for the sustainable development of countries.

A comparison of the current state of grain production in the region with the projected production volumes is an important indicator for assessing the development dynamics and potential of this sector.

Analyses of the current situation show that:

Current situation

- Production volumes mainly depend on the efficiency of existing irrigation systems, the state of land resource utilization and compliance with agrotechnical regulations.
- Decreased soil productivity and the impact of climate change are the main factors limiting the level of crop production.

- There are shortcomings in the application of modern technologies and the provision of agrotechnical services.

Forecasts

- Production is expected to increase due to the improvement of infrastructure, the introduction of modern seed varieties and the modernization of irrigation systems.
- Expansion of state support measures for the agricultural sector and an increase in subsidies will create conditions for increasing productivity.
- Although potential risks related to climate change continue, it is possible to minimize these impacts by applying adaptive methods.

The current production level has difficulty in fully satisfying the population's demand for grain products and increases dependence on imports. Forecasts show that as a result of the right policy and efficient use of resources in the agricultural sector, it is possible to increase production volumes and meet domestic demand. In this direction, special attention should be paid to increasing productivity and ensuring food security. Thus, a long-term strategy and sustainable development measures should be implemented to bridge the gap between the current state of grain production in the region and its projected potential.

First of all, various cereals and legumes are the main source of nutrition for the majority of the world's population. Studying the productivity of these crops will help develop effective methods to increase production to meet the growing demand for food and, as a result, determine ways to ensure food security for the country. It should be noted that since products such as corn are widely used in the production of biofuels in the country, increasing the efficiency of production in this area will significantly contribute to the stability of the energy sector, as well as create conditions for reducing our country's dependence on oil and gas. products. In this regard, it should be noted that studying the productivity of grain crops requires constant research and innovation, which, in turn, necessitates the development of new varieties, cultivation technologies, methods of combating diseases and pests in order to increase the efficiency. agriculture.

In general, studying grain yields not only contributes to food security, but is also a key element in the sustainable development of agriculture and the economy as a whole. Thus, at a time when issues of great importance to the country's economy, such as food security, sustainable development and energy efficiency, are becoming increasingly important, the relevance of econometric analysis of grain yields comes to the fore. An econometric approach to studying grain production not only provides tools for assessing the effectiveness of agricultural practices, but also plays a key role in making informed decisions in agriculture.

Grain plant productivity is a focus not only for agricultural enterprises but also for research institutes and the government of Azerbaijan. Population growth both globally and nationally, as well as the harsh conditions of climate change in recent years, have made identifying the factors affecting grain yields and determining optimal management strategies an integral part of achieving food sustainability and increasing agricultural productivity.

Econometric analysis of grain yields provides tools for modeling and assessing the impact of technological innovations, fertilizer use and other similar factors on the final results of agricultural production. This approach allows forecasting the current situation for a long-term period, as well as future trends, which in turn helps to develop effective management strategies and make informed decisions in the field of agriculture. In this context, econometric analysis of grain yields is an important tool for a rapidly changing world, where sustainability and efficiency of agriculture are becoming a necessity rather than a simple strategic choice.

Literature Review

Grain crop yield is one of the key indicators of agricultural efficiency, which directly affects food security and the economic development of the country. The scientific literature considers various approaches to studying the factors affecting crop yield, including agronomic, climatic and economic aspects.

Many authors emphasize the importance of climatic conditions, such as temperature, precipitation and soil moisture, as the main factors determining crop yield. Studies conducted in various regions show that fluctuations in weather conditions significantly affect the results of agricultural production.

Another important area of study is the impact of agronomic measures. Such measures include the introduction of modern soil cultivation technologies, the use of highly productive varieties of grain crops and the optimization of the fertilizer system. Research results demonstrate that increasing the level of mechanization and automation of agricultural production can significantly increase yields and reduce costs.

Particular attention is paid to economic factors, including government support for the agricultural sector. According to a number of studies, subsidy programs, preferential lending and tax breaks stimulate increased yields and sustainable development of agricultural production.

In the context of the Republic of Azerbaijan, the topic of grain crop yield analysis is of particular importance due to the dependence of the region's economy on the agricultural sector. Research by local authors emphasizes the need to take into account specific features, such as soil and climatic conditions and land tenure structure, to optimize production.

Econometric analysis methods are increasingly used in agricultural research. They allow identifying quantitative relationships between yield and the factors influencing it, which contributes to informed decision-making. An important contribution to this area is the work devoted to the use of regression models for yield forecasting based on climatic and economic data.

Thus, the literature confirms the need for an integrated approach to the study of grain crop yields. Analysis that integrates climate, agronomic and economic aspects helps develop effective strategies to improve agricultural productivity.

Modeling and methods of econometric analysis of grain crop yields. Empirical analysis of yields

The object of analysis is the time series of changes in the average yield of grain crops, which include winter wheat, spring wheat, oats, winter barley and spring barley, for the period from 2007 to 2021.

Conducting an analysis using descriptive statistics [2, p. 482], we see that the average yield of grain crops is 24.9 c/ha. Moreover, among the studied grain crops, the highest yields are shown by winter wheat and barley ($y_c = 28.4$ c/ha and $y_c = 26$ c/ha, respectively), and the lowest by oats ($y_c = 20.8$ c/ha).

Let us analyze the presence of a trend in the studied series using the Foster-Stewart criterion [3, p. 109].

Let us compare each level of the initial time series, starting from the second level, with all previous ones, and two numerical sequences are determined:

$$u_t = \begin{cases} 1, & \text{если } y_t > y_{t-1}, y_{t-2}, \dots, y_1 \\ 0, & \text{иначе} \end{cases}$$

$$m_t = \begin{cases} 1, & \text{если } y_t < y_{t-1}, y_{t-2}, \dots, y_1 \\ 0, & \text{иначе} \end{cases}$$

Next we calculate

$$S = \sum (u_t + m_t)_{t=1}^n, D = \sum (u_t - m_t)_{t=1}^n$$

To test the hypotheses about the random nature of the values $S-\mu$ and $D-0$ using the Student's criterion, we determine the calculated values of the criterion:

$$t_s = \frac{S-\mu}{\sigma_s} \quad t_D = \frac{D-0}{\sigma_D}$$

$t_s = 4.635/1.521$ and $t_D = 0.2153$, where the values of μ are the mathematical expectation of the value S , σ_s is the root-mean-square error of the value S and σ_D is the root-mean-square error of the value D , are found from the tables for $n=15$ [4, p. 76]. From the student's distribution table, we find the critical value, which will be $t_{cr}=2.13$.

If $t_D > t_{cr}$, then with a probability of 95% it can be stated that

Grain crop yield dynamics

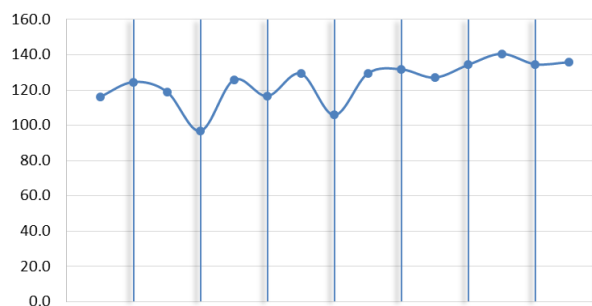


Figure 1: Dynamics of grain yield

there is a fundamental trend in the time series under study. Similarly, if $t_s > t_{cr}$, then the studied series contains periodic fluctuations. Calculations showed that the hypotheses about the absence of a trend in the mean and dispersion are rejected, therefore, in the dynamics series there is a trend and mean, and dispersion, and therefore, there is a trend. Let's conduct an analysis of the yield of grain crops on average (Fig. 1).

To select the best form of trend for grain as a whole, we compare the equations of linear, quadratic and exponential regression.

Linear trend

$y = 0.3502x + 22.104$, $R^2 = 0.4345$, in this regression, all parameters are significant according to Fisher's and Student's criteria [5, p. 62].

Quadratic trend

$y = 0.0256x^2 - 0.0602x + 23.266$, $R^2 = 0.4689$, all parameters are significant.

Indicative trend:

$y = 22.127e^{0.0142x}$, $R^2 = 0.3992$, all parameters are significant.

Thus, it is necessary to select a quadratic function as the trend equation. Parameter b_0 here shows the initial conditions of the process development, i.e. the average grain yield in 2007 in the Republic of Azerbaijan was 23.266 c/ha; parameter b_1 is a constant growth rate, in other words, every year the grain yield falls by 0.0602 c/ha; parameter b_2 is the growth rate, which shows the rate of change of this process, i.e. Every year the rate of decline in grain crop yields increases by 0.0256 c/ha.

The adequacy of models to the real process is tested based on the random component analysis. It is generally accepted that the model is adequate if the residual values satisfy the properties of randomness, independence and normality of distribution. The assumption of normality of residuals can be tested using the asymmetry and kurtosis indices [6, p. 315]:

$A = -1.0289$, $E = 0.812952$, then the hypothesis of normal distribution is accepted.

The independence of the residuals can be tested using the Durbin-Watson criterion [7, p. 108]. At a significance level of 5% and $n=15$, the critical values of Durbin-Watson are $dL = 1.08$ and $dU = 1.36$, then $4-dU = 2.64$ and $4-dL = 2.92$. The actual value $d = 2.62$, constructed for our model, belongs to the interval $[dU, 4-dU]$, therefore, the hypothesis of independence of random deviations is accepted. In other words, the constructed model can be used to forecast the yield of grain crops in Azerbaijan.

Let's construct a yield forecast using the selected quadratic model:

$y(t=2023)=28.06$ c/ha, $y(t=2024)=28.41$ c/ha. The approximation error is $A=0.0556=5.6\%$.

Results and Discussions

Based on the above, we came to the conclusion that, in general, there has been a dynamic growth in grain crop yields over the past 15 years. However, this growth is characterized by a quadratic trend. The decline in yields of all crops under consideration in 2010 is explained by natural disasters observed in the country. The reduction in the area under crops was a negative consequence of the torrential rains observed in the country in the spring. Thus, as a result of the Kura River overflowing its banks due to continuous rains, flooding occurred in 40 regions of Azerbaijan, and more than 1.529 million hectares of arable land were damaged. All this indicates qualitative changes in the agro-industrial complex, contributing to rational land

use and strengthening food security in Azerbaijan. Not only the process of reproduction and use of land resources itself is interdependent but also measures for their efficiency and sustainability.

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