

Econometric Analysis of the Poultry Industry Development in Kazakhstan

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Abstract

Background/Objectives: The article is aimed to assess the relationship between factors and determine predictive values of growth of the main indicators characterizing the development of the poultry industry in Kazakhstan. **Methods/Statistical Analysis:** We used such research methods in the study as analysis and synthesis, calculation and design methods, factor analysis, correlation and regression analysis and econometric methods and models for substantiation of poultry sector development in the country; identifying the link between performance indicator and factors determining it. **Findings:** The value of this article consists in developing proposals formulated as a result of calculations by statistical and econometric methods and models. According to the results of the study we identified and assessed factors influencing the efficiency of the poultry industry indicators. The econometric and correlation-regression models of forecasting and development of the poultry industry economy have been worked out, the impact of the selected factors on the production of poultry meat in the country has been identified and quantified and the extent of their impact on the industry growth and development has been revealed. **Improvements/Applications:** The research results can be used to develop strategic plans for the future and to enhance the competitiveness of the poultry industry in the country.

Keywords: Econometric Models, Factor Analysis, Forecast, Poultry Industry, Productivity, Regression Analysis

1. Introduction

General trends in the development of agricultural production are manifested in its branches in varying degrees. Food sub complexes are distinguished in food complexes on a sectoral basis. They are a collection of companies and organizations both for the production of raw materials and receiving finished products, as well as those serving sub complexes. Food sub complexes have their own specifics and their development is carried out by external and internal factors, the impact of which will be exemplified by the poultry sub complex of the country.

Poultry sub complex is a collection of entities belonging to different sectors of the economy associated with the production of eggs, poultry meat and its processing and bringing products to the consumer, as well as a set of economic relations arising between them¹.

As it is known, poultry farming is one of the most

highly effective and rapidly growing industries. Slaughter yield of poultry meat is on average 66% of the live weight, which is 1.5 times higher than that of cattle. Highly productive chicken of laying breed throughout the year can lay 320 eggs with an average weight of 60 grams each.

Enterprises of poultry sub complex can plan and organize their activities by one of the pre-designed strategies to create preconditions for the development and competitiveness, implementing the research and forecasting environmental change^{2,3}. With sufficient information, it is advisable to calculate the regression equation for the environment based on partial regression dependencies.

However, poultry sub complex, unlike other food sub complexes, is characterized by homogeneity of resources used in the production process, therefore, of this research is based on the sectoral approach, although in the future the territorial aspect will also be taken into

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consideration. It is necessary to select and justify the state of poultry sub complex internal factors, where the basic conditions of increase in efficiency of poultry production are the rational use of human and material resources and ensuring the growth of poultry products, mainly due to the increase in labor productivity.

Each of the considered indicators can be applied as a factor of another indicator, of a higher order and vice versa. Therefore, the peculiarity of the proposed approach is to analyze the factors concerning three issues: Trends of gross output; trends of production costs; trends of economic efficiency of poultry sub complex production⁴. At the same time, all subjects of poultry sub complex in market conditions are penetrated with complex organizational relationships, significantly affecting the feasibility of their economic interests, especially in terms of the efficient use of factors at enterprises and organizations. Therefore, the general order of calculation assumes the analysis of the poultry sub complex organizational level.

2. Materials and Methods

We used methods and techniques of analysis and synthesis of economic and statistical, computational and structural methods, correlation and regression and econometric models.

At deterministic analysis of trends of poultry sub complex gross output we initially suggest using the multiplicative model of the following type:

$$y = f(x_1, x_2, x_3, \dots, x_i, \dots, x_n). \quad (1)$$

The task of deterministic multivariate analysis is to identify and quantify the impact of each factor on a productive indicator^{8,9}. Calculations enabled to reveal the dependence of profit amount from the production of eggs (y) on the following four factors:

- x_1 - Average egg yield per one laying hen, pcs. eggs;
- x_2 - Eggs production per 100 hectare of cereal crops, thous. pcs.;
- x_3 - Prime cost of 10 pcs. eggs, tenge;
- x_4 - Feed consumption per 10 pcs. eggs, kg feed units.

The following mathematical functions have also been used to describe and quantify the relationship between two variables:

Linear Function

$$y = a + bx + \varepsilon \quad (2)$$

Polynomial Function

$$y = a + bx + cx^2 + \varepsilon \quad (3)$$

Exponential Function

$$y = ae^x + \varepsilon, \text{ etc.} \quad (4)$$

When analyzing trends of poultry sub complex gross product the multiplicative model of the following type was used:

$$y = \prod_{j=1}^n x_j = x_1 \cdot x_2 \dots x_n, \quad (5)$$

Where, y - A performance indicator;

x_1, x_2, x_3 - Factor indicators.

In this case, the modeling of multiplicative system is advantageously carried out by successive subdivision of factors of original system on factors-multipliers⁴. The process of gross product formation (Figure 2) should be presented in the form of the following deterministic models: $GP = Q \cdot p$; $Q = b \cdot q$; $GP = b \cdot q \cdot p$;

3. Results and Discussion

A research should be taken by consistent study of the elements of the system using methods of simulation of relationship between performance indicators and factors that determine their value. Its essence lies primarily in the fact that the interaction of the investigated indicator with factors is transmitted in the form of the particular mathematical relationship and both functional and correlation models can be used. With the use of factor models the functional relationship between the performance indicator and factors is investigated. When modeling deterministic factor systems, the following rules are used:

- Factors included in the model, and the models themselves have a pronounced character, do exist, and are not abstract values or events;
- Factors belonging to the system are in a causal relationship with the studied parameters;
- Indicators of factor models are quantitatively measurable;
- Factor models should be capable of measuring the effect of individual factors, i.e., they must take into account the proportionality of the changes of effective and factor indicators, and the amount of influence of

the individual factors should be equal to the overall increase in performance indicators.

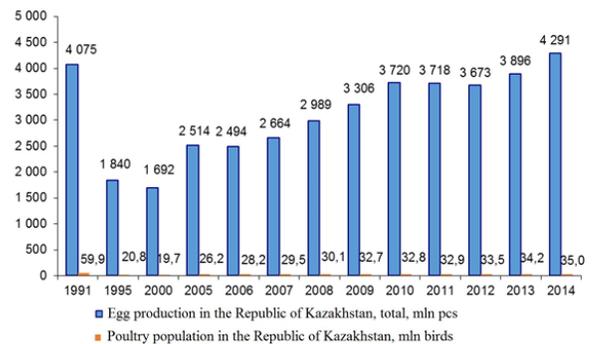
After the consistent study of the system, it is necessary to carry out the analysis and to evaluate and compare the data. When getting a positive result, it is necessary to formulate forecasts of development and introduction into production. The analysis of the organizational level of poultry sub complex, which for decades has undergone significant changes both at the level of the economy of the country as a whole and at the regional level characterizes the organizational environment of functioning of the poultry sub complex subjects⁵.

In the Republic of Kazakhstan (RK) the main part of the poultry population (65.2%) is concentrated in specialized poultry farms; it is 22.8 million birds. The increase in production of eggs and poultry in specialized poultry farms is determined to a greater extent by implementation of factors of an intensification of production; and in households this growth is determined rather by opportunities of guaranteed and profitable in terms of price-cost sale and the development of cooperation. Small-scale sector may get more favorable market positions in marketing of poultry meat and eggs, as well as to effectively organize production, taking only advantages of the cooperation.

Cooperation in poultry sub complex allows more effectively addressing strategic challenges of industry. Large processing plant of poultry meat offering high prices for poultry meat of a certain quality is interested in large wholesale suppliers of poultry, with the volume of daily shipments of more than 5-10 tons. This does not include small poultry producers whose seasonality of production is small which does not suit the largest processing plants interested in stable and balanced utilization of equipment. Therefore, in order to consolidate the poultry producers with production volumes from 4 to 20 tons per day, it is necessary to create sale cooperatives. Such cooperatives must ensure quality standards for poultry meat imposed on poultry meat by large processing plants⁶.

Production associations and plants have become more complex forms of integration and cooperation in the poultry industry. The integration of highly specialized enterprises in a single economic complex for the production, processing and sales was carried out in poultry associations for the production of certain types of

goods. In addition, all enterprises maintained economic independence, right of a legal entity.



Note. Compiled and calculated by the author according to the sources⁷.

Figure 1. Dynamics of poultry population and egg production in the Republic of Kazakhstan in 1991-2014.

General economic trends in the development of production of that period were directly reflected in Kazakhstan, where two specialized associations were formed to produce meat and eggs. Specialization and concentration of production, the development of economic links were important factors in the intensive progress of poultry farming, especially at the beginning of the industry drive to industrial basis. Strengthening of material and technical base in the poultry farming, further development of intra-industry specialization combined with the production concentration allowed more intensive exploitation of scientific and technological progress and the acceleration of the pace of production. All this allowed a rapid creation of a cost-effective poultry sub complex system in the country, acting as a holistic structure of managing the branch at all levels: National, regional and directly at the level of poultry farms.

An analysis of the dynamics of egg-laying capacity showed that it increased by 105.3% in 2014 compared to 1991 and it saw a steady growth by 1.6 times from 2007 to 2014. However, by the beginning of economy reforming the production reserves have been exhausted, it was costly and egg-laying hens' capacity was only 160 eggs in 1991⁷. The following characteristics of the economy of that time affected the state of the industry: A lack of common economic interests between partners-subcontractors for the production and bringing the final product to the consumer; violation of the equivalence of an inter-branch exchange; a lack of competitiveness; existing financial

and credit system; price mechanism, ignoring the laws of supply and demand. Reforming the economy and especially the privatization program changed the legal form of enterprises in poultry sub complex. Joint-stock companies, limited liability companies, cooperatives and farms emerged.

As a result of market changes, enterprises began to decide all questions of economic and financial activity by their own and at the regional level there were created independent poultry units and peasant (farmer) households. Competition mechanism requires new forms of cooperation, which are deeper and affect economic relations at all stages of the reproductive process. For example, they can be in the form of integration of engaged market participants and be an organizational form of competitiveness enhancement, whose effectiveness is justified in terms of the market mechanism activities.

The proposed models reflect the process of specification of the original factor system of multiplier type and its extension by disaggregation of multipliers of complex factors. The process of gross product formation (Figure 2) should be presented by the following deterministic models: $GP = Q \cdot p$; $Q = b \cdot q$; $GP = b \cdot q \cdot p$;

Factor system can be represented as a product of two factors of the first order: Comparable price and gross production, which, in turn, depends directly on the average annual poultry population and its productivity (Figure 2). The development of a deterministic factor

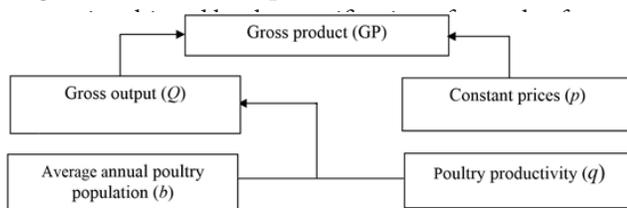


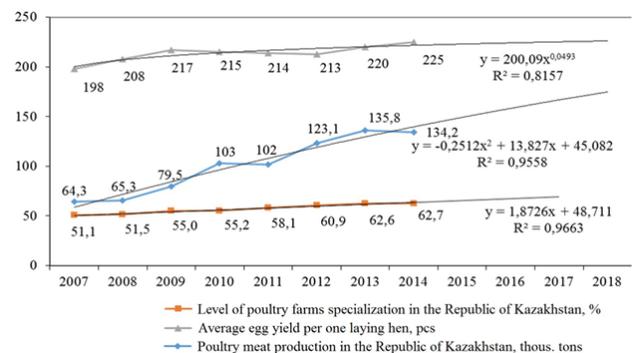
Figure 2. Deterministic factor system of poultry sub complex gross product.

It is necessary to consider the second order factors in more detail. The most important of them is the poultry productivity. We consider its condition and impact on the trends of gross product using the example of egg-laying capacity. Its amount is influenced by species composition, technological process peculiarities and housing conditions, feed ration, etc. Dynamics of egg-laying capacity in poultry sub complex of the country can be judged from the data in Figure 3.

As seen in Figure 3, egg-laying capacity varies from year to year. The absolute gain expresses the absolute rate of growth of dynamics level in egg production. Thus, there has been an increase in egg-laying capacity relative to the 2007 reference year during three years, it became to fall starting from 2010; the absolute growth peaked in 2014 and the level of egg-laying capacity reached 225 eggs.

To identify trends in egg-laying capacity changes we will make an analytical alignment of time series of egg-laying capacity along a straight line⁸. Having solved the system of equations, we get $y = 200,09x^{0,0493}$, $R^2 = 0,8157$.

Based on the obtained straight-lined equation we will represent the aligned series of egg-laying capacity, abstracted from the effects of random factors that determine its value.



Note. Compiled and calculated by the author on the basis of the data of the RK Statistical Agency⁷

Figure 3. Analytical alignment of time series of hens' egg-laying capacity in the Republic of Kazakhstan.

The change in hens' egg-laying capacity, taking into account the forecasted level for the calculated straight-line equation is shown in Table 1. Using the index analysis, we will determine the impact of the second order factors on the deviation of egg gross product – the average annual population of poultry and its productivity (egg-laying capacity). The table data show that in 2014 the production of eggs was by 1,591 million pieces more than in 2007. This increase (by 1,082 million pieces) is due to the growing number of layer pullets in the country.

The increase in production by 509 million pieces is due to an increase in egg-laying capacity. The analysis demonstrates that an increase in the average annual poultry population had a decisive influence on the gross product.

Prime cost of poultry products is affected by factors

Table 1. Results of calculations of factor influence on the change in gross egg-laying capacity in the Republic of Kazakhstan

Years	Average annual laying hen population		Egg-laying capacity, pcs. In total	Gross output of eggs, mln. pcs.	Deviation, mln. pcs.								
	Denotation	Mln birds			Including as a result of changes								
					Average annual population				Egg-laying capacity				
2007	b_0	13.6	q_0	198	$b_0 q_0$	2,700	-	-	-	-	-	-	-
2014	b_1	19.1	q_1	225	$b_1 q_1$	4,291	-	-	-	-	-	-	-
Conventional year	-	-	-	-	$b_1 q_0$	3,782	$b_1 q_1 - b_0 q_0$	1,591	$b_1 q_0 - b_0 q_0$	1,082	$b_1 q_1 - b_1 q_0$	$b_1 q_1 - b_1 q_0$	509

Note. Compiled and calculated by the author according to the sources⁹.

such as poultry productivity, labor productivity, the use of advanced technologies with a comprehensive mechanization of production processes, feeding level, use of productive poultry breeds.

First of all, it is necessary to determine the presence and direction of the connection between the prime cost of poultry products and each factor. Undoubtedly, there is a close connection between them. In this case only the poultry productivity has the direct impact on the production prime cost. All other factors affect the production prime cost, not only directly but also indirectly – through poultry productivity and labor efficiency. For example, a balanced feeding promotes poultry productivity which causes a decrease in unit prime cost under otherwise identical conditions.

However, we must take into account the fact that the use of expensive high-performance feed additives leads to an increase in the cost amount per output unit. And if the cost amount increases more rapidly than productivity, then the production prime cost will rather decrease than increase. So, the relationship between these indicators can be both direct and reverse. Similarly, the use of advanced technologies with a comprehensive mechanization of production processes affects the production prime cost. The use of such technologies can lead to higher costs. If they grow to a greater extent than the labor efficiency and poultry productivity, the production prime cost will increase and vice versa¹⁰.

Study of the relationship between the factors shows that of all the factors presented in this section there is no causal link between the feeding level, use of productive breed poultry and complex mechanization of production processes. There is no direct inverse dependence of these indicators from poultry productivity level as well. All other factors directly or indirectly influence each other.

In order to identify trends in the poultry meat production in Kazakhstan, we obtained polynomial equation by solving the trend model $y = 45.032 + 13.827x - 0.2512x^2$, $R^2 = 0.955$. The analysis of determination coefficient indicates a high level of approximation of the initial data (Figure 3).

Calculations show that the values of pair correlation coefficients indicate a very close relationship of poultry meat production volume y both with the poultry population in the country – x_1 as well as with the specialized poultry farms' expertise level – x_2 ($r_{yx_1} = 0.927$ and $r_{yx_2} = 0.974$). But at the same time cross factor relationship $r_{x_1x_2} = 0.936$ is very close and exceeds the degree of connection of x_2 with y .

The impact of the cyclical economic development law in recent years and therefore the occurrence of the world crisis had a significant impact on the pricing mechanism in the industry, so for the last five years the dynamics of this indicator reflects not only the objective processes in the country's poultry sub complex, but also external ones relating to sub complex processes; their study is a

necessary condition for an estimation and forecasting of future state of the industry.

The prime production cost is a value index, the amount of which is significantly affected by the state of the market, business environment, inflation, etc. The prime production cost is a general indicator of industrial sector activity; this indicator depends on the volume of production, consumption of resources and their efficient use. Evaluation of the effectiveness of the aggregate resource usage can be given by per-unit prime production cost (per 1000 pcs. eggs) index.

Summative evaluation of the financial state of the industry is given on the basis of such resulting financial performances, as profit that is an absolute indicator and profitability – a relative one. Profit and profitability reflect the production process efficiency.

As can be seen from Table 2, the profitability level of eggs reached up to 32.0% in the country in 2011, it affected the prime cost level for 1000 pcs. eggs, which equaled to minimum level of 8987 tenge; since 2013 the level of average sales price of eggs increased and this affected the growth of the profitability level to 16.9% in 2016.

In the cost structure of poultry production, the largest share belongs to material costs. Over the past three years their growth has been realized. The deviation in 2014 was more than 20% compared to 2011. This is due to the active use of a wide range of expensive feed additives, veterinary drugs at the country's poultry farms. A share

of fuel and electricity costs has also increased. The annual growth of these expenses is due primarily to the increase in electricity prices, fuel and gas costs.

An important final element is the aggregate index of prime production cost – expenses per 1 tenge of output. Firstly, it is universal: It can be calculated in any manufacturing industry, including poultry; secondly, it clearly shows a direct relationship between the prime cost and the profit. This indicator is calculated by the ratio of total cost of production and sales to the value of gross product in current prices.

As shown in Table 3, the level of this indicator increased by 3.6% over the reference period. During this period, a steady growth trend was observed, although its rates fluctuated over the years. Expenses per a tenge of output directly depend on changes in the total cost of production and sales and in the price of manufactured products. The total cost is influenced by production output of a poultry sub complex, its structure, the change of variable and fixed costs, which, in turn, may increase or decrease due to the level of production resource efficiency and prices of the consumed resources. And the price of the manufactured product depends on the output volume, its structure and product prices^{11,12}.

The current tendency to reduce expenses per a tenge of poultry sub complex product in the country as a whole has a positive effect on the final financial results and performance indicators for sub complex functioning.

Table 2. Dynamics and calculation of profitability ratio of eggs in Kazakhstan

Indicators	2010	2011	2012	2013	2014	2014 to 2010 (+/-)
Average selling prices of 1000 pcs eggs, tenge	11,293	11,864	11,803	13,121	13,066	1,773
Prime cost of 1000 pcs eggs, tenge	9,318	8,987	10,861	11,352	11,176	1,858
Profit from 1000 pcs eggs, tenge	1,975	2,877	942	1,769	1,890	-85
Level of profitability of eggs, %	21.2	32.0	8.7	15.6	16.9	-4.3

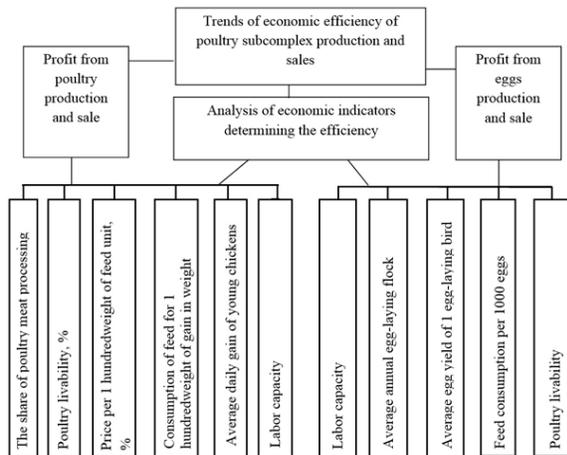
Note. Compiled and calculated by the author according to the sources⁷.

Table 3. Dynamics of the expenses per 1 tenge of poultry sub complex products in the Republic of Kazakhstan

Years	Indicator level, tenge	Growth rate (drawdown), %		Rate of increase (drawdown), %	
		Chain-type	Primary	Chain-type	Primary
2010	82.5	100	100	-	-
2011	75.8	91.8	91.8	-8.2	-8.2
2012	92.0	121.3	111.5	+21.3	+11.5
2013	86.5	94.0	104.8	-6.0	+4.8
2014	85.5	98.8	103.6	-1.2	+3.6

Note. Compiled and calculated by the author according to the sources⁷.

Economic efficiency trends and the factors that determine it are shown in Figure 4. Their peculiarity is a separate analysis of the trends of economic efficiency of production and sales of poultry and eggs. This approach at the final stage of the analysis of the factors is due to the peculiarities of the production and sales of poultry and eggs.



Note. Compiled and calculated by the author by the sources^{13,14}.

Figure 4. Factor system scheme of production efficiency.

Therefore, indicators of economic efficiency are closely related to the manufacture and prime production costs and they depend on a combination of factors – enterprise’s production, marketing and financial activity. Factors of the first level of subordination are reflected in the general algorithm of the system of analytical blocks of poultry sub complex factors; and the method of its analysis is given below^{15,16}.

The generation of profits from poultry is influenced by many factors, the connection of which with the performance indicator is probabilistic, correlational opposed to the functional one. We consider the relationship between the profit value and technological factors.

Multiple regression equation expressing the dependence of the profit (y) from the egg-laying capacity – x_1 , egg production per 100 hectares of cereal crops – x_2 , cost of 10 pcs eggs – x_3 , feed consumption per 10 pcs eggs – x_4 is the following one:

$$y = 79.282 + 0.125 x_1 + 1.535 x_2 - 0.789 x_3 - 25.692 x_4 \quad (2)$$

The coefficient of multiple correlations between performance and factor characteristics reflects a direct,

substantial connection $R^2 = 0.699$. The coefficient of multiple determination shows that the variation of profit by 69.9% depends on four factors. Thus, the selected factors have a significant impact on profit^{9,14}.

The analysis of regression coefficients of the multiple regression equation allows making a conclusion about a degree of influence of each of the four factors on the profit amount. Thus, when egg-laying capacity increases by 1 egg, egg production per 100 hectares of crops per unit increases as well and the profit increases by 0.125 and 1.535 tenge, respectively. With cost development by a unit and an increase of feed consumption by 10 eggs per unit, the profit declines by 0.789 tenge and 25.692 tenge, respectively.

The analysis of trends and patterns of economic processes in the poultry sub complex, the indicator assessment of capacity, the system of econometric models developed during the evaluation process, the expert method allowed identifying the main lines of further increase in production and economic potential of poultry sub complex enterprises¹⁷.

4. Conclusions

In comparison with other sectors of animal husbandry poultry industry has the greatest possibility of achieving food security, due to the rapid reproduction of the population, the lowest cost of material resources per output unit, the highest rate of increase in the volume of production, the lowest payback period, as well as lower consumer prices.

The main conditions for increasing poultry efficiency are the rational use of resources and ensuring the growth of poultry products, mainly due to the increase in labor productivity.

As a result of factor analysis, the value of multiple determinations co-efficient was of a very high degree of conditionality, so the creation of competitive poultry units involves the justification of their parameters according to the production areas and consideration of existing specialization of production region-wise.

The values of pair correlation coefficients indicate a very close relationship of poultry production volume, both with the poultry population in the country and with the proportion of specialized poultry units; furthermore,

improving the technology of production of eggs and poultry of all kinds involves maximum use of operating capacities due to their expansion and modernization, stimulation of the processes of formation of medium and large commercial poultry industry; assistance for poultry concentration in farms by their association in cooperatives.

The sector development cannot be achieved without control of external and internal factors of production, affecting the cost performance of enterprises.

In the study of the status and trends of industry development the comparative and factor analysis was performed, indicators were selected, the impact of individual factors on a performance indicator was determined. The research proved reserves of growth for each of them and showed the implementation mechanism.

Using index analysis, we determined the influence of the average annual poultry population and its egg-laying capacity on the deviation from the gross production of eggs. An increase in the average annual poultry population had a decisive impact on the gross product.

Tools of economic-statistical and econometric modeling of poultry industry development were used. Based on the stage-wise analysis the models were identified and the algorithm for solving them was justified. This model system allows creating a single tool of production development management at the poultry sub complex enterprises.

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