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# ALGORITHMIZATION AND PROGRAMMING OF ECONOMETRIC MODELS OF POPULATION DEMAND FOR MEAT AND DAIRY PRODUCTS

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***Abstract.*** *In this article, the theoretical basis of the processes of using food resources in the Republic of Uzbekistan is studied. Also, the issues of production and use of primary food products delivered to the population were considered, and the meat and dairy products produced and delivered to the population in 2001-2021 were analyzed economically. In studying and analyzing the consumption of these products, numerical results were obtained by creating an econometric model of this process. Based on the results, economic analyses, conclusions and proposals were developed. Also, in this article, a program was created using the Python programming language to perform correlation and regression analysis.*

***Keywords:*** *food safety, econometric model, correlation, regression, regression equation, pair correlation, mean square deviation, dispersion.*

# АҲОЛИНИНГ ГЎШТ ВА СУТ МАҲСУЛОТЛАРИГА ТАЛАБИНИНГ ЭКОНОМЕТРИК МОДЕЛЛАРИНИ АЛГОРИТМЛАШТИРИШ ВА ДАСТУРЛАШ

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***Аннотация.*** *Ушбу мақолада Ўзбекистон Республикасида озиқ-овқат ресурсларидан фойдаланиш жараёнларининг назарий асослари ўрганилган. Шунингдек, аҳолига етказиб берилган бирламчи озиқ-овқат маҳсулотларини ишлаб чиқариш ва улардан фойдаланиш масалалари кўриб чиқилиб, 2001-2021 йилларда ишлаб чиқарилган ва аҳолига етказиб берилган гўшт ва сут маҳсулотлари иқтисодий таҳлил қилинган. Ушбу маҳсулотлар истеъмолини ўрганиш ва таҳлил қилишда ушбу жараённинг эконометрик моделини яратиш орқали сонли натижалар олинди. Олинган натижалар асосида иқтисодий таҳлиллар, хулоса ва таклифлар ишлаб чиқилди. Шунингдек, ушбу мақолада Python дастурлаш тили ёрдамида корреляцион ва регрессион таҳлилни амалга оширувчи дастур яратилди.*

***Калит сўзлар:*** *озиқ-овқат хавфсизлиги, эконометрик модель, корреляция, регрессия, регрессия тенгламаси, жуфт корреляция, ўртача квадратик четланиш, дисперсия.*

# АЛГОРИТМИЗАЦИЯ И ПРОГРАММИРОВАНИЕ ЭКОНОМЕТРИЧЕСКИХ МОДЕЛЕЙ СПРОСА НАСЕЛЕНИЯ НА МЯСНУЮ И МОЛОЧНУЮ ПРОДУКЦИЮ

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***Аннотация.*** *В данной статье исследуются теоретические основы процессов использования продовольственных ресурсов в Республике Узбекистан. Также рассмотрены вопросы производства и использования первичных пищевых продуктов, поставляемых населению, а также произведенные и поставленные населению мясомолочные продукты в 2001-2021 годах проанализированы экономически. При изучении и анализе потребления этих продуктов были получены численные результаты путем создания эконометрической модели этого процесса. По результатам были разработаны экономические анализы, выводы и предложения. Также в данной статье создана программа с использованием языка программирования Python для проведения корреляционного и регрессионного анализа.*

***Ключевые слова:*** *пищевая безопасность, эконометрическая модель, корреляция, регрессия, уравнение регрессии, парная корреляция, среднеквадратическое отклонение, дисперсия.*

## Introduction.

Currently, a number of important reforms are being carried out in our country to provide the population with quality primary food products. In particular, if we look at the types of primary food products, these are meat and meat products, milk and milk products, wheat, rice, vegetables, fruits, sugar and dairy products. Also, when it comes to the lifestyle and health of the population, the role of protein-rich meat and dairy products in these food products is incomparable. Of course, the issue of regularly delivering products necessary for human health to the population is a complex one. The reason is that in order to solve this problem, it is necessary to produce the necessary amount of product per capita. This production process is directly related to the development of animal husbandry. It is also necessary to determine the amount of necessary production products, to determine the factors affecting it, and to perform econometric modeling.

Therefore, a number of decisions and decrees have been issued in our country on the development of animal husbandry and the study of the experiences of developed countries in the use of modern technologies. In particular, the decision PQ-4243 of the President of the Republic of Uzbekistan "On measures to further develop and support the livestock sector" defines the following measures and priority tasks. Rapid development of the livestock sector plays an important role in providing our people with cheap and high-quality meat and other food products, especially in increasing the employment and income of citizens living in rural areas. At the same time, the current state of affairs in the regions requires specific comprehensive measures to support the enterprises of this sector, increase the feed base, improve breeding, including the development of artificial insemination, and strengthening the material and technical base of breeding farms. it is necessary to implement the measures. Comprehensive support for entrepreneurial initiatives of our people in the development of animal husbandry, wide introduction of scientific approaches and advanced modern technologies in this sector, further stimulation of the production and processing of import-substituting and exportable livestock products, and ultimately the welfare of the population In order to improve and increase their income, the following priority tasks are defined.

Therefore, in order to fulfill these priority tasks and satisfy the population's demand for high-quality meat and dairy products, it is necessary to carry out an analysis of these products in relation to the population and determine the amount of resources that will be needed in the

future. Based on these determined indicators, it is possible to clearly define strategies for the development of the livestock sector. It is also necessary to use the elements of econometric modeling in the study of this economic process. In this case, it will be possible to calculate economic changes by determining correlation coefficients and creating a regression equation.

## Literature review.

At present, consistent reforms are being carried out to further improve and develop the infrastructure of agriculture and animal husbandry in our country. In particular, the decision of the President of the Republic of Uzbekistan "On measures to further develop and support the livestock sector" dated 18.03.2019 No. PQ-4243 defines priority tasks for the development of this sector (Decision, 2019).

Consistent scientific research is being carried out by scientists from all over the world to further develop the livestock sector. In particular,scientists Gorbatovsky in his scientific work "Management of Fodder Production Reserves and Evaluation of Its Economic Efficiency" discussed in detail the types of feed needed for livestock and its feed units. Also, in the development of animal husbandry and increasing its economic efficiency, he cited models for the development of feed rations using optimization methods (Greene, 2011). In addition, Lenkov in his scientific works, instructions were given on the use of optimization models and econometric models for economic mathematical modeling and forecasting of agricultural activities (Gujarati, 2022).

We can cite significant scientific results of our country's scientists on solving these issues. In particular, Saukhanov (2022) economic mathematical models and econometric models for assessing the economic efficiency of agricultural development in the conditions of Karakalpakstan and reducing transaction costs are proposed. In this scientific research work, the results of these scientific works and the developed models were studied and analyzed.

Saidova, Rustamova, Tursunov's "Agrarian Policy and Food "Food Safety" (2016).

Economic analytical opinions are presented. Ishnazarov, Nurllaeva. In the work "Introduction to Economics," the econometric analysis of economic processes methods and techniques necessary for modeling and economic analysis Methodologies of use are given. Along with this, Saukhanov in a number of scientific works on agriculture in the Aral Sea region on growing and increasing the economic efficiency of agricultural products analytical data are presented (Tashev et al., 2022).

## Research methodology.

During this scientific research, empirical results were obtained using systematic analysis of the opinions and recommendations of scientists of the world and our country, empirical research methods, analytical synthesis methods, economic mathematical modeling and the method of least squares in econometric modeling.

## Analysis and discussion of results.

Due to the rapid increase in the population and limited opportunities for food production, the issue of providing the population with quality food is becoming a major problem in many countries. During the years of independence in Uzbekistan, great achievements were made in this field, including the production of agricultural products doubled. Taking this into account and taking into account the growing demand for meat and dairy products, it is necessary to study the factors affecting it. Population growth in our republic leads to an increase in the demand for meat and dairy products. The results of econometric analysis of food products are necessary to study the impact of meat and dairy products on population growth and to fully satisfy the demand (Kazievish, 2020; Juraev and Rakhimberdiev, 2022; Karimov et al., 2022).

Statistical data on the production and use of food products in our country for 2000-2021 (Table 1 and Table 2) are presented. In the economic analysis of this economic process, we need to create an econometric model using these statistical data.

In the analysis of this economic process, we need to separate statistical data into the following variables. The mentioned issue is a multi-factor economic process, and we will analyze it according to the statistical data of 2 types of primary food products for 2000-2021. Here, $x_1$ is the volume of meat products delivered to the population (thousand tons), $x_2$ is the volume of dairy products (thousand tons) and $y_i$ is the growth rate of the population. In our case, the influencing factors are defined in the interval $x_i$, $i=1,2$ . In the economic analysis of this economic process, we need to create an econometric model using these statistical data (Rakhimberdiev et al., 2022).

**Table 1**

**Indicators of meat and dairy products delivered to the population in 2000-2010**

| Years | Demographic change of the population (thousand people) | Products | |
|---|---|---|---|
| $i$ | $y_i$ | $x_1$ -Meat products (thousand tons) | $x_2$ -Dairy products |
| 2000 | 24487,70 | 841,80 | 3632,50 |
| 2001 | 24813,10 | 853,50 | 3665,20 |
| 2002 | 25115,8 2 | 865,10 | 3721,30 |
| 2003 | 25427,90 | 936,70 | 4031,10 |
| 2004 | 25707,40 | 998,30 | 4280,50 |
| 2005 | 26021,30 | 1061,50 | 4554,90 |
| 2006 | 26312,70 | 1139,40 | 4855,80 |
| 2007 | 26663,80 | 1208,70 | 5097,50 |
| 2008 | 27072,20 | 1288,00 | 5426,30 |
| 2009 | 27533,40 | 1367,80 | 5802,50 |
| 2010 | 28001,40 | 1461,40 | 6169,00 |

**Table 2**

**Indicators of meat and dairy products delivered to the population in 2011-2022**

| **Years** | **Demographic change of the population (thousand people)** | **Products** | |
|---|---|---|---|
| $i$ | $y_i$ | $x_1$ -Meat products (thousand tons) | $x_2$ -Dairy products |
| 2011 | 29123,40 | 1564,20 | 6766,20 |
| 2012 | 29555,40 | 1672,90 | 7310,90 |
| 2013 | 29993,50 | 1787,80 | 7885,50 |
| 2014 | 30492,80 | 1906,30 | 8431,60 |
| 2015 | 31022,50 | 2033,40 | 9027,80 |
| 2016 | 31575,30 | 2172,50 | 9703,40 |
| 2017 | 32120,50 | 2286,80 | 10047,90 |
| 2018 | 32656,70 | 2430,50 | 10466,40 |
| 2019 | 33255,50 | 2473,60 | 10714,30 |
| 2020 | 33905,20 | 2519,60 | 10976,90 |
| 2021 | 34558,90 | 2635,10 | 11274,20 |
| 2022 | 35271,30 | 2642,30 | 11278,20 |

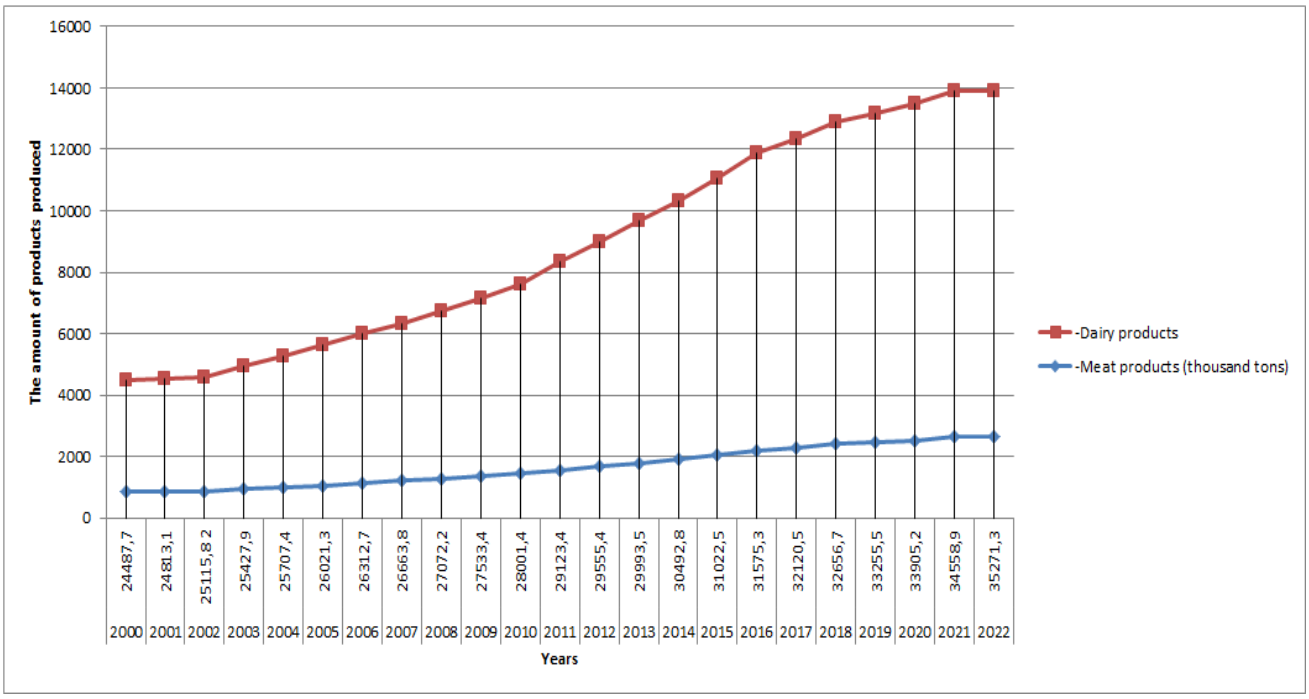



**Figure 1. Changes in meat and dairy products produced in 2000-2021**

***Source:*** *author's development.*

In the analysis of the economic problem presented in Table 1, we need to create an econometric model of the process presented in Figure 1. This issue should be brought to a multi-factor econometric model. Based on the statistics presented in the table, we can see that the process is linear. Then, in our case, we will perform an economic analysis by determining the linear regression equation. The general view of the linear multifactor regression equation is given as follows (Rakhimberdiev et al., 2022; Juraev et al., 2022).

$$y = a + b_1 x_1 + b_2 x_2 \quad (1)$$

Where, $a, b_1, b_2$ - regression equation parameters (Gujarati, 2009)

The least squares method is used to determine parameters $a, b_1, b_2$ in this regression equation. In that case, the regression equation parameters are calculated as follows in formulas (2), (3), (4) (Arzieva et al., 2022; Rakhimberdiev, 2022).

$$b_1 = \frac{\sigma_y}{\sigma_{x_1}} \cdot \frac{r_{yx_1} - r_{yx_2} \cdot r_{x_1x_2}}{1 - r^2_{x_1x_2}} \quad (2)$$

$$b_2 = \frac{\sigma_y}{\sigma_{x_2}} \cdot \frac{r_{yx_2} - r_{yx_1} \cdot r_{x_1x_2}}{1 - r^2_{x_1x_2}} \quad (3)$$

$$a = \overline{y} - b_1 \overline{x_1} - b_2 \overline{x_2} \quad (4)$$

where

$\sigma_y$, $\sigma_{x_1}, \sigma_{x_2}$ - $y, x_1, x_2$ - mean square deviations of quantities.

$r_{yx_1}, r_{yx_2}, r_{x_1,x_2}$ -pair correlation coefficients,

The following formulas are used to calculate these values.

$$\sigma_y = \sqrt{\overline{y^2} - \overline{y}^2} \quad (5)$$

$$\sigma_{x_1} = \sqrt{\overline{x_1^2} - \overline{x_1}^2} \quad (6)$$

$$\sigma_{x_2} = \sqrt{\overline{x_2^2} - \overline{x_2}^2} \quad (7)$$

$$r_{yx_1} = \frac{\overline{y \cdot x_1} - \overline{y} \cdot \overline{x_1}}{\sigma_y \cdot \sigma_{x_1}} \quad (8)$$

$$r_{yx_2} = \frac{\overline{y \cdot x_2} - \overline{y} \cdot \overline{x_2}}{\sigma_y \cdot \sigma_{x_2}} \quad (9)$$

$$r_{x_1x_2} = \frac{\overline{x_1 \cdot x_2} - \overline{x_1} \cdot \overline{x_2}}{\sigma_{x_1} \cdot \sigma_{x_2}} \quad (10)$$

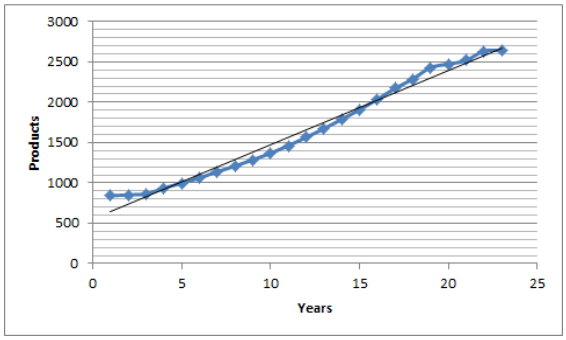
Numerical solutions of mean square deviations of quantities $y, x_1, x_2$ and pair correlation coefficients using equations (5)-(10) given above are presented as follows (Table 3).

**Table 3**

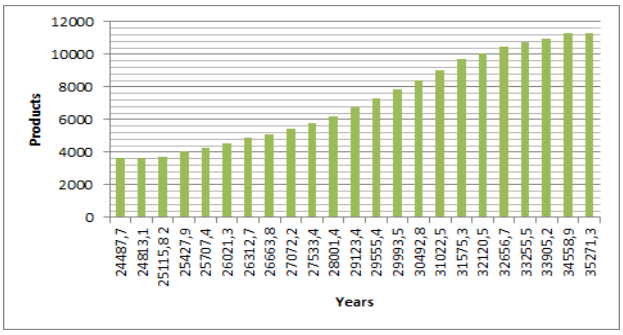
**$y, x_1, x_2$ - mean square deviations of quantities and values of pair correlation coefficients**

| $\sigma_{x_1}$ | $\sigma_{x_2}$ | $\sigma_y$ | $r_{yx_1}$ | $r_{yx_2}$ | $r_{x_1x_2}$ |
|---|---|---|---|---|---|
| 618,567451 | 2713,685257 | 3324,324825 | 0,995212652 | 0,993871648 | 0,999004961 |

Also, the correlation graphs of meat and dairy products with population demography are presented in Figures 2-3.




**Figures 2.Dependence of population demography on meat products**




**Figures 3. Dependence of population demography on Dairy products**

Regression equation of population demography dependence on meat products: **y = 92,446x + 549,22**

Correlation coefficient of dependence of population demographics on meat products: **$R^2$ = 0,9828**

Regression equation of population demography dependence on milk products: **y = 404,65x + 2323,4**

Correlation coefficient of dependence of population demographics on milk products: **$R^2$ = 0,9783**

***Source:*** *author's development.*

Using the values presented in Table 2, it is necessary to form a regression equation of the form (1). To create a regression equation, first, (1) it is required to determine the parameters $a, b_1, b_2$ from equations (2), (3), (4) in the regression equation. In this case, we will have the

values $b_1 = 8{,}186482$, $b_2 = -0{,}646685$, $a = 20225{,}0845$. As a result, the following multifactor regression equation is derived.

$$y = 20225{,}0845 + 8{,}186482x_1 - 0{,}646685x_2 \quad (11)$$

The effect of meat and dairy products on population demography is realized through this result. It is possible to get an economic analytical result of the multifactor regression equation that relates the factors to the demographics of the population. The parameter $b_1 = 8{,}186482$ of the regression equation determined in the form (11) increases the annual demand for meat products and increases the population by $818648{,}2$. Also, the $b_2 = 0{,}646685$ parameter indicates that the annual increase in the demand for dairy products will increase the population by $646685$.

**Algorithmization and programming of the correlation coefficient calculation process.**

Nowadays, computers and other computing tools are used in the research of most scientific and technical processes in mathematical modeling and simulation modeling of models. Programming tools are used to perform calculation processes using electronic calculators. before implementing the programming process, it is necessary to create an executable algorithm of the process. We make the block diagram of the correlation coefficient calculation algorithm as follows Figure 4[18].

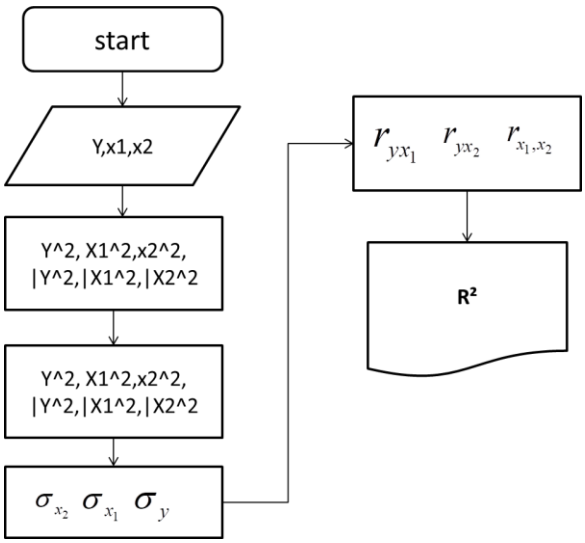



**Figure 4. Block diagram of the correlation coefficient calculation algorithm**

Currently, Python programming language is used for most of the problem solving and programming. This programming language has several special functions for calculating the correlation coefficient, as follows[10].

The statistics module in Python comes with many statistical functions that help analyze numerical data. The **statistics.correlation()** method in Python is used to return Pearson's correlation coefficient between two inputs[14].

- Syntax:

**statisticcs.corrrelation(x,y,/);**

- Parameters

The **statistics.correlation()** method takes the x and y parameters which represent the x and y values for which the correlation coefficient is to be determined.

- Return value

The **statistics.correlation()** method returns the Pearson's correlation coefficient for two given inputs.

Let's use the **statistics.correlation()** method to determine the Pearson's correlation coefficient for two inputs, x and y:

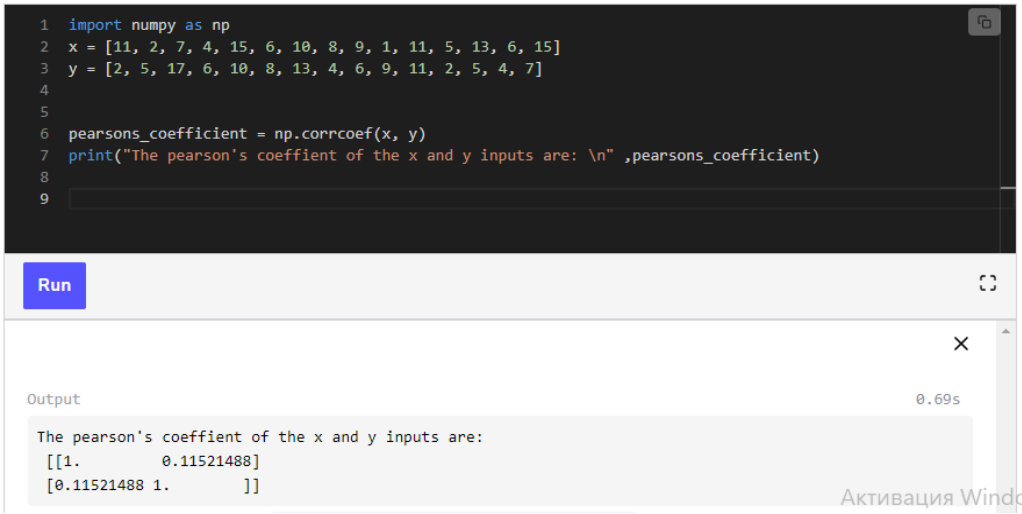



**Figure 5. Program code for calculating the correlation coefficient in the Python programming environment**

***Source:*** *author's development.*

## Conclusion and suggestions.

Currently, in the Republic of Uzbekistan, the issues of providing the population with quality food products are considered urgent. For this purpose, it is important to determine the level of food supply and economic analysis of the population in the republic. Therefore, in this article, the size of the population of meat and dairy products delivered to the population of the Republic of Uzbekistan and the demographic impact were studied. In this case, the correlation between the milk and meat products produced in 2000-2022 and the demographics of the population was determined. As a result, the correlation of population demographics with respect to meat products is 0.98, which means that it has a strong relationship. the correlation coefficient of 0.97 for dependence on dairy products is considered a strong connection. From this, it follows that the importance of dairy and meat products among high-quality food products in improving the lifestyle of the population is very high.

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