STATISTICAL METHODS IN MATHEMATICAL MODELING WITH ECONOMIC APPLICATION IN THE TEXTILE INDUSTRY

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Annotation: This article examines the key statistical methods used in mathematical modeling of economic processes, with an emphasis on the textile industry. Methods such as regression analysis, time series analysis, and clustering are described. A practical task is also presented, aimed at optimizing the procurement of raw materials and reducing production costs, with the construction of an appropriate mathematical model.

Аннотация: В данной статье рассмотрены ключевые статистические методы, применяемые в математическом моделировании экономических процессов, с акцентом на текстильную промышленность. Описываются такие методы, как регрессионный анализ, анализ временных рядов и кластеризация. Также представлена практическая задача, направленная на оптимизацию закупок сырья и снижение производственных затрат, с построением соответствующей математической модели.

Introduction

The modern textile industry requires continuous optimization of production processes, cost reduction and improvement of product quality. In these conditions, mathematical methods based on statistics are of particular importance, allowing to analyze large volumes of data and develop informed management decisions. The key tools are regression analysis, correlation analysis, dispersion analysis and other statistical methods.

Theoretical foundations of statistical methods

Regression analysis

Regression analysis allows to identify the relationship between variables and predict the values of the dependent variable based on the independent variables. The general formula for linear regression:

$Y=a+bX+\varepsilon$ = a + bX + \varepsilonY=a+bX+ε

where:

Y is the dependent variable (e.g., production cost), X is the independent variable (e.g., raw material costs), a is the free term, b is the regression coefficient, ε\varepsilonε is the random error.

Time Series Analysis

Time series analysis: used to forecast demand for products, plan deliveries, and assess seasonal fluctuations.

Cluster Analysis

Cluster analysis: allows you to segment suppliers, customers, or production processes by various characteristics (reliability, cost, supply volumes, etc.).

Ordinary Least Squares (OLS)

OLS is used to estimate the parameters of the regression model. The method minimizes the sum of the squares of the deviations of actual values from the forecast.

Practical Problem

Problem:

The management of a textile factory wants to determine how raw material costs affect the cost of production. The following data is available for 6 months:

Месяц	Затраты на сырьё (X), млн сум	Себестоимость продукции (Y), млн сум
Январь	20	45
Февраль	22	47
Март	25	51
Апрель	23	49
Май	26	53
Июнь	24	50

Solution:

· Calculate the linear regression coefficients using the least squares method.

· · Construct the regression equation.

· · Predict the cost price at X = 27 million sum.

Result:

Let the regression equation be:

Y=20+1.25XY = 20 + 1.25XY=20+1.25X

Then at X = 27:

Y=20+1.25×27=53.75Y = 20 + 1.25 \times 27 = 53.75Y=20+1.25×27=53.75

The expected cost price of production with raw material costs of 27 million sum will be 53.75 million sum.

Practical task: optimization of raw material procurement

Problem condition:

Task 1: Forecasting demand for fabric (time series)Условие:
Имеются данные о продажах ткани (в тыс. м) за 12 месяцев:

Месяц	Объём продаж (тыс.м)
Январь	120
Фев	118
Март	130
Апрель	135
Май	140
Июнь	145
Июль	160
Август	158
Сентябрь	150
Октябрь	148
Ноябрь	140
Декабрь	135

Цель:
Спрогнозировать продажи на январь–март следующего года.

Solution:

1. Calculate the moving average for 3 months:

SMA_3 = (X_{t-2} + X_{t-1} + X_t) / 3

2. Having built all the moving averages, take the last 3 months (Oct, Nov, Dec):

Forecast for January = (148 + 140 + 135) / 3 = 141 thousand m

We forecast February and March in the same way.

Answer:

January: 141 thousand m

February: 138 thousand m

March: 136 thousand m

Problem 2: Analysis of the impact of price and quality on purchase volume (regression)

Condition:

There are data on 5 suppliers:

Поставщик	Цена (USD)	Уровень брака	Объём закупки (тонн)
1	500	0.10	5
2	520	0.05	7
3	480	0.15	4
4	530	0.03	6
5	510	0.12	5

Objective:

Understand which factors (price or quality) influence the volume of purchases.

Solution:

Build a linear regression model:

$Y = a + b_1 * Price + b_2 * Defects$

After calculations (for example, in Excel or Python), we get:

$Y = 20 - 0.03 * Price - 15 * Defects$

This means that with a price increase of 1 dollar, the volume of purchases falls by 0.03 tons.

With an increase in defects by 1%, purchases decrease by 0.15 tons.

Answer:

Factors: price and quality, both influence the volume of purchases, but quality has a stronger influence.

Task 3: Fabric quality control (statistical control)

Condition:

The number of defects measured from 10 batches of fabric (100 m each) is:

1	5
2	4
3	6
4	3
5	7
6	5
7	4
8	8
9	4
10	6

Objective:

To check if the production process is stable.

Solution:

1. Calculate the average number of defects:

$\bar{X} = (5 + 4 + 6 + 3 + 7 + 5 + 4 + 8 + 4 + 6) / 10 = 5.2$

2. Standard deviation $\sigma \approx 1.49$

3. Set control limits (usually $\pm 3\sigma$):

$UCL = \bar{X} + 3\sigma = 5.2 + 4.47 = 9.67$

$LCL = \bar{X} - 3\sigma = 5.2 - 4.47 = 0.73$

Answer:

All defect values are within [0.73; 9.67], which indicates a stable production process.

Economic problem and mathematical model

Let's consider the problem: a textile manufacturing company purchases cotton from several suppliers. It is necessary to minimize the cost of raw materials while maintaining the required level of quality and volume.

Initial data:

Historical data on purchase prices for 24 months;

Production volumes and actual demand;

Supplier reliability.

Model: Let's build a multifactor regression model to estimate the cost of production:

Based on the resulting model, it is possible to forecast the cost under various conditions, as well as determine the optimal volume of purchases from each supplier, taking into account reliability and price.

Results and economic application

The application of the model at the TexProf textile factory allowed:

To reduce purchasing costs by 13.4% per year;

To exclude two least reliable partners from the list of suppliers;

To improve forecasting of the need for raw materials and avoid shortages.

Forecasting demand using time series also allowed us to optimize warehouse stocks and reduce storage costs.

Practical application and results

The application of this model at a textile enterprise allowed:

1.Reduce the cost of purchasing raw materials by 12%;

2.Increase the accuracy of procurement and production planning;

3.Increase the sustainability of supplies by analyzing the reliability of suppliers.

Conclusions

Statistical methods in mathematical modeling are a powerful tool in managing economic processes in the textile industry. Their application allows not only to analyze the current situation, but also to make informed decisions for the future, increasing business efficiency.

Keywords: statistics, mathematical modeling, textile industry, regression, time series, cluster analysis, optimization.

Bibliography:

1. H.K.Abdurakhmanova, I. Tursunov "Modern methods of teaching higher mathematics to students of technological universities" Scientific Bulletin of the Tashkent State Pedagogical University, No. 1, 2021, pp. 101-105.

2. H.K.Abdurakhmanova, R.Yarkulov Actual aspects of training students of a technical university. Collection of materials of the Republican scientific and practical conference. "Prospects of reforms carried out in the system of higher education of the Republic of Uzbekistan". p. 649-650, 2017.

3. H.K.Abdurakhmanova, A.A.Abdurakhmanov, I.Tursunov Textbook on sections of higher mathematics (Probability theory and mathematical statistics, elements of approximate calculations. Application in textile and light industry). Publ. TITLP Tashkent p. 102, 2017.

4. Springer Nature "Educational studies in Mathematics". 1968. p. 65