DIFFERENTIAL METHOD FOR FORECASTING LABOR RESOURCES BASED ON CORRELATION MODELS

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Abstract: *The article proposes an universal method for developing a correlation model that can be applied in solving economic problems in planning and forecasting. Based on the equation of the developed correlation model, the number of labor resources of the Bukhara region for the period 2021-2030 is predicted and their prospective trends are determined*

Key words: *modeling, correlation model, labor resources, correlation and regression analysis, forecasting, accuracy, suitability, labor market.*

Introduction

Scientific management in economics is to ensure the efficient use of factors. For this, you need to know how many units this or that indicator will change if the other changes by one. To study the intensity and form of dependencies, correlation-regression analysis is used, which is a methodological tool for solving problems of forecasting, planning and analyzing the economic activity of an enterprise.

A correlation model is a mathematical expression of the equation type, in which the average value of the effective indicator is formed under the influence of one or more factors. It allows you to determine the expected value of the performance indicator. The correlation model is used to check whether resources are used correctly and to justify the value of economic indicators for the future.

The main part

The existing method of constructing correlation models of the type y=f(x) in the presence of data on the state of the object under study y_i and x_i is widely used in the practice of planning and forecasting. We described the shortcomings of this method in published works. [1,2,3]

In this article, we propose a universal method for determining the dependence of the type y=f(x) that differs from the existing ones.

Let the real process proceed on some law y=f(x). And let the function f(x) be continuous and smooth i.e. has an n-th derivative. As you know, all the functions used in predicting socio-economic phenomena are such. And the data x_i at our disposal is the value of the function y=f(x) at the points x_i.

Since in our condition the function □(x) has an n-th order derivative, then

$$\lim_{x_{i+1}\to x_i} \frac{f(x_{i+1})-f(x_i)}{x_{i+1}-x_i} = f^n(x_i) \quad (1)$$

Consequently $\lim_{x_{i+1}\to x_i} \frac{f'(x_{i+1})-f'(x_i)}{x_{i+1}-x_i} = f^n(x_i)$ (2)

Accordingly $\lim_{x_{i+1}\to x_i} \frac{f'^{n-1}(x_{i+1})-f'^{n-1}(x_i)}{x_{i+1}-x_i} = f^n(x_i)$ (3)

Based on (1), (2), (3), we can write the following equality:

$$\lim_{x_{i+1}\to x_i} \frac{f^{n-1}(x_{i+1})-f^{n-1}(x_i)}{x_{i+1}-x_i} \approx f^n(x_i) \quad (4)$$

Now let's look at a specific example

The following table 1 shows real data on the population of the Bukhara region of the Republic of Uzbekistan in the period 2016-2020. It is required to make a forecast for these indicators in the period, for example, 2020-2025.

Let $\lim_{x_{i+1}\to x_i} \frac{f^{n-1}(x_{i+1})-f^{n-1}(x_i)}{x_{i+1}-x_i} \approx f^n(x_i) = \Delta^n Y_i$

Based on this equality, we fill in other graphs of the table. Here x_{i+1} = x+1 and $x_i = t$ accordingly $x_{i+1} - x_i = t + 1 - t = 1$ for all *i*=1, x_n and x=1, x_n

Table 1

t_i	y_i	$\Delta^1 Y$	$\Delta^2 Y$	$\Delta^3 Y$	$\Delta^4 Y$
1	1815	-	-	-	-
2	1843	28	-	-	-
3	1870	27	-1	-	-
4	1894	24	-3	-2	-
5	1923	29	5	8	10

And so according to our data $y^{IV} = 10$, subject to $y^{III}(1) = -2$. That's why y

$$y^{III} = 10x + e$$

$y^{III} = 10 * 1 + e = -2$, from here $e = -12$ and $y^{III} = 10x - 12$

Thus

$\frac{d^2y}{dx^2} = \int (10x - 12)dx \Rightarrow y' = 10\frac{x^2}{2} - 12x + e$, at $y''(1) = -1$ and

$y''(1) = 5*1-12+e=-1 \rightarrow e=6$.

That's why $y'' = \int(5x^2 - 12x + 6dx)$

$y' = 5\frac{x^3}{3} - 6x^2 + 6x + e \rightarrow y'(1) = 28$.

Further $\frac{5}{3} - 6 + 6 + e = 28 \rightarrow e = 28 - 1{,}67$ $\quad e = 26{,}33$;

$y' = \frac{5}{3}x^3 - 6x^2 + 6x + 26{,}33$, provided y (1)=1815;

$y = \int(\frac{5}{3}x^3 - 6x^2 + 6x + 26{,}33)\,dx = \frac{5}{12}x^4 - 2x^3 + 3x^2 + 26{,}33\,x + e$

$y(1) = \frac{5}{12} - 2 + 3 + 26{,}33 + e = 1815 \rightarrow e = 1787$

The desired function has the following form:

$$Y = \frac{5}{12}x^4 - 2x^3 + 3x^2 + 26{,}33x + 1787$$

By checking this function, you can verify the suitability of the constructed model. But the proposed method has the following disadvantages:

if the amount of data increases, then the degree of the polynomial y=f(x) also increases in proportion to the amount of data. For example, if the amount of data is n=20, then we get a polynomial of the 20th degree, after n=20 a short integrated;

As an accuracy of the constructed models depends on $|x_{i+1} - x_i| < \delta$ when solving economic problems $|t_{i+1} - t_i|$ = 1. Especially if time series are considered, but when solving the problem of physics, chemistry and biology Δx=$x_{i+1} - x_i$ can be reduced indefinitely, as this will depend on the desire of the scientific researcher conducting the experiment.

When solving economic problems, it is possible to successfully apply the proposed method, limiting the calculation $\Delta^2 y, \Delta^3 y$.

Table 2 shows data on labor resources for the Bukhara region of the Republic of Uzbekistan in the period 2010-2020. It is necessary to make a forecast based on these indicators for the period 2021-2030. We use the above method. At the same time, we limit ourselves only $\Delta^2 y$ or $\Delta^3 y$.

Table 2

T	y	Δy	$\Delta^2 y$	$\Delta^3 y$
1	971,9	-	-	-
2	1008,3	36,4	-	-
3	1025,7	17,4	-19	-
4	1035,1	9,4	-8	11
5	1045	9,9	0,5	8,5
6	1055,8	10,8	0,9	0,4
7	1065,4	9,6	-1,2	-2,1
8	1073,1	7,7	-1,9	-0,7
9	1081,6	4,7	-3	-1,1
10	1083,8	3,2	-1,5	1,5
11	1070,4	-10,6	-13,8	-12,3

Subsequently, to determine the function y=f(x), we calculate the average value

$$\Delta^2 Y_{cp} = \frac{-19-8+0,5+0,9-1,2-1,9-3-1,5-13,8}{9} = \frac{-47}{9} = -5,2$$

y''=-5,2 or

$\frac{d^2y}{dx^2} = -5,2$ provided $y'(1) = 36,4$

$\frac{dy}{dx} = -5,2x + c$ and 36,4=5,2*1+e →e=41,6

$y' = -5,2x + 41,6$ under the initial condition y (1) = 971,9

$$\frac{dy}{dx} = -5,2x + 41,6$$

$$y=-1,73x^2+41,6x+e$$

$971{,}9 = -1{,}73x^2 + 41{,}6x + e \rightarrow e = 932{,}03$

As a result, this function looks like: **$y = -1{,}73x^2 + 41{,}6x + 932{,}03$**

To check the reliability of the found function, we compare the actual $y_ф$ and calculated values of the process under study using the Excel program.

Table 3

$y_ф$	9 71,9	1 008,3	1 028	1 035	1 048	1 056	1 065	1 073	1 077	1 081	1 070
y_x	9 71,9	1 005,3	1 034	1 057	1 076	1 084	1 098	1 095	1 099	1 093	1 082
$y_ф - y_x$	0	+ 3	- 6	- 22	- 28	- 28	- 32	- 22	- 22	- 12	- 12

If $y' = (-1.73 + 41.6x + 932.03)' = 0$ then we get $x = \frac{41{,}6}{1{,}73} = 12.02$.

This means that the maximum value of labor resources reached in the period $12 < x \leq 13$. And in the future there is a decrease in the number of labor resources in this area. For example, in 7 years the volume of labor resources in the region will decrease by 20% (Table 4).

Table 4

Years	2021	2022	2023	2024	2025	2026	2027	2028	2029	2030
Number of labor resources	1182,28	1180,43	1174,6	1166,75	1154,72	1097,6	1120,08	1098,4	1072	1042,67

Thus, the predicted value of the number of labor resources by 2030 will decrease by 28 thousand people compared to 2020, this is 3%, which is primarily due to a decrease in population growth in the Bukhara region.

It should also be emphasized that finding and integrating the mean value Δy *и* $\Delta^2 y$ is not the only way to establish the relationship $y = f(x)$.

Consider the data in table №1. $\Delta^2 Y$ has the value $\Delta^2 y(1) = -1$; $\Delta^2 y(2) = -3$ *и* $\Delta^2 y(3) = 5$

We find the function y'' in the form $y'' = \alpha_o + \alpha_1(x - x_1) + \alpha_2(x - x_1)(x - x_2)$ or $\alpha_o + \alpha_1(x - 1) + \alpha_2(x - 1)(x - 2)$.

We will substitute x=1 $y''(1) = -1$ and find $\alpha_o = -1$ and for $x=2$ $y''\, 2) = -3$ and find$\alpha_o = -2$, then for x=3 $y''(3) = 5$ find$\alpha_2 = 5$.

And so our function looks like $y'' = -1 - 2(x - 1) + 5(x - 1)(x - 2)$ or

$y'' = 5x^2 - 17x + 11$

Now integrating twice the last function based on the initial conditions $y'(1) = 28$ и $y'(1) = 1815$ we will define the function. It looks like $y = 0{,}467x^4 - 2{,}83x^3 + 5{,}5x^2 + 23{,}8x + 1788$

The suitability of this model can be tested by supplying x to the appropriate values.

Based on the above theory, the following conclusions can be drawn:

If in the available static data $x_{i+1} - x_i < \delta$ or in other words $\Delta x = x_{i+1} - x_i \Rightarrow$ othen as in table 1.

We will find $\Delta^n Y = A$, , where A = cong t or after replacing $\Delta^n Y$ with $Y^{(n)}$ we get. Integrating n times, we get the required function.

If $x_{i+1} - x_i = \Delta x$ does not go to zero, then $f(x_{i+1}) - f(x_i) \approx f'(x_i)(x_{i+1} - x_i)$ it violates. Therefore, it is necessary to proceed as follows, it is enough to calculate Δy, $\Delta^2 y$ or $\Delta^3 y$.

In the next step, we will calculate these values. The average value and is replaced by Δy, $\Delta^2 y$, $\Delta^3 y$ by y', y'' and y''' we get an equation like $y'(x) = A$, y'', = β or $y''(x)$ = e.. By solving these differential equations, we get this model.

At this stage, we will finish the calculations of Δy, $\Delta^2 y$, $\Delta^3 y$, , and replace the point value of these variables with a continuous function. For example, if the column $\Delta^2 y$ has only 3 data, then the function looks like this:

$$y'' = \rho(x) = \alpha_o + \alpha_1(x - x_1) + \alpha_2(x - x_1)(x - x_2).$$

After integrating this function twice, we get this function.

Conclusion

The most important advantage of the proposed technique is the construction of correlation models based on the definition of the derivative of the function. Based on this, the desired function is not taken from a certain function, but is obtained as a result of successive integration. Mathematical justification is the theorem of high approximation of any continuous function using polynomials and degree in the course of mathematical and functional analysis. The model described in this article is the first step towards building a truly functioning system for making managerial decisions by regional authorities based on a labor market forecast. The forecast of the situation on the labor market is of great economic, social and political importance. In conclusion it is important to note that the proposed methodology lends itself to computer programming and can be used in assessing the prospects for the development of the labor market in the development of employment promotion programs, making a forecast of the main indicators of the socio-economic development of the region.

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