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New Square Method

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Abstract

The "new square method" is an improved approach based on the "least square method". It calculates not only the constants and coefficients but also the variables' power values in a model in the course of data regression calculations, thus bringing about a simpler and more accurate calculation for non-linear data regression processes.

Keywords: Multi-dimensional; Non-linear; Data regression; Model application

Preface

In non-linear data regression calculations, the "least square method" is applied for mathematical substitutions and transformations in a model, but the regression results may not always be correct, for which we have made improvement on the method adopted and named the improved one as "new square method".

Principle of New Square Method

While investigating the correlation between variables (x,y), we get a series of paired data $(x_1,y_1,x_2,y_2......x_n,y_n)$ through actual measurements. Plot these data on the x–y coordinates, then a scatter diagram as shown in Figure 1 will be obtained. It can be observed that the points are in the vicinity of a curve, whose fitted equation is set as the following Equation 1 [1,2].

$$y = a_0 + a_1 x_i^k \tag{1}$$

where a_0, a_1 and k indicate any real numbers.

To establish the fitted equation, the values of a_0, a_1 and k need to be determined via subtracting the calculated value y from the measured value y_i, i.e., via $(y_i – y)$.

Then calculate the quadratic sum of m $(y_i–y)$ as shown in Equation 2.

$$\Phi = \sum_{i=1}^{m} (y_i - y)^2 \tag{2}$$

Substitute Expression 1 into Expression 2, as shown in Expression 3:

$$\Phi = \sum_{i=1}^{m} (y_i - a_0 - a_1 x_i^k)^2 \tag{3}$$

Find the partial derivatives for a_0, a_1 and k respectively through function Φ so as to make the derivatives equal to zero:

$$\frac{\partial \Phi}{\partial a_0} = -2\sum_{i-1}^{m} (y_i - a_0 - a_1 x_i^k) = 0 \tag{4}$$

$$\frac{\partial \Phi}{\partial a_1} = -2\sum_{i=1}^{m} ((y_i - a_0 - a_1 x_i^k) x_i^k) = 0 \tag{5}$$

$$\frac{\partial \Phi}{\partial k} = -2\sum_{i=1}^{m} ((y_i - a_0 - a_1 x_i^k) x_i^k Ln(x_i)) = 0 \tag{6}$$

Through derivation it is found that there is no analytic solution to this equation set, then computer programs are utilized to calculate its arithmetic solutions and obtain the solutions for a_0, a_1 and k as well as the correlation coefficient R. It is observed that the closer the correlation coefficient R is to 1, the better the model fits.

Comparison between the "New Square Method" and the "Least Square Method"

If Equation 7 as shown below is adopted to fit any data (Table 1)

$$y = a_0 + a_1 x_i^k \tag{7}$$

- In the "new square method", the power value k of the dependent variable is calculated, while in the "least square method", k is assumed to be 1. With the calculated power value for the dependent variable, the "new square method" is able to have the fitted equation generate a fitted line at any curve to better fit the non-linear data [3].

- In the "new square method", non-linear data with one factor (x) can be regressed by applying the following Equation 8 in the computer programs to obtain more accurate fittings of non-linear data by regression models [4].

$$y = a_0 + a_1 x^{k1} + a_2 x^{k2} + \cdots\cdots + a_n x^{kn} \tag{8}$$

In Equation 8:

x: Variable;

y: Function;

x,y: Dimensional (two-dimensional);

x^{k1}, x^{k2}, x^{kn}: Element;

a_0: Constant;

a_1,a_2,a_n: Coefficient;

k_1,k_2, kn: Power.

	Least Square Method	New Square Method
Fitted Equations:	$y=a_0+a_1x$	$y = a_0 + a_1 x_i^k$
Calculated Regression Results:	a_0 and a_1	a_0, a_1 and k

Table 1: The comparison table between the new square method and the least square method.

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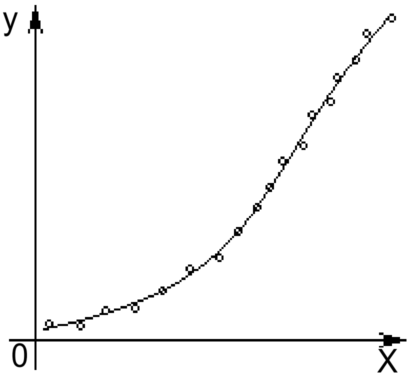

Figure 1: Scatter diagram.

- As for the regression of non-linear data with multi-factors in the "new square method", the following Equation 9 can be utilized in computer programs for this purpose. This equation takes into account both the contribution of factors ($x_1, x_2 \ldots\ldots x_n$) to the objective function (y) and the interplays among factors ($x_1, x_2 \ldots\ldots x_n$) during the regression calculation, that is why the fitted models are of high correlation.

$$y = a_0 + a_1 x_1^{k11} + a_2 x_2^{k21} + a_3 x_1^{k12} x_2^{k22} + a_4 x_1^{k13} x_2^{k23} + \cdots\cdots + a_{n+2} x_1^{k1n+1} x_2^{k2n+1} \quad (9)$$

In Equation 9:

x_1, x_2: Variable;

y: Function;

x_1, x_2, y: Dimensional (three-dimensional);

$x_1^{k11}, x_2^{k21}, x_1^{k12} x_2^{k22}, x_1^{k13} x_2^{k23}, x_1^{k1n+1} x_2^{k2n+1}$: Element;

a_0: Constant;

$a_1, a_2, a_3, a_4, a_{n+2}$: Coefficient;

$k_{11}, k_{21}, k_{12}, k_{22}, k_{13}, k_{23}, k_{1n+1}, k_{2n+1}$: Power.

Note: Equation 9, which takes three-dimensional data as its example, can be applied for the regression of data in curved surface data.

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