FACTOR ANALYSIS OF QUALITY CHARACTERISTICS

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Abstract: *Factorial analysis is a statistical technique designed to link a set of variables observed by a smaller number of latent dimensions.*
Factorial analysis is the method of explaining correlation relationships between two or more variables, in the case of quality, these variables being the quality characteristics of electrical equipment.
The main idea on which the factorial analysis is based is that behind the quality characteristics (observable variables) there are latent variables (factors) that influence the dependent variables (output). Factors are linear combinations of the values of the quality characteristics, the coefficients of these linear combinations being called saturations or "loadings" of factors.

Keywords: Quality, factorial analysis, quality indicators,

Introduction

The term calimete was adopted by the EOQC (European Organization for Quality) in 1971 and officiated in 1981 as "the science of quality measurement." In the Russian bibliographic references, for example, it is mentioned that the scientific discipline "calimetry", defined as the scientific theory that studies and realizes the methods of quality estimation, was developed in the former USR.S.S. By Garri Gaikovici Azgaldov, since 1968.

Quality measure is the quantitative measure of the characteristics and attributes of a product. The quality measure assigns numerical values to a specific quality characteristic. Quality measures can be of different forms: physical and chemical measures, the percentage of non-compliant products.

Quality level means a relative measure of quality, obtained by comparing the observed values with imposed values. Evaluating the quality level obtained from the manufacturing process of the product involves knowing its quality, by measuring, counting, etc.

Quality assessment

According to other authors [4], the data quality dimensions are as follows:
Accessibility: The extent to which data is available or can be obtained easily and quickly
Data sufficiency: The extent to which the data volume is appropriate for quality assessment
Veridity: The extent to which data is considered true and credible
Completeness: The extent to which data is not lacking and is sufficient for quality assessment
Conclusion: The extent to which the data is represented as compact
Consistency: The extent to which data is presented in the same format
Ease of Handling: The extent to which data is easy to handle
Lack of errors: the extent to which data is accurate and reliable
Interpretability: The extent to which the data is in the appropriate languages, symbols and units and the definitions are clear

Objectivity: The extent to which data are unpredictable and unbiased
Relevance: The extent to which data is applicable and useful for determining quality
Reputation: The extent to which data is considered reputable according to its source
Security: The extent to which access to data is properly restricted to maintain their security
News: The extent to which the data is updated enough to spoil quality
Comprehensibility: The extent to which data is easy to understand
Added Value: The extent to which data is beneficial and provides benefits from use

The quality level can be expressed as:

* A rating (exceptional quality, appropriate level, low level);
* A quality indicator, index, or coefficient.

In industry, product quality measurement is measured to measure product quality characteristics, as well as to determine indicators, indices, or quality coefficients.

Product quality indicators are quantitative expressions of their characteristics and show the extent to which a particular product, during use, meets the conditions specific to its intended purpose. The product quality indicators system consists of two groups: indicators for assessing qualitative performance and indicators for assessing lack of quality.

The quality characteristic of a product, process, or system is its intrinsic distinctive trait relating to a requirement. Measuring a quality feature is to obtain the numerical value by which the absolute value of that characteristic is expressed in certain measurement units.

In assessing the quality of a product we distinguish between objective characteristics and subjective quality characteristics. The objective characteristics are those directly measurable characteristics of the product, while the subjective characteristics are those characteristics that can not be measured directly, but are more perceptible.

Quality assessment for products with only objective characteristics

Products with only objective features represent a particular case, most of them having both objective characteristics and subjective quality characteristics.

For this type of product, it is possible to establish a global quality indicator, starting from the logical criteria that such an indicator has to fulfill.

Logical Criteria:

A) Comparability
B) The calculation with discrete elements, the values of the qualitative characteristics should be used directly
C) Expression of a structure
D) Expression of Characteristics
E) Substitutability of certain characteristics
F) Indication of the favorable evolution of the characteristics

By using the above criteria, the overall quality indicator for the product (i) is determined relative to the reference product (I):

$$Qi = K * \prod_{j=1}^{n} \left(\frac{x_{ij}}{x_{Ij}}\right)^{\pm yj}$$

In this relation the notations used are the following:

K - the constant defining the technical level of the reference product (I), usually K = 1000
I - the product considered to be the reference
I - the product analyzed
Xij - the value of j characteristic for product i
Yj - the share of the j characteristic
+/- the chosen weight of the weight based on the proportionality of the j characteristic with the quality

Factor Analysis / Analysis of the main component for the quality characteristics of a batch of electrical equipment

The table summarizes the grades of performance for a batch of ten types of coffee makers.

No	Coffee Maker	Tank	Capacity	Power	Tea Maker	Integrated Coffee Grinder	Price
1	Bosch TAS 4012 Tassimo	1	5	3.91	5	1	4.13
2	Philips Saeco HD8323 Poemia Focus	1	1	2.09	1	1	4.32
3	Gaggia Classic	1	5	2.82	1	1	2.29
4	Philips Saeco HD8751 Intelia Focus	5	3	5	1	5	1.96
5	Bosch TAS 4013 Tassimo	1	5	3.91	5	1	4.36
6	Philips Saeco HD8743 Xsmall	5	1	3.18	1	5	2.62
7	DeLonghi EC330	1	1	2.09	1	1	3.92
8	Rohnson R 955	1	2.2	1.73	1	1	4.53
9	ZASS ZEM 05	1	1	1	1	1	5
10	BOSCH TES50129RW	5	3.8	3.91	5	5	1

The stages of factorial analysis are as follows:
1. Matrix table matrix characterization / product - obtaining the transformed matrix Z:

$$Z = \frac{x - E(x)}{s}$$

Where E (x) represents the average of the matrix of the characteristic matrix / product, and s represents the standard deviation of the matrix of the characteristic product / product.

No	Coffee Maker	Tank	Capacity	Power	Tea Maker	Integrated Coffee Grinder	Price
1	Bosch TAS 4012 Tassimo	-0.62	1.23	0.76	1.45	-0.62	0.54
2	Philips Saeco HD8323 Poemia Focus	-0.62	-1.00	-0.71	-0.62	-0.62	0.68
3	Gaggia Classic	-0.62	1.23	-0.12	-0.62	-0.62	-0.84
4	Philips Saeco HD8751 Intelia Focus	1.45	0.11	1.64	-0.62	1.45	-1.09
5	Bosch TAS 4013 Tassimo	-0.62	1.23	0.76	1.45	-0.62	0.71
6	Philips Saeco HD8743 Xsmall	1.45	-1.00	0.17	-0.62	1.45	-0.59
7	DeLonghi EC330	-0.62	-1.00	-0.71	-0.62	-0.62	0.38
8	Rohnson R 955	-0.62	-0.33	-1.00	-0.62	-0.62	0.84
9	ZASS ZEM 05	-0.62	-1.00	-1.59	-0.62	-0.62	1.19
10	BOSCH TES50129RW	1.45	0.56	0.76	1.45	1.45	-1.81

2. Computation matrix of characteristics:

$$Cor = \frac{1}{n-1} Z'Z$$

Characteristic	Coffee Tank	Capacity	Power	Tea Maker	Integrated Coffee Grinder	Price
Rezervor cafea	1.00	-0.08	0.59	0.05	1.00	-0.80
Capacitate	-0.08	1.00	0.61	0.69	-0.08	-0.29
Putere	0.59	0.61	1.00	0.53	0.59	-0.63
Preparare ceai	0.05	0.69	0.53	1.00	0.05	-0.13
Rasnita cafea integrata	1.00	-0.08	0.59	0.05	1.00	-0.80
Pret	-0.80	-0.29	-0.63	-0.13	-0.80	1.00

3. Diagonalization of the correlation matrix of the characteristics and choice of factors:

$$Cor = U * S * V'$$

The matrix of factors is: $$Y = U * \sqrt{S}$$

No.	Characteristic	F1	F2
1	Coffee Tank	-0.88	0.45
2	Capacity	-0.38	-0.86
3	Power	-0.86	-0.34
4	Tea Maker	-0.39	-0.79
5	Integrated Coffee Grinder	-0.88	0.45
6	Price	0.89	-0.17

Considering that the sum of the first two own values reported for the diagonal matrix S is ($\lambda 1 + \lambda 2$) / tr (S) = 0,8815, the two chosen factors explain 88,15% of the total variance.

In order to be able to calculate accurately, a specialized program for calculating the quality indexes was used through the utility value analysis method in the Octave 3.6.2 software environment:

```
function [ ret ] = Qevalpca ()
        ##load the names of the I/O files
        fid=fopen("Date.csv","r");
        disp("Fisierele utilizate sunt:");
        a=fgetl(fid);
        disp(a);
        b=fgetl(fid);
        disp(b);
        c=fgetl(fid);
        disp(c);
        d=fgetl(fid);
        disp(d);
        fclose(fid);
        ##load the matrix of fulfilling of characteristics
        q=csvread("GIC_in.csv");
        n=rows(q); disp("Numarul de produse este:"); disp(n);
        m=columns(q);
        ##disp("Gradele de indeplinire a caracteristicilor pentru cele n produse sunt:");
        ##disp(q);
        for j=1:m
           for i=1:n
             t(j)=sum(q(:,j))/n;
                  k(j)=std(q(:,j));
                  z(i,j)=(q(i,j)-t(j))/k(j);
                endfor
        endfor
        disp("miu si (q-miu)/std")
   disp(t); disp(z);
        disp("matricea de corelatie este:")
        cor=(z'*z)/(n-1)
```

```
        disp(cor)
        disp("diagonalizarea este:")
   [u,s,v]=svd(cor)
        y=u*sqrt(s);
        disp("factorii sunt:")
   disp(y)
        disp("y*y'")
        disp(y*y')
        dlmwrite("factors_out.csv",y)
        dlmwrite("z_out.csv",z)
        dlmwrite("cor_out.csv",cor)
endfunction
```

Conclusions:

- Use of correlation matrix - reduction of number of features (coffee tank / integrated grout)
- F1 / F2 are the main factors that account for 88.15% of the total variation
- Case interpreting: the price is not the expression of the other quality characteristics, which leads to the conclusion that it is either "fashion" or "brand" or the positive quality characteristics should be reconsidered

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