The research of methodical ways of factor analysis

Zoryana Skybinska[1], Tetiana Gryniv[2]

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Annotation. Factor analysis is an analysis of influence of separate factors (reasons) on the resulting indicator by using deterministic or stochastic techniques of research. It allows you to explore the functional relationship between the general resulting indicator (function) and certain factors that are called arguments. There are two types of relationships, which are explored in the process of factor analysis: functional and probabilistic. The choice of method depends strongly on the type of factor analysis. In strictly deterministic relations the following methods are used: chain substitutions, absolute and relative differences, index, logarithm, integral, etc. For the analysis of stochastic dependencies use methods of mathematical statistics: correlation, dispersion, regression and so on.

Key words: Factor analysis, resulting indicator, deterministic methods, stochastic methods.

Анотація. Факторний аналіз - це аналіз впливу окремих факторів (причин) на результативний показник за допомогою детермінованих чи стохастичних прийомів дослідження. Він дає змогу вивчити функціональний зв'язок між загальним результативним показником (функцією) та окремими факторами. Якщо взаємозв'язок між результативним показником та факторами має функціональний характер, коли відповідному значенню фактора відповідає строго визначене значення результативного показника, то такий тип зв'язку називають детермінованим. Коли зміна факторної ознаки дає кілька значень функції, то такий вид зв'язку між результативним показником і факторами називають стохастичним.

Вибір методу факторного аналізу суттєво залежить від типу залежностей у факторних моделях. При жорстко детермінованих зв'язках застосовують такі методи: ланцюгових підстановок, абсолютних і відносних різниць, індексним, логарифмування, інтегрування тощо. Для аналізу стохастичних залежностей використовують методи математичної статистики: кореляційний, дисперсійний, регресійний тощо.

Детермінований факторний аналіз можна виконувати різними методами, більшість з яких (ланцюгових підстановок, абсолютних і відносних різниць, індексний) ґрунтуються на прийомі елімінування.

Із посиленням впливу ринкових факторів на діяльність підприємств виникає потреба використовувати стохастичний факторний аналіз (економіко-математичні методи (ЕММ)).

[1] PhD in Economics, Associate Professor, Department of Accounting and Analysis, National University "Lviv Politechnic", https://orcid.org/0000-0001-8959-1393
[2] PhD in Economics, Associate Professor, Department of Accounting and Analysis, National University "Lviv Politechnic", https://orcid.org/0000-0002-7173-9158

За рахунок використання ЕММ скорочуються терміни проведення аналізу, здійснюється більш повне охоплення впливу чинників на результати комерційної діяльності, заміна приблизних або спрощених розрахунків точними обрахунками.

Ключові слова: факторний аналіз, фактори впливу, результативний показник, детерміновані методи, стохастичні методи.

Introduction

In economic analysis, one of the important tasks is the measurement of impact of factors on the resulting indicator.

Factor analysis is an analysis of influence of separate factors (reasons) on the resulting indicator by using deterministic or stochastic techniques of research. It allows you to explore the functional relationship between the general resulting indicator (function) and certain factors that are called arguments. Moreover, factor analysis can be both direct (analysis by itself), that is the fragmentation of the resulting indicator on components and reverse (synthesis) when its separate elements are connected to the overall resulting indicator.

The implementation of factor analysis is carried out by the following algorithm:

1. Setting the purpose of the analysis - formulation of the need to conduct this analysis,defining of the object of research.
2. Selection and characteristics of factor.
3. Determining the type of relationship between the factor and effective indicator.
4. Building of a factor model (mathematical formula for calculating the effective rate).
5. The choice of method of factor analysis and performance of necessary calculations.
6. The formulation of the conclusions and recommendations. According to the results of analysis they form analytical derivation, which reveal a total change of effective indicator and impact on the change of each factor indicator.

This article aims to research of methodical ways of factor analysis.

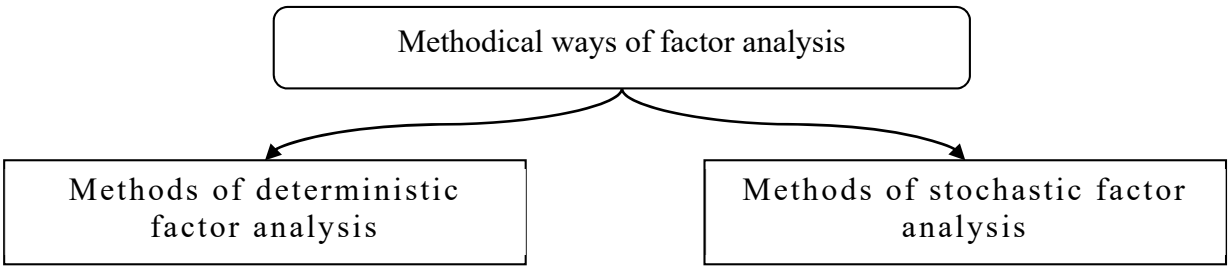
Researching results

There are two types of relationships, which are explored in the process of factor analysis: functional and probabilistic. If the relationship between resulting indicator and factors has a functional nature when the respective value of factor corresponds to strictly defined value of the effective rate, then this type of connection is called deterministic. When the change of factor indicator gives some values of the function, then this kind of connection between resulting indicator and factors is called stochastic;

Modeling of deterministic factor system should be carried out subject to the following rules:

- factors and the model itself must be real, not abstract, that is, to exist in reality and have clearly defined parameters;
- factors included in the model should be in the reason-result connection with the resulting indicator and other factors;
- it is necessary to submit indicators in the model in quantities using absolute, relative or average values;
- factor model must meet its main purpose - to provide the possibility to determine the effect of individual factors on the effective value.

Kinds of factor analysis are divided into two types (picture 1).



Picture 1. Methodical ways of factor analysis

The choice of method of factor analysis depends strongly on the type of factor analysis. In strictly deterministic relations the following methods are used: chain substitutions, absolute and relative differences, index, logarithm, integral, etc. For the analysis of stochastic dependencies use methods of mathematical statistics: correlation, dispersion, regression and so on.

Methods of deterministic factor analysis. If a few factors influence analyzed indicator it is needed to set the separate influence of each of them. Deterministic factor analysis can be performed by various methods, most of which are based on the approach of elimination. Essence of this method consists in consistent examination of every factor influence on the resulting indicator without counting factors inter-influence, while other factors are invariable.

Chain substitutions consists in definition of influence of individual factors on the change in the resulting indicator through gradual replacement of the basic value of each factor on the actual value in the reporting period. For this a number of conditional values of the resulting indicator are calculated. A comparison of the value of the resulting indicator before and after the replacement of the level of one or another indicator neutralize the impact of all other factors, except one that allows determining the effect of the last indicator increase on the effective rate.

The technology of calculation by the method of chain substitutions can be represented as a series of following analytical operations:

1) calculation of the planned value of the effective rate;
2) replacement of the planned value of the first factor on actual (substitution);
3) calculation of conditional value of the effective rate;
4) determine the influence of the first factor by subtracting from the conditional planned value of the effective rate.

Consequently, the method of chain substitutions provides a consistent replacement of the indicator of previous (base) period or planned indicator on indicator of the reporting period with the following rules:

- in multiplicative models at first replace quantitative indicators and then qualitative ones; if in factor model there are some quantitative and qualitative indicators - at first substitute value of factors of the first level (indicators), then the lower levels;
- in aliquot models at first provide replacement of the value of indicator *a*, which is the numerator in the formula and then of indicator *b*, while the replacement procedure must comply with role of factor in the formation of effective rate;
- in mixed models - multiplicatively-additive type - $y = a\ (b\text{-}c)$ or aliquot-additive type - $y = a\ /\ (b + c)$, first substitute indicator *a* and then *b*, and finally *c*.

Comparison of the result of each subsequent calculation (substitution) with the previous one enables to determine the impact on the effective rate (in the first substitution all indicators except one are used in their base (planned) value, and in the last - all in their reported values. Number of substitutions is equal to the number of factors affecting the effective rate.

Zero substitution (initial value): $y_0 = a_0 b_0 c_0$ (1.1)

First substitution: $y_{01} = a_1 b_0 c_0$ (1.2)

Second substitution: $y_{02}=a_1b_1c_0$ (1.3)

Third substitution: $y_1 =a_1b_1c_1$ (1.4)

The calculation of influence of factors *a, b, c* on changing the effective rate by the method of chain substitutions can be represented by a system of equations:

$$\begin{cases} \Delta y_a = a_1b_0c_0 - a_0b_0c_0 = y_{01} - y_0 \\ \Delta y_b = a_1b_1c_0 - a_1b_0c_0 = y_{02} - y_{01} \\ \Delta y_c = a_1b_1c_1 - a_1b_1c_0 = y_1 - y_{02} \end{cases} \quad (1.5)$$

Where Δy_a, Δy_b, Δy_c - changing of the value of effective rate due to the action of the factor *a, b, c*.

To determine factors also, besides forming a system of equations you can build a table in which from left to right all needed factors are fixed, beginning from quantitative and concluding qualitative. Then resulting indicator is provided, and, finally, the column for factors influencing value calculation. In the first table row (zero substitution) write down planned, or base, indicators. Such process of four factors calculation is shown in a table 1.

Table 1.

Exposure of factors influencing by the method of chain substitutions

Number of substitution and factor	Factors				Resulting indicator	Value of factor influence
	a	b	c	d		
Zero substitution	a_0	b_0	c_0	d_0	y_0	-
First substitution, first factor	a_1	b_0	c_0	d_0	y_{01}	y_{01}-y_0
Second substitution, second factor	a_1	b_1	c_0	d_0	y_{02}	y_{02}-y_{01}
Third substitution, third factor	a_1	b_1	c_1	d_0	y_{03}	y_{03}-y_{02}
Fourth substitution, fourth factor	a_1	b_1	c_1	d_1	y_1	y_1-y_{03}

The method of chain substitutions is considered universal because it can be used for calculating the impact of factors in all types of factor models (additive, multiplicative, aliquot and mixed) and it enables to get full factorial decomposition. It is necessary to follow the order of the factors' changes since breaking of order of replacing leads to another factor decomposition (changing the absolute values of partial increments). To avoid this shortcoming in the theory of economic analysis adopted rules:

- subdivide all factors into quantitative and qualitative and record in factor model quantitative factors at first and then qualitative;
- if formula contains many quantitative, qualitative or structural indicators a sequence of replacement depends on the assessment of which ones are essential and which are derivative, which are primary and which are secondary.

Method of absolute differences. Calculations which are conducted in the table of chain substitutions can be simplified, if in every substitution to change the absolute factor value, which is being calculated by its actual deflection from base (planned) one.

The sequence of calculations by this method is as follows:

- calculate absolute deviation of each factor and the effective rate;
- the impact of each factor is calculated by multiplying the absolute deviation of factor by constant value of other factors from factor model.

The algorithm of calculation by this method will present as a system of equations.

In multiplicative models such as *y= abc*:

$$\begin{cases} \Delta y_a = (a_1 - a_0)b_0c_0 = \Delta a b_0c_0 \\ \Delta y_b = a_1(b_1 - b_0)c_0 = a_1\Delta b c_0 \\ \Delta y_c = a_1b_1(c_1 - c_0) = a_1b_1\Delta c \end{cases} \quad (1.6)$$

where *Δa, Δb, Δc* - absolute deviation of the value of factorial indicators respectively *a, b, c.*

In mixed models of multiplicatively- additive type y = a(b-c):

$$\begin{cases} \Delta y_a = (a_1 - a_0)b_0c_0 = \Delta a b_0 c_0 \\ \Delta y_b = a_1(b_1 - b_0) = a_1 \Delta b \\ \Delta y_c = a_1(c_1 - c_0) = a_1(-\Delta c) \end{cases} \quad (1.7)$$

Method of absolute differences has all the advantages and disadvantages of the method of chain substitutions and it should be used mostly for calculating the impact of factors in the multiplicative and mixed models.

Method of relative differences. This method is grounded on the calculation of differences in percent. The value of every factor influence is determined by the product of difference in adjoining indexes (percent) and planned value of summarizing indicator. A calculation needs to be conducted tabular or in un-tabular way.

The algorithm of calculation according to this method in multiplicative models such as *y = abc* submit in a system of equations:

1. Provide information in% as for every factor which affects the resulting figure.
2. Calculate the difference in % of plan fulfillment for each factor:

$$\Delta a\% = a\% - 100 \quad (1.8)$$

$$\Delta b\% = b\% - 100 \quad (1.9)$$

$$\Delta c\% = c\% - 100 \quad (1.10)$$

3. This difference is multiplied by planned resulting indicator (the impact of this difference on the resulting indicator).

$$\begin{cases} \Delta y_a = \frac{y_0 \Delta a\%}{100} \\ \Delta y_b = \frac{(y_0 + \Delta y_a)\Delta b\%}{100} \\ \Delta y_c = \frac{(y_0 + \Delta y_a + \Delta y_b)\Delta c\%}{100} \end{cases} \quad (1.11)$$

where *Δa%, Δb%, Δc%* - relative deviation (in percentage) of the value of factor indicator respectively *a, b, c*.

4. Calculate the sum of factors' influence on the resulting indicator and determine the amount of reserves to improve the effective rate that is analyzed (balance checking).

The method of relative differences is used to calculate the impact of factors only in multiplicative models and with a large number of factors.

Index method in economic analysis mostly is used in multiplicative and aliquot models of type:

$$I_y = \frac{a_1 b_1 c_1}{a_0 b_0 c_0} \quad (1.12)$$

Determining the impact of separate factors in this case is based on building local indexes with consistent chain replacement. The calculation of separate indexes is carried out by the formulas:

$$I_a = \frac{a_1 b_0 c_0}{a_0 b_0 c_0} \quad (1.13)$$

$$I_b = \frac{a_1 b_1 c_0}{a_1 b_0 c_0} \quad (1.14)$$

$$I_c = \frac{a_1 b_1 c_1}{a_1 b_1 c_0} \quad (1.15)$$

$$I_y = I_a \times I_b \times I_c \quad (1.16)$$

While defining the difference between the product of the indicators presented in the numerator and denominator of the above formula we get absolute increases of the effective rate in general also due to each factor separately, that is, as well as when using the method of chain substitutions.

Considered methods of elimination as deterministic factor analysis techniques have a significant drawback: during their use we are basing on the fact that factors act independently from each other, in fact they are changing jointly, mutually and interdependently, that causes additional change of the effective rate. This result of combined effect of all factors when using the elimination methods as a rule attach to the influence of one of the factors, mostly the last one in factor model. In this regard the value of influence of factors on the resulting indicator depends on the location of factor in the factor model. To get rid of this drawback of deterministic factor analysis use logarithm and integral method which are more complex in practical application than discussed above.

Although all considered methods of elimination differ by the calculations method, they give identical results, as far as they are based on the same principle.

Method of stochastic factor analysis. With strengthening of market factors influence on enterprises activity there is a necessity of economic-mathematical methods (EMM) usage in analytical researches. For their qualified application should submit objects in a mathematical model to simulate their behavior when changing situation.Through the use of EMM reduce deadlines of analysis, carry out better coverage of factors influence on the results of business activities, and replace approximate or simplified calculations by accurate calculations.

In modern economic theory is accepted to allocate the following economic and mathematical methods that can be used for analytic research:

1. Methods of elementary mathematics (higher) are used to solve many analytical tasks, applied in usual and traditional economic calculations during substantiation of needs in resources, accounting of production costs, plans', projects' development and more.

2. Methods of classical higher mathematics (differential and integral calculus, theory of probability and methods of analytical geometry) are used not only in other methods, such as methods of mathematical statistics and mathematical programming, but separately. Thus, factor analysis of changes in many economic indicators may be performed using differentiation and integration.

3. Methods of mathematical statistics (correlation analysis, regression, variation range, distribution laws, the sampling method, dispersion method, component analysis) are used in cases where changes of the analyzed parameters can be represented as a random process, and relationships that occur between indicators are not deterministic but mediated (indirect) which differ by probabilistic, uncertain character - that is there is a stochastic dependence between factors.

Dispersion analysis is a statistical method for the analysis of observations, which depend on various factors of simultaneous action, choice of the most important ones and evaluation of their impact. This is a statistical method intended for establishing a link between effective and factorial features. The task of dispersive analysis is to evaluate the ratio between the factors in order to determine the essentiality or insignificancy of different conditions of observation.

This method can be used to analyze the economic efficiency of introducing innovations, especially where the results of this implementation will not be exposed to precise quantity measurement (introduction of a new system of organization or preparation of production, work organization, restructuring of management and accounting, presenting new forms of economic activity, workers' training, etc.).

Regressive analysis is a method of analytical reflection of stochastic dependence between the explored features establishment. Regression equation shows how resulting (dependent) indicator changes at a change of any independent indicator (factor). A regressive analysis is used mainly for plans prognosis, and also development of normative base.

Correlation analysis is a method of research interdependence of features in general totality, which are random values and normally distributed. The correlation is a relationship between the features of social and economic phenomena in which on the value of resultant

feature, besides factor, influence many other features that can act in different directions simultaneously or sequentially.

Main requirements for the use of correlation analysis are a sufficient number of observations, totality of factor and resulting indicators, as well as their quantitative measurement and display in informational sources.

The use of correlation analysis methods allows to define changes of result indicator under the influence of one or a few factors, and also to define the relative degree of indicators' dependence on every factor. Thus the role of every factor is determined in indicators level formation and economic phenomena development regularity. It enables to define unused reserves completer, to substantiate plans and managerial decisions.

The application of correlation analysis is closely associated with regression, that it is why it is often called correlation-regression analysis.

Correlation and regressive analysis in analytical researches are often united in one correlation regressive analysis. This method is used for determination of close connection between indicators which are unconnected between each other functionally. It foresees such stages:

- task raising and choice of result and factor features;
- information collection and its primary processing;
- verification of data homogeneity;
- selection of factors for a model;
- factors interdependence elimination and clarification of the set of indicators;
- equation of regression construction by the system of normal equations;
- verification of received equation significance;
- estimation of analysis results and preparation of recommendations in relation to their practical use.

4. Econometric methods (matrix-balance models, method of analysis "input-output") are based on a synthesis of three disciplines: economics, mathematics and statistics. When using this method there are often created complex economic models which adequately reflect the relationship between observable phenomena and processes. The basis of econometrics is the econometric model, by which is meant a schematic representation of the economic phenomena or processes with a scientific abstraction, displaying their characteristics.

The most widespread in the modern economy is the method of economic analysis "input-output". Those are matrix (balance) models which are based on the chess pattern and enable in the most compact form to submit interconnection of expenses and results of production.

5. Methods of mathematical programming (linear, block, nonlinear and dynamic programming), mainly used to solve optimization problems of production and financial activities and assessment of intensity of planned tasks. With their help assess the degree of achievement of potential; determine "bottlenecks", the degree of competitiveness and insufficiency.

6. Methods of operations research (inventory control, calculation of the optimal replacement of equipment, game theory, theory of mass service, net planning) are used to analyze the development of methods for targeted actions (operations), quantitative assessment of the decisions and the choice of a better one.

The main sections of operations research:

a. game theory - the theory of mathematical models of optimal decision making under uncertainty or conflict of several parties with different interests;
b. theory of mass service - through probability theory explores mathematical methods of quantitative assessment of mass service processes. Any of structural units of industrial enterprises may be subject to the system of service.

7. Economic cybernetics analyzes the economic phenomena and processes as complex systems in terms of laws and management mechanisms and movements of information in them.

8. Most widely used in economic analysis have received modeling techniques and system analysis. In some cases, have to look for a solution of extreme problems with incomplete knowledge of the mechanism of the phenomena. Such a solution is sought experimentally.

Conclusions

Factor analysis is a rather broad concept and is inherent not only in the economic field. With the help of a fairly significant number of methods of factor analysis, it is possible to study the results, plan and forecast indicators for the future in all areas of human activity. The main thing is to clearly establish the factors that affect the performance indicator and choose the right methods of analyzing these factors.

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