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Statistical assessment of project economic priority in company's investment management

Evaluación estadística de la prioridad económica del proyecto en la gestión de inversiones de la empresa

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Resumen:

Se discuten los temas de formación y manejo del portafolio de inversiones de la empresa en las condiciones del déficit global de recursos financieros provocado por la pandemia COVID-19. Se determinan los síntomas-factores que influyen en el nivel de prioridad de los proyectos de inversión, que se considera una característica latente y oculta. Se fundamenta la posibilidad de estimar esta característica latente con la ayuda de métodos y modelos estadísticos multidimensionales, en particular, sobre la base de métodos taxonómicos, método de componentes principales. Se dan ejemplos concretos de la aplicación de estas herramientas especificadas en el curso de la

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gestión de inversiones de la empresa ucraniana PJSC "Yantar". Está comprobado que la implementación simultánea de los dos proyectos de inversión estudiados de la empresa, es decir, toda la cartera de inversiones reales analizada es óptima desde el punto de vista de las condiciones establecidas. Si las condiciones financieras de la empresa son tales que solo es posible la implementación secuencial de las acciones planificadas, primero es necesario implementar una inversión relacionada con la mejora de la línea de empaque de productos terminados, y solo entonces, un proyecto para reemplazar equipos obsoletos en producción.

Palabras clave: proyecto de inversión, punto de Fisher, gestión de inversiones, análisis taxonómico; evaluación de inversiones.

Abstract:

The issues of formation and management of the company's investment portfolio in the conditions of the global deficit of financial resources caused by the COVID-19 pandemic are discussed. Symptoms-factors influencing the level of priority of investment projects, which is considered as a latent, hidden feature, are determined. The possibility of estimating this latent feature with the help of multidimensional statistical methods and models, in particular, on the basis of taxonomy methods, principal components method is substantiated. Concrete examples of application of these specified tools in the course of investment management of the Ukrainian company PJSC "Yantar" are given. It is proved that the simultaneous implementation of both studied investment projects of the company, i.e. the whole analyzed portfolio of real investments is optimal from the standpoint of the set conditions. If the company's financial conditions are such that only the sequential implementation of the planned actions is possible, then first it is necessary to implement an investment related to the improvement of the line for packaging finished products, and only then – a project to replace obsolete equipment in production.

Keywords: investment project, Fisher's point, investment management, taxonomic analysis; investment assessment.

1. Introduction

There is a constant shortage of funding sources in the context of the global financial and economic crisis observed in the last two years in all sectors of the economy caused by the COVID-19 pandemic. This situation requires top managers of companies to compare planned investment projects, taking into account the evaluation of a large number of important financial and economic criteria. At the same time, the analyzed projects can be not only alternative, but also dependent due to lack of free funds in companies.

As a rule, the company's production and economic units have many eligible projects of real and financial investments, and the main limitation of their implementation is the availability of financial resources. Therefore, the task is not only to determine the acceptability and effectiveness of a particular single project, but also to establish the priority of some investment projects over others, i.e. to rank them in the order of future implementation. In this regard, it is especially important to have criteria, indicators, as well as appropriate methodological approaches and recommendations for their use in the arsenal of modern top managers of the company, which could help to solve this problem objectively. Let us consider the current state of these issues in both historical and substantive aspects.

The problem of determining the main financial and economic criteria for assessing the effectiveness of the investment project can be considered solved. Thus, the guidelines of many countries indicate that seven main criteria should be used for this purpose:

1. Net Present Value – *NPV*.
2. Profitability Index – *PI*.
3. Internal Rate of Return – *IRR*.
4. Modified Internal Rate of Return – *MIRR*.
5. Discounted Payback Period – *DPP*.
6. Payback Period – *PP*.
7. Accounting Rate of Return – *ARR*.

The first five criteria are used to account for changes in the value of money over time through discounting, the last two - accounting estimates.

As for the task of ranking projects in the investment portfolio, it remains unresolved due to a certain subjectivity of top managers, as well as different goals and priorities of individual companies. In this regard, we propose ordering of future financial and production activities of the company based on the acceptation of the concept of "priority of the investment project" as a latent feature, which can be assessed using multidimensional statistical methods and models.

2. Methodology

In order to solve the task successfully basing on the relevant mathematical formulas, we will introduce the following designations: $PV = \sum_{k=1}^{n} \frac{P_k}{(1+r)^k}$ – discounted current total value of cash receipts from the project; P_k – receipts from the project in the *kh* year (*k* = 0, 1, 2, …, *n*); $IC = \sum_{k=0}^{n} \frac{IC_k}{(1+r)^k}$ – discounted current total value of investment in the project; IC_k – investment in the project in the *kh* year; *n* – duration of the project (years); *r* – discount rate, which is based on a risk-free rate, risk premium, percentage of inflation; *Norm* – normative value of payback, or reserve of security of the project. In addition, through *q* denoted the number of the used economic criterion for assessing the investment project (*q* = 1, 2, ..., *w*), and through *s* – the investment project number (*s* = 1, 2, ..., *m*).

Taking into account the properties, advantages, disadvantages and interrelations of the criteria for assessing investment projects, we believe that it is expedient to use the following indicators based on discounted estimates for ranking these investment projects (Table N°1).

Table N°1: Economic criteria and indicators of investment projects

Indicator	Calculation formula	Conclusion on project acceptability
1. Net Present Value (*NPV*)	NPV=PV-IC	*NPV* > 0 – the project is acceptable *NPV* < 0 – the project is not acceptable *NPV* = 0 – decision is not defined
2. Modified Internal Rate of Return (*MIRR*)	$MIRR = \sqrt[n]{\frac{\sum_{k=1}^{n} P_k (1+r)^{n-k}}{\sum_{k=0}^{n} \frac{IC_k}{(1+r)^k}}} - 1$	*MIRR* > *r* – the project is acceptable *MIRR* < *r* – the project is not acceptable *MIRR* = *r* – decision is not defined

3. Discounted Payback Period (*DPP*)	DPP=min, where PV≥IC	*DPP* < *Norm* – the project is acceptable *DPP* > *Norm* – the project is not acceptable *DPP* = *Norm* – decision is not defined
4. Provisional Safety Reserve (*PSR*)	*PSR* = *MIRR* – *r*; $PSR' = \frac{MIRR - r}{r} \times 100.$	*PSR* > *Norm* – the project is acceptable *PSR* < *Norm* – the project is not acceptable *PSR* = *Norm* – decision is not defined

Source: built by authors.

The first criterion of Table 1 (*NPV*) provides an idea about the scale of the project and characterizes the probabilistic assessment of capital growth in the case of acceptability of the project, which fully corresponds to the main objective of the company's management. The second criterion (*MIRR*) is an objective and universal indicator of the investment project efficiency and can be used as a basis for calculating the profitability index (*PI*). The third criterion (*DPP*) of the investment project can be considered as a characteristic of liquidity and risk of the project. The fourth criterion (*PSR, PSR'*) is an indicator of absolute and relative risk of investment.

3. Literature review

Modern development of science, including economic, indicates that the most significant theoretical, methodological and practical results are usually achieved at the junction of various directions of scientific research. As a result, such a symbiosis new scientific disciplines: econometrics, optimal management, economic-statistical modeling and predicting arise. Recently, the researches devoted to issues of formation and management of the investment portfolio of the company in the context of a global deficit of financial resources become relevant.

Methodological approaches to investment analysis as an instrument in choosing and economic assessment of investment projects were set out in the study (Behrens W., Hawranек P.M., 1978). Subsequently, investment analysis was used to improve the quality of investment proposals and standardization of industrial feasibility research (State Agency of Ukraine for Investment and Development, 2010). Similar recommendations can be found in modern inventory of analysis benefits from investment projects (European Commission, 2014). Further research of the statistical assessment of the dynamics of investment and investment projects in conditions of uncertainty was based on a multicriteria approach (Shvetsova, Rodionova, Epstein, 2018; Shkolnyk, I., & Koilo, V., 2018), as well as using neural networks (Hajek, Henriques, 2017).

The concept of "priority of the investment project" is impossible in principle to reflect by one financial and economic indicator of the metric scale. This concept is multifaceted and described by a plurality of criteria (see Table 1). We propose to consider it from the position of the theory of latent features using the appropriate methods for its assessment. Therefore, the theory of latent economic features is the second (methodological) component of this article, which is considered in the works (Yankoviy O., 2015; Nadtoka T., Vinogradov A., 2014). And the third direction of the carried out research relates to methods for evaluating of latent economic features, including a taxonomic analysis, which relates to multidimensional statistical methods and models (Plyuta V., 1989; Yankoviy O., 2001).

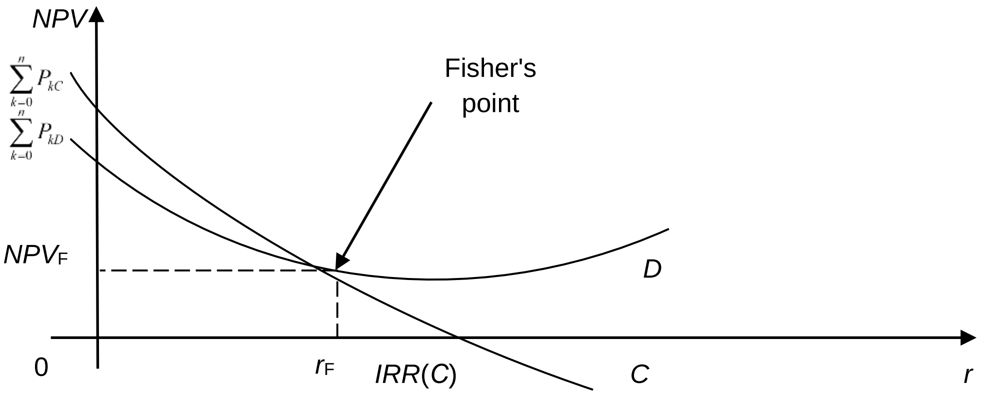
We believe that the combination of arsenal of these three directions of scientific research is a guarantee of obtaining new results in modern investment management at the level of individual companies. Examples of productiveness of such a combination can be evidenced by works of authors (Yankovyi O., Koval V., Trokhymets O., Karpenko M., Matskevich Y., 2020; Yankoviy O., Mel'nyk N., Yankovyy V., 2015).

4. Results and Discussion

4.1. Graphical method for prioritizing investment projects

The use of multidimensional analysis models usually precedes the study of the cash flow structure, as well as a graphical analysis of the function $NPV = f(r)$. For example, when the number of analyzed alternative projects is small, the task of determining of their priority can be successfully solved on the base of pairwise comparison of the graphs of their functions $NPV = f(r)$. The situation is getting complicated when the graphs of the functions *NPV* = *f*(*r*) for two alternative projects are crossing so their assessments are no longer so definite (Fig. 1).

Figure 1. Graphics of functions *NPV* = *f*(*r*) for two investment projects in the presence of Fisher's point



Source: function *NPV = f(r)*.

If cash flow schemes generated by two investment projects *C* and *D* arbitrary as presented in Fig. 1., the graphs of their functions *NPV* = *f*(*r*) can cross in so-called the Fisher's point with coordinates (NPV_F, r_F), for which NPV_F = *NPV*(*C*) = *NPV*(*D*).

Visual analysis of the graph in Fig. 1 shows that the abscissa axis is divided into three intervals:

1) 0 < r < r_F – both projects are acceptable, but the project *C* is prevailing;

2) r_F < *r* < *IRR*(*C*) – also both projects ar acceptable, but the project *D* is prevailing;

3) *IRR*(*C*) < *r* – project *D* is still acceptable, and the project must be rejected.

The main property of the Fisher's point is that investment projects change their priority in accordance with the *NPV* indicator. Indeed, to the left of the r_F point in Fig. 1 *NPV*(*C*) > *NPV*(*D*), and to the right *NPV*(*C*) < *NPV*(*D*).

Fisher's point can be found provided that the equation

$$\sum_{k=0}^{n} \frac{P_k}{(1+r_F)^k} = \sum_{l=0}^{g} \frac{P_l}{(1+r_F)^l} \qquad 1)$$

has at least one root. Here P_k, P_l are relevant cash flows of projects *C* and *D*, the duration of which *n* and *g* years.

Equation (1) follows to the next expression

$$\sum_{k=0}^{n} \frac{P_k}{(1+r_F)^k} - \sum_{l=0}^{g} \frac{P_l}{(1+r_F)^l} = 0. \qquad (2)$$

This means that the value of r_F in Figure 1 can be considered as an internal rate of return (*IRR*) of some new investment project (*C* - *D*), the cash flow of which is equal to the difference between the relevant inflows and outflows of projects *C* and *D*, and its duration is max (*n; g*). According to the property of the *NPV* = *f*(*r*) function for the conditional production project (*D* - *C*), the value of r_F does not change.

Obviously, in the case of an extraordinary cash flow of a new investment project (*C* - *D*) or (*D* - *C*) equation (2) may have not only one, but several roots. It follows to the conclusion of the fundamental possibility of finding several Fisher's points. In addition, the equation (2) may have no valid roots at all and it means that the Fisher's point is absent.

4.2. A case of using a graphical method for prioritizing investment projects

As an example, consider two alternative investment projects scheduled for implementation in production of PJSC "Yantar" for their own funds (discount rate *r* = 14%).

The first project (1) provides improvement of the line of packaging of finished products of the flushed cheeses production shop and the second one (2) provides substitution of obsolete equipment for complex mechanized lines for the production of solid cheese and butter.

The results of calculations of the basic initial and secondary economic characteristics of investment projects are presented in Table N°2.

Table N°2: Main economic characteristics of investment projects of PJSC "Yantar"

Indicator	Project (1) (*n* = 3)	Project (2) (*n* = 5)	Project (2 - 1) (*n* = 5)	Project (1 + 2) (*n* = 5)

1. Investment, UAH, thousands	580	760	180	1340
2. Inflows, UAH, thousands				
1st year	500	40	-460	540
2nd year	190	125	-65	315
3rd year	25	280	255	305
4th year	-	345	345	345
5th year	-	490	490	490
3. *NPV*, UAH, thousands	21.67	19.02	-2.65	40.69
4. *PI*, %	103.74	102.50	98.53	103.04
5. *IRR*, %	17.27	14.76	13.86	15.3
6. *MIRR*, %	15,4	14.57	13.66	14.68
7. *DPP*, years	1.97	4.93	> 5	4.84
8. *PSR*				
a) absolute, percentage points	1.4	0.57	-0.34	0.68
b) relative,%	10	4.07	-2.43	4.86
9. Fisher's point, r_F, %	13.86	13.86	-	-
NPV_F, UAH, thousands	22.65	22.65	-	-
10. $\sum_{k=0}^{n} P_k$ UAH, thousands	135	520	385	655

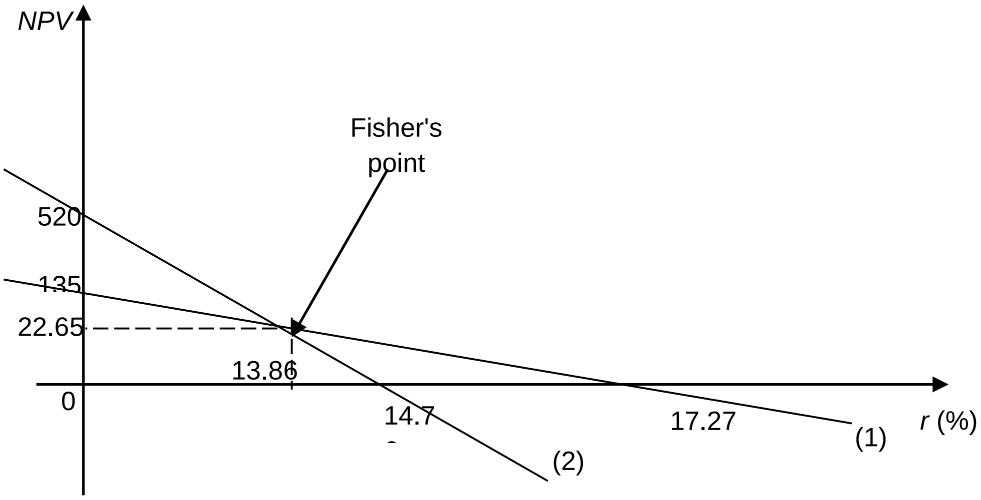
Source: built by authors.

In the last column of Table 2 the characteristics of the investment portfolio PJSC "Yantar", consisting of two projects (1 + 2), are presented.

The penultimate column of Table 2 show some parameters of the conditional project (2 - 1). The internal rate of profitability (line 5 of Table 2) determines one of the Fisher's point coordinates (r_F) – the intersection of the graphs of the functions $NPV = f(r)$ of each project.

The graphical analysis of the studied real investment (Fig. 2) based on the economic characteristics of Table 2 was carried out.

Figure 2. Graphics of functions *NPV* = *f*(*r*) of investment projects (1) and (2) of PJSC "Yantar"



Source: built by authors.

The entire abscissa axis in Fig. 2 can be conditionally divided into 4 segments:

1) $0 \leq r < r_F = 13.86$. Here both projects are acceptable and $NPV_1 < NPV_2$. At the point $r_F = 13.86$, the equality $NPV_1 = NPV_2 = 22.65$ thousand UAH is fulfilled.

2) $r_F < r < IRR_2 = 14.76$. At this point, both projects are still acceptable, but $NPV_1 > NPV_2$. At the point, $IRR_2 = 14.76$ the second project provides zero profit ($NPV_2 = 0$).

3) $IRR_2 < r < IRR_1 = 17.27$. The first project remains acceptable ($NPV_1 > 0$), and the second becomes unprofitable ($IRR_2 < 0$). At the point $IRR_1 = 17.27$, the first project provides zero profit ($NPV_1 = 0$).

4) $IRR_1 < r < +\infty$. Both projects are unacceptable because $NPV_1 < 0$ and $NPV_2 < 0$.

In this case, the value of $r = 0.14$ falls to the second segment, so the first project provides a greater increase of company capital. Information of table 2 indicates its higher efficiency ($15.40 = MIRR_1 > MIRR_2 = 14.57$) and lower risk of investment in the purchase of lines for packaging finished products compared to the substitution of obsolete equipment.

The absolute and relative safety margin of the first project 1.4 percent points 10.0% are higher than corresponding 0.6 percentage points and 4.0% of the second one. In addition, as noted above, the liquidity of the first project is much higher than the second one ($DPP_1 = 1.97 < 4.93 = DPP_2$).

Therefore, we recommend the management of PJSC "Yantar" to prefer investment (1), as one that is the best by all economic criteria for evaluating real production projects. As for the substitution of obsolete equipment (project (2)), this investment may become economically attractive in terms of using a cheaper ($r < 14$) source of funding. Figure 2 shows that the profit from the implementation of the second project will be higher than the same indicator of the project 1 on the segment $8 \leq r \leq 13$ percent, i.e. with the use of cheaper funds.

It should be noted that when evaluating independent projects, the MIRR criterion is fully concerted with the *NPV* criterion. Contradictions between alternative projects may arise if the investment differs significantly in scale or duration.

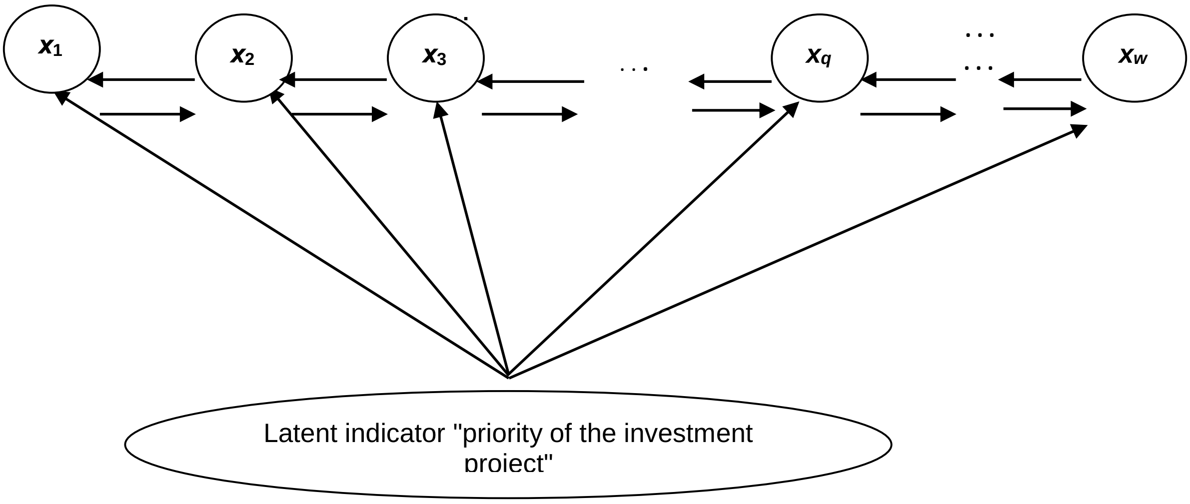
In the first case, taking into account the specific circumstances, it is necessary to determine what is more important for the company at the moment: to get a high profit or to provide relatively risk-free development? If the first investment strategy prevails, the *NPV* criterion should be preferred. In the opposite situation, more attention should be paid to the values of *MIRR*, *PSR* and *DPP* indicators, which reflect the effectiveness of the project, its safety margin and liquidity.

In the second case, special methods are used to eliminate the influence of the time factor when evaluating investment projects. These are the method of chain repetition during the total term of projects, the method of infinite chain repetition of comparable projects and the method of equivalent annuity.

4.3. Taxonomic analysis of the priority of investment projects in the framework of the theory of latent features

In the case when the number of alternative projects is large ($m > 3$), the task of determining their priority is significantly complicated and its successful solution requires other, more powerful methods than graphical analysis of functions $NPV = f(r)$. As mentioned above, in this situation, which is most characteristic of the economic reality of modern companies, we recommend using the theory of latent features. It allows us to consider the priority of the investment project as a hidden indicator that manifests itself in the form of many factors-symptoms: the values of individual financial and economic criteria of investment projects, for example, from Table 1 (Fig. 3).

Figure 3. Interrelation q of symptom factors between each other and the latent indicator "priority of the investment project"



Source: built by authors.

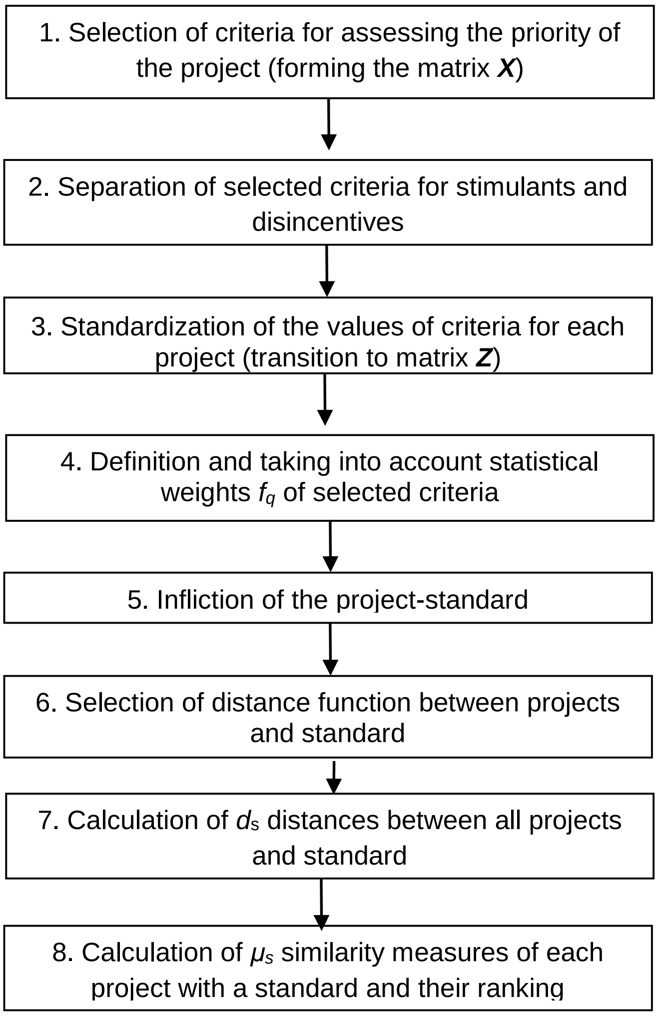
As part of the theory of latent features, appropriate methods for their evaluation have been developed, for example, with the help of multidimensional statistical models. Such models include multidimensional statistical analysis, in particular, taxonomy methods, which will be discussed in detail in this article.

The classical method with use of the standard which is the top point of *m*-dimensional space of investment projects are most often applied in the taxonomic analysis. Obviously, the smaller the distance from each point (project) to the standard (or the greater the similarity with it), the higher the priority (higher rank) is given to the planned project. The modified approach, on the contrary, is based on the use of anti-standard – the lower point of the studied *m*-dimensional space of criteria and the distance of each investment project from the anti-standard is interpreted as an assessment of its priority.

It is proved that the greater the distance from the object to the standard, the greater is the probability of error.

Based on the above theoretical conclusion, later in this article we will use as a tool for ranking of investment projects of the company a classic version of taxonomic analysis, which provides the most accurate solution to the problem. Its essence is to perform the following main stages (Fig. 4).

Figure 4. Block diagram of the classical algorithm of taxonomic analysis of the priority of investment projects



Source: built by authors.

4.4. Ranking of investment projects using classical taxonomic analysis

Let us consider the practical implementation of the classical algorithm of taxonomic analysis of the priority of investment projects on the example of three (m = 3) planned activities at PJSC "Yantar" without losing generality. These are the first two production projects to improve the line for packaging of finished products and to substitute of obsolete equipment for the production of hard cheese and butter and also the third project which is all the portfolio of investments of the company consisting of two initial projects (1 + 2).

At *the first stage* of the block diagram of the classical algorithm of taxonomy it is necessary to define and apply the most important criteria for assessing the priority of investment projects of the company, which will ensure the most accurate results of this study. As justified above, in this article we used four main criteria for assessing the priority of projects: *NPV*, *MIRR*, *PSR*, *DPP*, which best meet these requirements. However, since the economic services of PJSC "Yantar" provided for the financing of all projects without exception at their own funds with a discount rate of r = 14%, according to the formula of the safety margin *PSR* (line 4 of table 1) the ratio is

$$MIRR = r + PSR = 14 + PSR. \tag{3}$$

From formula (3) it follows that the indicators of *MIRR* and *PSR* are functionally dependent. They carry only one piece of information about the priority of the analyzed investment projects. Therefore, it is advisable to consider only one of them, for example, the security reserve of the *PSR* project. Hence the number of columns of the matrix of the original data is w = 3.

Therefore, the matrix $\boldsymbol{X}$ has the dimension 3 × 3and following form:

$$\boldsymbol{X} = \begin{pmatrix} 21.67 & 1.40 & 1.97 \\ 19.02 & 0.57 & 4.93 \\ 40.69 & 0.68 & 4.84 \end{pmatrix}$$

The second stage of the block diagram in fig. 4 is devoted to the division of selected economic criteria into stimulants and disincentives. In the fifth stage of the procedure, it ensures the correct definition of the standard of investment projects. In the second stage, based on the theory of investment, it is determined which growth of criteria is desirable, and which is not in terms of the studied latent feature. Based on the economic essence of these criteria, we found that the first two indicators (*NPV*, *PSR*) refer to stimulants, and the last one (*DPP*) is disincentive.

Standardization of criterion values and transition to the matrix of standardized data ***Z*** is carried out in *the third stage* of the procedure. Its task is to level the influence of *NPV*, *PSR*, *DPP* units on the results of taxonomic analysis. The transition to the matrix of standardized features ***Z*** is carried out using the formula:

$$Z_{sq} = \frac{x_{sq} - \bar{x}_q}{\sigma_q} \tag{4}$$

where $\bar{x}_q$ σ_q– is the average value and standard deviation of the data of the *q*-th criterion for all projects.

Standardization by formula (4) allows you to bring the original information to one dimensionless order (all data vary from -3 to +3). Standardized values of the criteria have the following three properties:

1) the arithmetic mean is zero, ie $\bar{z}_q = 0$;

2) the variance coincides with the standard deviation and is equal to one ($\sigma_q^2 = \sigma_q = 1$);

3) the pairwise correlation coefficient between the two criteria 1 and 3 is equal to the covariance between them, for example, for z_{NPV} and z_{DPP} is valid r(1;3) = *cov*(1;3).

Standardization of the values of the matrix ***X*** by formula (4) and the transition to the matrix ***Z*** takes place in the system of the program "STATISTICA". The obtained matrix of standardized values of three criteria for the studied investment projects has the next look:

$$\boldsymbol{Z} = \begin{pmatrix} -0.462 & 1.146 & -1.154 \\ 0.686 & -0.695 & 0.604 \\ 1.147 & -0.451 & 0.550 \end{pmatrix}$$

All values of the matrix ***Z***, which has the same dimension as the matrix ***X***, are free of units and are in the range from -2 to 2. The sum of z_s in the column is zero, and the variance is one.

The determination of statistical weights fq of the criteria selected at the previous stage is *the fourth stage* of the algorithm in condition: $\sum_{q=1}^{w} f_q = 1$.

This stage of the study allows you to differentiate *NPV*, *PSR*, *DPP* indicators according to their role in forming the level of priority of the company's investment projects by multiplying the set weights f_q by the corresponding columns of the source data matrix ***X***.

It is often necessary to reflect the different role of individual criteria in the ranking of investment projects according to their priority. This priority is based on practical experience, qualitative economic theory or taking into account the target settings that investment managers receive from the owners of the company. We propose to use the following statistical weights of the three selected criteria: f_1 = 0.5; f_2 = 0.3; f_3 = 0.2, which are based on the expert assessments of top managers of PJSC "Yantar".

Hence, the matrix of standardized data taking into account the statistical weights of the selected criteria has the following final form:

$$\boldsymbol{Z} = \begin{pmatrix} -0.231 & 0.344 & -0.231 \\ -0.343 & -0.209 & 0.121 \\ 0.574 & -0.135 & 0.110 \end{pmatrix}$$

The coordinates of the standard are determined in *the fifth stage* of the procedure based on the division in the second stage of the selected criteria (*NPV*, *PSR* and *DPP*) into stimulators and disincentives. The standard is a conditional or real point in the three-dimensional space of symptom factors, the coordinates of which characterize the best (from the standpoint of the division of variables into stimulants and disincentives) properties of the company's projects. The standard is the maximum possible, potential level of latent indicator (project priority). It performs a function of a kind of reference point for all studied investments (Andryeyeva, Tiutiunnyk, 2020).

There are different methods of setting the standard: 1) based on the values of the criteria for this set of investment projects only; 2) taking into account the values of the criteria of other companies, industries, countries, etc.

In the first case, the coordinates of the reference values (denoted by 0) for stimulators are set as follows:

$$z_{0q} = \max_s z_{sq} \tag{5}$$

and for disincentives:

$$z_{0q} = \min_s z_{sq}, \quad \text{or} \quad z_{0q} = 0. \tag{6}$$

In the second case, the target values are set, for example, to achieve results according to these criteria of similar investment projects of other companies.

Let us set the reference project in the considered problem on the basis of the values of the criteria of this set of investment projects, i.e. by formulas (5), (6). As a result, the standard project has the following coordinates:

$$z_0 = (\max_s z_{s1};\ \ \max_s z_{s2};\ \ \min_s z_{s3}) = (0.574;\ \ 0.344;\ \ -0.231).$$

This is a conditional point in the three-dimensional space of the criteria because the most significant *NPV* is observed for the third project, and the highest *PSR* and the lowest *DPP* are the properties of the first investment project.

The sixth stage of the classical algorithm of taxonomy is devoted to the choice of a specific function (metric) to measure the distance between all investment projects and the standard. In this case, the step metrics are in use usually. They are presented in table 3 and using the following notation: z_p, z_t - standardized points of multidimensional space, between which the distances are measured; *N*, *P*, *R* - parameters of degree metrics that determine their specific form.

Table N°3: Distance functions used in taxonomic analysis

Distance name (metrics)	Formula
1. Linear (city blocs, Manhattan) metrics	$d_1(z_p, z_t) = \sum_{q=1}^{w} \lvert z_{pq} - z_{tq} \rvert$
2. Euclidean metrics	$d_2(z_p, z_t) = [\sum_{q=1}^{w} (z_{pq} - z_{tq})^2]^{1/2}$
3. Supreme norm (Chebyshev's) metrics	$d_\infty(z_p, z_t) = max \lvert z_{pq} - z_{tq} \rvert$
4. Minkowsky's metrics	$d_N(z_p, z_t) = [\sum_{q=1}^{w} \lvert z_{pq} - z_{tq} \rvert^N]^{1/N}$
5. Degree metrics	$d_{P,r}(z_p, z_t) = [\sum_{q=1}^{w} \lvert z_{pq} - z_{tq} \rvert^P]^{1/R}$

Source: built by authors.

The most popular in economic research are the first three metrics: linear metrics, Euclidean metrics, Supreme norm (Chebyshev's) metrics. They are generalized by the fourth metric (Minkowsky's metrics), which at N = 1 gives a linear distance, at N = 2 - Euclidean metrics, at $N = \infty$ - Supreme norm (Chebyshev's) metric. Other metrics corresponding to $N \neq 1, 2, \infty$ are used very rarely.

For Minkowsk's metrics with increasing degree N, the value of the distance for given points z_p, z_t does not increase. Therefore, you can write:

$$d_1(z_p, z_t) \geq d_2(z_p, z_t) \geq \ldots \geq d_\infty(z_p, z_t). \quad (7)$$

The fifth metric - degree distance summarizes the first four metrics: at $P = R$ we get the Minkowsky's distance, at $P = R = 2$ - Euclidean distance, etc.

The choice of the distance function between the projects and the standard does not have clear theoretical recommendations, so in the future we will use the most popular Euclidean metric in economic research. Moreover, all distance functions are correlated in some way on the basis of inequalities (7).

The calculation of the distances ds between all projects and the standard takes place at *the seventh stage* automatically in the system of the program "STATISTICA" and the following matrix is obtained (Table 4).

Table N°4: Euclidean distances from each investment project to the standard

Investment project	1	2	(1 + 2)	Standard
Distance to the standard, d_s	0.805	1.127	0.588	0.000

Source: built by authors.

Visual analysis of data table 4 shows that the values of all distances vary from 0.5 to 1.3, i.e. the planned investment projects are quite homogeneous in terms of profitability, efficiency, risk and liquidity. Epy calculations show that the closest between all investment projects to the standard is project (1 + 2) (0.588), and the farthest - investment (2) (1.127). The values of the distances ds of investment projects to the standard can be interpreted as the values of synthetic reserves to increase the priority of each project.

At *the eighth stage* of the algorithm of taxonomic analysis after finding the distances to the standard, the measures of similarity μ_s of each project with the standard are determined by the following formula:

$$\mu_s = \frac{1}{1 + d(z_s, z_0)}, \qquad (8)$$

where d (z_s, z_0) is selected from table 3 distance function.

The values of μ_s vary from zero to one and are interpreted naturally: the higher the value of the similarity of the investment project with the standard, the higher the level of the required latent indicator. The priority of this project for the standard is $\mu_0 = 1$. Based on calculated values of similarity, the whole set of potentially acceptable projects is ranked according to the principle: rank 1 receives the planned investment project corresponding to the maximum value of μs, rank 2 gets the project for which the value of similarity with the standard is on second place, etc.

Thus, the ordering of investment projects is based on a one-dimensional (scalar) value of μs, which serves as a statistical assessment of the sought latent indicator - the priority of the planned project.

The calculation of the measures of similarity of the three analyzed projects with the standard and their ranking is carried out with the help of a visual definition of projects as leaders, medium and outsiders. It is usually carried out using the Excel editor by formula (8) based on the calculated distances d_s (Table 5).

Table N°5: Results of ranking of investment projects of PJSC "Yantar"

Investment project	1	2	(1 + 2)	Standard
Distance to the standard, d_s	0.805	1.127	0.588	0.000
Similarity with the standard, μ_s	0.554	0.470	0.630	1.000
Rank	2	3	1	–

Source: built by authors.

Table 5 data analysis shows that among the studied investment projects of PJSC "Yantar" can be identified a leader, medium and outsider. The leader in terms of profitability, efficiency, riskiness and liquidity of the planned projects is the whole company's investment portfolio (1 + 2), i.e. the parallel implementation of both real investments 1 and 2. It has maximum similarity with the standard (0.63). The medium in this set of projects is investment 1 with similarity to the standard 0.554, and the outsider is the project 2 with μ_S = 0.47.

5. Conclusions

Eventually, the study, based on the junction of three different areas of modern science (investment analysis, theory of latent economic indicators, statistics), has successfully solved the problem of formation and management of the company's investment portfolio in a global shortage of funds. As a result it became possible to objectively determine the priority of three investment projects of PJSC "Yantar" using models and algorithms of taxonomy on the base of the proposed symbiosis of the main provisions of project analysis, the theory of latent economic characteristics and multidimensional statistical methods.

It is statistically proven that the optimal from the standpoint of the set conditions (profitability, efficiency, risk and liquidity) is the simultaneous implementation of both studied investment projects of the company, i.e. the whole analyzed portfolio of real investments (1 + 2). If the company's financial conditions are such that only consecutive implementation of the planned projects is possible, then first it is necessary to implement investment 1 (improvement of the line for packaging of finished products), and only then proceed to investment 2 (substitution of obsolete equipment for production cheese and butter).

In future developments, a certain theoretical and practical interest is the use of other multidimensional statistical methods, for example, factor analysis models, in particular, the principal component method, in solving the assigned tasks of prioritizing investment projects.

Researchers may encounter other multidimensional statistical methods and models for estimating latent economic characteristics in future development in area of project analysis. For example, it is possible factor analysis, in particular, the method of principal components, or a combination of methods of clustering and determination. Therefore, the comparison of the consistency of the obtained results and management conclusions obtained by taxonomy models and using other multidimensional statistical methods is of some theoretical and practical interest.

References

Andryeyeva, N., & Tiutiunnyk, H. (2020). Assessment of Innovation and Investment Potentials As a Strategic Basis for Identification of Smart Specialization of Regions of Ukraine. Economics Ecology Socium, 4 (3), 24-41. DOI: 10.31520/2616-7107/2020.4.3-3

Behrens, W., & Hawranek, P. M. (1978). Manual for the preparation of industrial feasibility studies. Published by Vienna: UNIDO – United Nations Industrial Development Organization.

European Commission (2014). Guide to Cost-Benefit Analysis of Investment Projects Economic appraisal tool for Cohesion Policy 2014-2020 European Commission Directorate-General for Regional and Urban policy. https://ec.europa.eu/inea/sites/default/files/cba_guide_cohesion_policy.pdf

Hajek, P., & Henriques, R. (2017). Modelling innovation performance of European regions using multi-output neural networks. PloS one, 12(10), e0185755.

Koval, V., Prymush, Y., & Popova, V. (2017). The influence of the enterprise life cycle on the efficiency of investment. Baltic Journal of Economic Studies, 3(5), 183–187. DOI: 0.30525/2256-0742/2017-3-5-183-187

Nadtoka, T. B., & Vinogradov, A. G. (2014). Mnogomernoye otsenivaniye urovnya sotsial'no-ekonomicheskogo razvitiya predpriyatiya. Bíznes Ínform, 1, 184-191. (in Ukraine).

Plyuta, V. (1989). Sravnitel'nyy mnogomernyy analiz v ekonometricheskom modelirovanii. Moscow: Finansy i statistika (in Russia).

Shkolnyk, I., & Koilo, V. (2018). The relationship between external debt and economic growth: empirical evidence from Ukraine and other emerging economies. Investment Management and Financial Innovations. 15(1), 387–400. DOI: 10.21511/imfi.15(1).2018.32

Shvetsova, O. A., Rodionova, E. A., & Epstein, M. Z. (2018). Evaluation of investment projects under uncertainty: multi-criteria approach using interval data. Entrepreneurship and Sustainability Issues, 5(4), 914-928. DOI: 10.9770/jesi.2018.5.

State Agency of Ukraine for Investment and Development (2010). Methodical recommendations on development of business plans of investment projects, 73, v0073537-10. https://zakon.rada.gov.ua/rada/show/v0073537-10#Text.

Yankoviy, O. G. (2015). Latentní oznaki v yekonomítsí: monografíya. Odesa, Atlant.

Yankoviy, A. G. (2001). Mnogomernyy analiz v sisteme STATISTICA. Odessa, Optimum (in Ukraine).

Yankoviy, O. H., Melnyk, N. V., & Yankoviy, V. O. (2015). Do problemy vyznachennya priorytetnosti investytsiynykh proektiv promyslovoho pidpryyemstva. Ekonomika kharchovoyi promyslovosti, 1(25), 71-76. (in Ukraine).

Yankovyi, O., Koval, V., Trokhymets, O., Karpenko, M., & Matskevich, Y. (2020). Economic assessment of investment on the basis of production functions. Turismo: Estudos & Práticas (UERN), Mossoró/RN, Caderno Suplementar 02, 1-11. http://dspace.oneu.edu.ua/jspui/bitstream/123456789/12250/1/Economic%20assessment%20of%20investment%20on%20the%20basis%20of.pdf.