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ОЦЕНКА СТЕПЕНИ РИСКА ИНВЕСТИЦИЙ С НЕЧЕТКОЙ ЭФФЕКТИВНОСТЬЮ

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Ключевые слова: инвестиционный проект; управление риском; оценка риска.

Аннотация: Борьба с риском и управление им является основной задачей инвестора, как на стадии разработки, так и на стадии реализации проекта. В статье рассматриваются, наряду с традиционным методом, новые подходы к оценке степени риска инвестиционных вкладов, на основе применения нечетких множеств, исследуется эффективность α-level оценки, применяемой в инвестиционном проекте и ограниченном параметре эффективности, предлагается введение нечетких множеств в зону риска α-level, и т.д.

INTRODUCTION

In the contemporary period of transition to market economy, the decision-making on assessment and selection of investment projects. Evidently, each investment project is characterized with many groups of efficiency criterions, such as reliability, affordability and environment-friendliness. Each of these criterions, on its turn, creates a multitude of other criterions. As researchers fairly mark, «the economic risk is inevitably projected on procedures of registration, an estimation and information generalization in money terms about property and organization obligations. It is connected with constantly changing legislation, an illegibility of standards of the accounting, alternative principles of accounting, in certain degree with the human factor, absence of enough high qualification of bookkeepers, managers» [4, c.32]. The transition to market economy, while maintaining the values of the reliability and environment-friendliness criterions, intensifies the attention to economic criterions, such as: net present value (NPV), internal rate of return (IRR), payback period of project (PP), project profitability index (PI) and other criterions.

All above-noted criterions are necessary prerequisites for selection of oil production projects. However, they are clearly not sufficient for making investment decisions, as decisions on selection of investment project cannot be made by using just one criterion. Indeed, the nature, purpose and requirements of each specific project are different. The most case it is accompanied with uncertainty and fuzziness. In this case, none of criterions can, on its own, provide sufficient information which can be used as a basis for judgment on the project's attractiveness. Such judgment is possible only after study and assessment of each criterion (indicator) of efficiency and risk (resulted from the fuzziness of criterions), and after estimation of the attractiveness of the project and the cumulative risk based on all criterions.

The presented paper examines the common methods of risk assessment by each separate criterion of investment efficiency. These methods enable to assess risk based on each of criterions which are necessary for determination of cumulative risk for projects.

PRELIMINARIES AND SOME NOTATIONS

Let's assume that the efficiency indicator of an investment project *N* is membership function,μ_N,where Ñ=(N_{min},μ_n,N_{max})given as fuzzy set μ_N=0,i.e.Ñ-respectively,left and right frontiers of the set carrier N_{min},N_{max} $x \geq N_{max}$ and when $x \leq N_{min}$ when.

As far the limitary parameter C, we would assume that it is given as a fussy-μ_c.$x \geq C_{max}$or $x \leq C_{min}$ if μ_c=0 with the constitutions C˜=(C_{min},μ_c,C_{max})set, too is taken as a membership function.

functions may have different shapes and $\mu_c(x)$and $\mu_N(x)$ the graphs of may lay differently in respect to each other. For the ease of explanation, we would assume that these graphs are located on a coordinate plane.

Following [1] we can determine the risk zone and the assessment of risk by fuzzy sets.C˜and Ñ-levels of α means of.

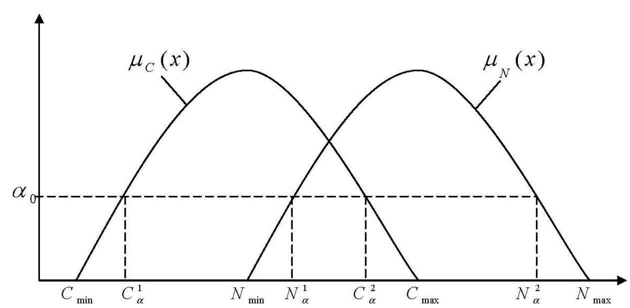
For certainty we will take the case when investment project is considered affordable for *N* indicator, if the value of *N* is not below than that of the –level will be α limitary parameter. Then, the risk zone of *N* and *C* for the given the area where *N*<*C*.

The risk zone is empty set (i.e.$\alpha \geq \alpha_0$-levels with α as seen from figure1,for segment .in this [N_{min}, C_{max}] the risk zone is $\alpha<\alpha_0$ no risk exists), and when will correspond to some part of this segment's<α_0-level(α case, each, the whole segment will become a risk zone.α=0when.)

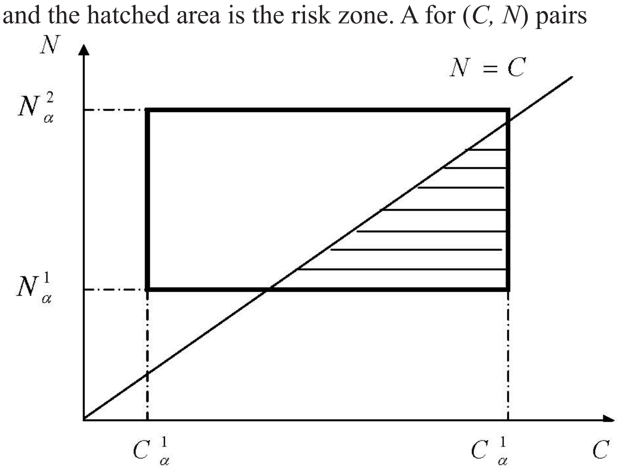
We will $\alpha<\alpha_0$ level (α Now, to estimate the risk relevant to the given apply two approaches):

fuzzy sets is used – in this C˜and Ñ-level of twoα_0.the approach where Ñ-level for both α traditional approach[2],we identify the frontiers of the fuzzy sets.C˜and

And N_α^1 and $\tilde{C}$ for the fuzzy set C_α^2 and C_α^1.the frontiers are marked as on figure1. These frontier points are then depicted on C $\tilde{N}$ for the fuzzy set N_α^2 and N axis, and the risk zone is defined.



to the risk zone (*C, N*). The geometric probability of the incidence of point-level.the *α* (see Figure 2) is taken as the estimation for the risk relevant to rectangle with bolded lines on Figure 2 – is the area of probable values of -level, and the hatched area is the risk zone. A for (*C, N*) pairs



Definition 2.1. Will correspond to following value: Thus, each

$$\varphi(\alpha) = \frac{S_\Delta}{S_\Pi} = \frac{(C_\alpha^2 - N_\alpha^1)^2}{2(C_\alpha^2 - C_\alpha^1)(N_\alpha^2 - N_\alpha^1)} \qquad (1)$$

square of the S_Δ - the square of the hatched triangle on Figure 2, S_Π where values are derived C_α^1, C_α^2, N_α^1, N_α^2 rectangle with bolded sides. We note that from evident correlations:

$$C_\alpha^1 = \mu_{CL}^{-1}(\alpha);\ C_\alpha^2 = \mu_{CR}^{-1}(\alpha);\ N_\alpha^1 = \mu_{NL}^{-1}(\alpha);\ \ N_\alpha^2 = \mu_{NR}^{-1}(\alpha).$$

- are the values of the invest function for $\mu_{CL}^{-1}(\alpha), \mu_{CR}^{-1}(\alpha), \mu_{NL}^{-1}(\alpha), \mu_{NR}^{-1}(\alpha)$ where and μ_C the left *(L)* and the right *(R)* parts of the membership function μ_N respectively.

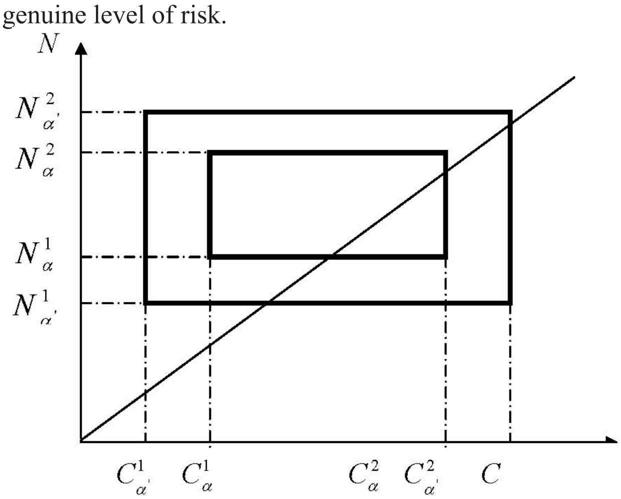
Definition 2.2. Further, the final risk level of non-affordability (inefficiency) of investment project is determined with the following formula in the traditional approach: [2]:

$$Risk = \int_0^{\alpha_0} \varphi(\alpha) d\alpha \qquad (2)$$

However, in our viewpoint, determination of inefficiency risk of project with the formula (3) cannot always accurately (correctly) reflect its real value (estimation).

The reason of such circumstance can be explained with following considerations:

Assume that we have defined the areas of all possible realizations of the level and *α* – (see Figure 3) for some *C* and the limitations of *N* indicator, α′ < *α* level where α′ - identified risk zone in this area. Now, if we take other, then the corresponding areas of realization and risk will have previous areas each *α* respectively (as shown on Figure 3). So, with consistent decrease of, consecutive derived areas of the realization (rectangle) and the risk (triangle) will contain preceding areas respectively. Therefore, the results of the operation on integration with such mutually-embedded areas will contain much excess (surplus) information, and may provide distorted view about the genuine level of risk.



For that reason, we believe that it is more appropriate to deal with the *α*

Definition 2.3. maximum risk level which is determined as the maximum of the variable of function:

$$Risk = \max_{0\le\alpha\le\alpha_0} \varphi(\alpha) = \max_{0\le\alpha\le\alpha_0} \frac{[\mu_{CR}^{-1}(\alpha) - \mu_{NL}^{-1}(\alpha)]^2}{[\mu_{CR}^{-1}(\alpha) - \mu_{CL}^{-1}(\alpha)][\mu_{NR}^{-1}(\alpha) - \mu_{NL}^{-1}(\alpha)]} \qquad (3)$$

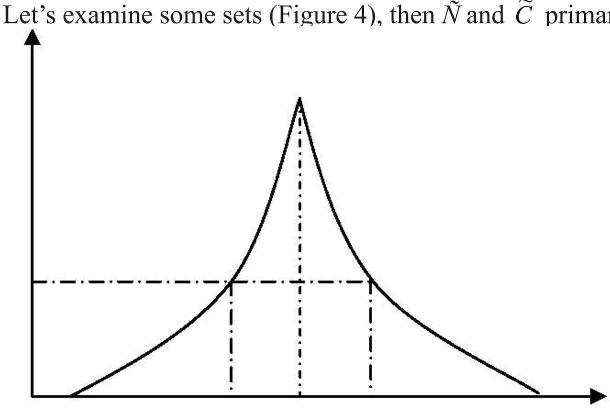
The computation of risk with the formula (3) uses relatively less number of excess (i.e. not relating to risk zone) information. The excess information is function. the excessiveness of *φ*(*α*) contained in the denominator of The information is due to the fact that the calculated square of the rectangle contains the non-risk area as well.

2. The second approach that we propose doesn't use such excess is defined *φ*(*α*) information. The essence of this approach is that the function of risk zone at each. To clarify the *α* only by means of the parameters of risk zone at each $\tilde{C}$ essence of this approach, let's examine the intersection of fuzzy sets and $\tilde{N}$

$$\mu_I(x) = \begin{cases} 0, & if \ x \le N_{\min} \ or \ x \ge C_{\max} \\ \mu_{NL}(x), & if \ N_{\min} \le x \le P \\ \mu_{CR}(x), & if \ P < x \le C_{\max} \end{cases} \text{, where } \tilde{I} = \tilde{C} \cap \tilde{N}.$$

$\mu_N(P) = \mu_C(P)$. *P* – is the point at which

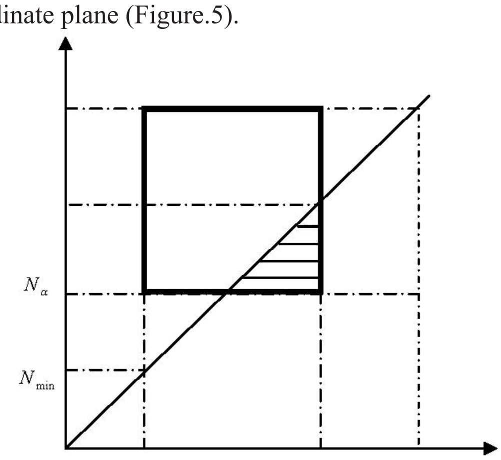
-Level of *α*-level is the *α*-level of this set. Since this *α* Let's examine some sets (Figure 4), then $\tilde{N}$ and $\tilde{C}$ primary



As seen from figures 1 and 4, the risk zone for the indicator *N* is the segment.

If we depict these $[N_{\min}, C_\alpha]$ and for the indicator *C* is the segment $[N_\alpha, C_{\max}]$

Then the following figure will appear (*C, N*) areas to coordinate plane (Figure.5).



If we take the ratio of the triangles square to the rectangle's square as-level then the value of risk is calculated with the value of risk relevant to, the following formula:

$$\varphi_1(\alpha) = \frac{(C_\alpha - N_\alpha)^2}{2(C_\alpha - N_{\min})(C_{\max} - N_\alpha)}$$

Corollary 2.4. In this case, it is also expedient to consider the cumulative risk not as the, i.e. $\varphi_1(\alpha)$ but as the maximum value ofintegral of

$$Risk = \max_{0\le\alpha\le\alpha_P} \varphi_1(\alpha) = \max_{0\le\alpha\le\alpha_P} \frac{[\mu_{CR}^{-1}(\alpha) - \mu_{NL}^{-1}(\alpha)]^2}{2[\mu_{CR}^{-1}(\alpha) - N_{\min}][C_{\max} - \mu_{NL}^{-1}(\alpha)]} \qquad (4)$$

$\alpha_P = \mu_{ML}(P) = \mu_{CR}(P)$ where

As seen from the formula (4), in the approach we propose the value of risk on inefficiency of the project is determined only through the parameters of the primary risk zone. Thereby, it is possible to more precisely determine the risk.

Hence, by determining risk level for each criterion on efficiency assessment of hydrocarbon resource exploitation projects, we can conduct a multi-criterion analysis of the project's efficiency based on aggregate criterions. For instance, the cumulative risk of a project, being the aggregate of all criterions, can be determined as the weighted sum of all risks:

$$Risk_{\Sigma} = \Sigma\, \sigma_i \cdot Risk_i$$

The level of importance of i^{th} criterion σ_i where n-number of criterions;

Can be done by means of σ_i Determination of the level of importance (expert estimations or based on paired comparison.)

In particular when the fuzzy sets $\tilde{C}$ and $\tilde{N}$ are presented by the triangle numbers,

$\tilde{C} = (C_{\min}, C, C_{\max})$, $\tilde{N} = (N_{\min}, N, N_{\max})$

We have ;

$$\mu_{Cl}(X) = \begin{cases} \dfrac{1}{C - C_{\min}} x + \dfrac{C_{\min}}{C_{\min} - C} & IFC_{\min} < x < C \\ 0 & IFx < C_{\min} \end{cases}$$

$$\mu_{Cl}(X) = \begin{cases} \dfrac{1}{C - C_{\max}} x + \dfrac{C_{\max}}{C_{\max} - C} & IFC < x < C_{\max} \\ 0 & IFx \geq C_{\max} \end{cases}$$

$$\mu_{Cl}^{-1}(\alpha) = C_{\alpha}^{1} = (C - C_{\min})\alpha + C_{\min} \qquad \mu_{Cr}^{-1}(\alpha) = C_{\alpha}^{2} = (C - C_{\max})\alpha + C_{\max}$$

see Figure 6;

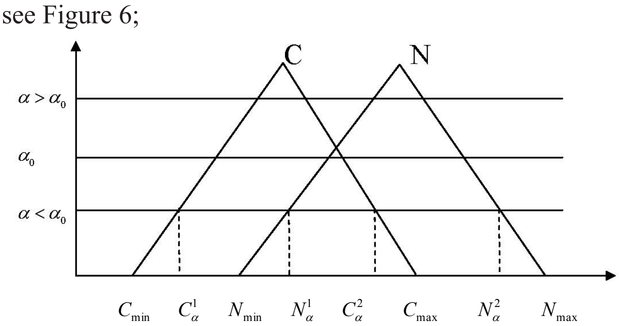


Figure 6.

$$Then\, \varphi(\alpha) = \frac{1}{2PQ}\left(\frac{(A_\alpha + B)}{\alpha - 1}\right)^2 where,\quad A = (C - N) - (C_{\max} - N_{\min}) < 0, B = (C_{\max} - N_{\min}) > 0$$

$P = C_{\min} - C_{\max} < 0$, $Q = N_{\min} - N_{\max} < 0$

Let us find the maximum of the function $\varphi(\alpha)$ on the interval $(0, \alpha_0)$,

$$\varphi'(\alpha) = \frac{1}{PQ}$$

$$P = C_{\min} - C_{\max} < 0,\ Q = N_{\min} - N_{\max} < 0$$

$$\frac{A_\alpha + B}{\alpha - 1} \cdot \frac{A(\alpha - 1) - A_\alpha - B}{(\alpha - 1)^2} = -\frac{A + B}{PQ} \cdot \frac{A_\alpha + B}{(\alpha - 1)^2} = 0; \alpha = \frac{-B}{A} = \alpha_0$$

Thus, the function $\varphi(\alpha)$ has not an Extremism on the interval $(0, \alpha_0)$. It is easy to see, that when $\alpha > \alpha_0$, A_α+B>0 and , since A < 0 , B > 0 , P.Q > 0 , we have $\varphi'(\alpha) < 0$ on the interval $(0, \alpha_0)$. It means that $\varphi(\alpha)$ is the degreasing function on the interval $(0,\propto 0)$.The maximal value of the function is $\max_{0\leq\alpha\leq\alpha 0}$, $\varphi(\alpha) = \varphi(0) = B^2(2PQ)$ and the takes on the minimal value at the point $\alpha = \alpha_0$ $\min_{0\leq\alpha\leq\alpha 0}$, $\varphi(\alpha) = \varphi(\alpha_0) = \varphi(-B/A) = 0$

See figure 7.

Consequently, the maximal Risk of inefficiency of investments is, Max Risk = max = $\varphi(\alpha) = B^2(2PQ)$, Min Risk = $\varphi(0) = 0$. In the second approach from Formulas

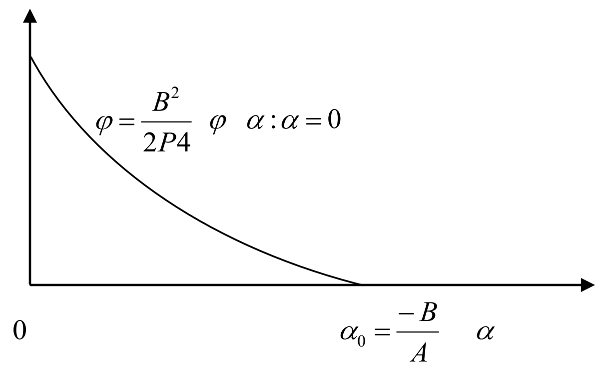


Figure 7.

(4-5) we obtain ;

$$\varphi_1(\alpha) = \frac{(C - N) + (N_{\min} - C_{\max})\ \alpha + (C_{\max} - N_{\min})^{\ 2}}{2\ (C - C_{\max})\alpha + (C_{\max} - N_{\min})\ \ (N_{\min} - N)\alpha + (C_{\max} - N_{\min})} =$$

$$= \frac{(A_\alpha + B)^2}{2\ (C - C_{\max})\alpha + B\ \ (N_{\min} - N)\alpha\ + B}$$

Lemma 2.5. Denote $D = C - C_{\max}$, $E = N_{\min} - N$. Then $\varphi_1(\alpha) = (A_\alpha + B) / (2(D_\alpha + B)(E_\alpha + B))$

$$\varphi_1'(\alpha) = B(A_\alpha + B)\frac{(A^2 - 2DE)\alpha + AB}{2\ (D_\alpha + B)(E_\alpha + B)^{\ 2}} = 0$$

Proposition 2.6. From this Equation we have;

A_α + B = 0 $\alpha_1 = -B/A = \alpha_0$ $(A^2 - 2DE)\ \alpha = -AB$

$\alpha_2 = \dfrac{-AB}{A^2 - 2DE}$ Since DE > 0 Then A^2-2DE < A^2 And ;

$\alpha_2 = \dfrac{-AB}{A^2 - 2DE} > \dfrac{-AB}{A^2} = \dfrac{-B}{A}\alpha_0$, i . e, $\alpha_2 > \alpha_0$, α = 0, A_α+B=0+B=0, $\alpha = -B/A$

Again both of the critical points not belong to the interval $(0, \alpha_0)$ and the function $\varphi_1(\alpha)$ is degreasing too. Hence, $\max_{0\leq\alpha\leq\alpha 0} \varphi_1(\alpha) = \varphi_1(0) = 1/2$, i.e. max Risk = 1/2

CONCLUSION

The paper introduces new approach for the risk assessment of project's inefficiency in the investment process and the main idea of this methodology is that, we determine the risks by taking the maximal value of the risk function, instead its integral $\varphi(\propto)$.

Such an assessment determines the investment risk more precisely, Because integral of the risk function artificially increase the risk.

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RISK ASSESSMENT OF INVESTMENTS WITH FUZZY EFFICIENCY

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Keywords: the investment project, management of risk, risk estimation**.**

Annotation: The paper introduces along with traditional method, new approaches for risk of fuzzy sets the efficiency of an α-level assessment based on the investment project and the limitary parameter of efficiency are presented as of the introduced fuzzy sets the risk zone α-level a fuzzy sets and for each is defined. The geometrical probability of belonging of value of the efficiency to the risk zone as the degree of risk is considered.