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CHOOSING THE RISK CURVE TYPE

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Abstract. Dialectics of categories of risk and return are becoming increasingly important in business process. The knowledge of risk indices allows to shape the judgement and make a decision. The provided risk-management method lets to make more reasonable and adequate managing decisions. The paper provides the substantiation of necessity of the enterprise risk level integral estimation. A calculation method for determining the probability curve of enterprise financial losses level has been worked out. Examples of risk curve use are given. Methodology of plotting the curve of possible loss probability or at least determination of regions and indices for acceptable, critical and catastrophic risk is seen as quite an efficient tool of management decision-making by an organization.

Keywords: uncertainty, risk curve, probability, normal distribution, loss level, representative points.

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1. Introduction

The empirical literature suggests that one reason for the lack of widespread acceptance of risk analysis methods by firms in assessing projects is that it is marred by some inherent and practical problems still to be resolved (Armin 1997). Economic literature profusely expounds decision-making methods under conditions of uncertainty, still economic and mathematical tools of their practical implementation have not been developed completely enough and not quite account for correlation of such categories as 'risk" and "profitability". As a result, they do not scientifically substantiate solution of urgent business tasks and reduce accuracy of financial and economical activity indices (Van Horn and Vahovich 2001). Risk analysis has recently emerged as a structured and precise methodology to help modern companies understand their risks and plan the relative countermeasures well in advance. It is based on a number of indicators: parameters that quantify the key concepts on which an enterprise designs its

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security and safety investments (Hardle *et al.* 2006). Hence, development of new approaches and proposals for practical implementation of new tools are particularly urgent.

The review and generalization of publications on questions of treatment, the analysis, an estimation and management of risk shows the following:

- there is no standard interpretation of the term "risk" till this moment;
- there is not of standard classification of risks;
- the method of a quantitative estimation of the generalized parameter of risk suitable for various theoretical and practical cases has not been worked out yet (Roland 2001);
- features of risk analysis in the field of the finance have not received an appropriate reflection;
- there are no scientifically proved recommendations of borders of a risk level for concrete situations (Dembo *et al.* 2000);
- the mathematical substantiation of questions of risk level reduction is not developed.

Problems of risk level integral estimation are regularly discussed in economic literature. Therefore even not absolutely correct ways of estimating a risk level for certain economic situations have a definite value, as they allow to make the best decision in concrete cases.

Under conditions of objective existence of risk and connected with it financial and other losses, there is a need for a certain mechanism which would allow to take risk while making decisions (Geoff 1999).

The most vivid and illustrative risk representation can be given by diagram of probability of loss as function of its level (the so-called distribution curve of probability of loss, or curve of risk). The purpose of the present work is plotting the risk for a legal economic entity of the Republic of Belarus.

2. Experimental methodology and results

To choose the type of curve for probability of loss, profit is considered as a random value. First, distribution curve of probability of certain profit level is plotted (one of the alternatives of calculating parameters for distribution of certain profit level probabilities is described in detail below). To plot distribution of profit probability the following assumptions have been taken.

1. The most probable is the profit equal to calculated value – CPr_c .Probability of such a profit (P_c) is maximum: $P = P_c$. Correspondingly, CPr_c can be considered as mathematically expected profit. Probability of higher or lower profit against the calculated one will be the lower, the more such profit differs from the calculated one, i.e. probability values of deviation from calculated profit monotonically decreases with a deviations increase.

2. Profit loss (PrL) is considered as its reduction in comparison with the calculated value (CPr_c). If real profit equals CPr, then $PrL = CPr_c - CPr$.

3. Probability of extremely great (theoretically infinite) loss practically equals zero, as losses have higher level (except for losses that are impossible to evaluate quantitatively).

Certainly, assumptions taken are arguable to some degree, for they really may not be observed in all kinds of risk. But generally, they truly reflect general logic of entrepreneur risk changes and are based on the hypothesis, that as a random value, profit is subject to normal or close to normal distribution law.

After plotting probabilities of profit, the next step is plotting probability distribution for probable profit loss, which in fact is a curve of risk. It is actually the same curve, but plotted in another system of coordinates (Fig. 1).

Let's pick out a number of representative points on the distribution curve of profit loss probabilities (Table 1 for coordinates and features thereof).

Table 1. Parameters of representative points on the risk curve

Representa-tive point	Coordinates		Characteristic
	PrL	P	
1	0	P_c	Defines zero profit loss probability. As for assumptions, probability of zero loss is maximum, though is <1
2	CPr_c	P_a	Is defined by the value of possible loss, equal to expected profit, i.e. complete profit loss
3	IC	P_{crP}	Corresponds to loss value, equal to calculated value, IC
4	PS	P_{ctT}	Is characterized by losses, equal to property status (PS) of the entrepreneur

Losses that exceed property status of an entrepreneur are not considered, as they are impossible to recover.

Three main ranges can be picked out of the risk curve (Table 2 for parameters) (Хохлов 2001).

The most simple and reliable method of calculation is statistical approach to plotting distribution curve of probability of certain profit level (though some authors, like W. Sharp argue that information about the past is unreliable conductor to future (Sharp *et al.* 1999).

Still, the author prefers statistical method of forecasts, rather than method of Delphi.

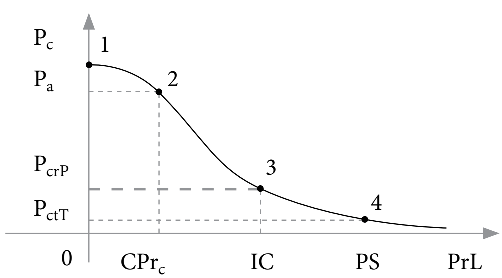

Fig. 1. Distribution curve for probability of occurrence of definite profit loss level

Table 2. Risk zones

Range of risk curve	Zone description	Characteristic
Between representative points 1 and 2	Zone of allowable risk	Profit loss in this range won't exceed calculated profit
Between representative points 2 and 3	Zone of critical risk	Profit loss in this range will exceed calculated profit, but won't reach sales income
Between representative points 3 and 4	Zone of catastrophic risk	Profit loss in this range will exceed sales income, and will equal to organization equity in the worst case

Statistical approach is based on the accurate reference data (Половинкин 1999). The gist of the method chosen is in the analysis of profit statistics observed for a number of time periods, magnitude and frequency of certain economic return; probability of a certain outcome, mathematical expectation, standard deviation are assessed, and the most probable future forecast is made (in our example, calculation is based on monthly profit of an enterprise (in US dollars) in the "f" period from January 2003 till December 2006 ($f = 48$))

Table 3 shows initial data array used for plotting probability curve for a certain profit level.

Then a scale of ranges is selected, within which profit magnitude will be ranked. In the example, ranges were chosen starting with profit magnitude of 78 thous. dollars with step 1. Frequency of occurrence of a certain profit level F_i (inclusion in the given range) is determined by the correlation of the number of instances of a certain profit level occurrence (repeatability of the actual profit level inclusion in the selected range) f_i with total number of instances in the statistical sampling ($f = 48$).

Table 3. Monthly profit of an organization, thous. dollars

Month	Year			
	2003	2004	2005	2006
1	78.00	81.75	82.17	85.96
2	78.65	81.89	83.11	84.97
3	78.27	81.66	83.95	86.26
4	79.94	82.36	82.51	85.62
5	79.13	81.50	83.45	85.88
6	80.12	81.98	83.45	85.87
7	79.49	82.64	83.11	86.39
8	80.26	83.54	84.04	86.60
9	80.64	84.67	84.85	86.92
10	79.86	82.37	84.70	87.25
11	80.62	82.15	85.08	88.10
12	80.54	84.11	85.28	87.29

Tables 4 and 5 show calculation of parameters of possibilities distribution P_i, mathematical expectation a, standard deviations *SD*.

Table 4. Calculation of probability

Interval No.	Range of profit, thous. dollars	f_i	F_i	K_i	$P_i = F_i \times K_i$
1	2	3	4	5	6
1	78–79	3	0.0625	0.45	0.028
2	79–80	4	0.0833	0.55	0.046
3	80–81	5	0.1042	0.60	0.062
4	81–82	5	0.1042	0.85	0.088
5	82–83	6	0.1250	1.15	0.144
6	83–84	6	0.1250	1.18	0.147
7	84–85	6	0.1250	1.20	0.150
8	85–86	6	0.1250	1.25	0.156
9	86–87	4	0.0833	1.30	0.108
10	87–88	2	0.0417	1.40	0.058
11	88–89	1	0.0208	1.50	0.031
Total		48	1	–	1

The calculated frequency of event (given sum of profit) realization is corrected by coefficients K_i (column 5). It's reasonable to introduce frequency correcting coefficients F_i that are subjectively determined on the basis of profit dynamics analysis.

With advancement to the finite time period probability of profit similarity to the previous time period increases. Thus, it's more probable that sum of profit Pr_{i+1} will be closer to sum of profit Pr_i, rather than to sum of profit Pr_{i-23}. Coefficients K_i were introduced with the purpose of singling out this tendency.

Besides, the profit dynamics of the organization can carry a strongly pronounced seasonal nature within one year (Riseberg 1992), and with a view of reflection of the given trend it is necessary to enter an adjusting parameter. It is important to reflect rates of a gain of financial result in comparison with the similar periods of the previous years. For example, it is known that the organization earns in December by 1,5 times more than in November, and 30% it is less than in May. In such a situation adjusting coefficients will promote flattening of lines and thus atypical results of each concrete month will not distort a picture. In general, it seems the most expedient to carry out the calculation of coefficients K_i. by a method of expert estimations, based on a representative initial database and the analysis of the profit dynamics tendencies, taking into account the current economic reality, capable to affect the result of the enterprise work.

Hence, as seen from column 3 of Table 5, mathematical expectation of profit $a_{i+1} = 85.5496$ thous. dollars. Column 4 of Table 5 serves the calculation of standard deviation *SD*.

As we know distribution parameters, it's not difficult to use table of probability values for occurrence of event *P* versus *a* and *SD*.

Table 5. Calculation of distribution parameters

Interval No.	Mean value in range, $\overline{\text{Pr}_i}$	$\overline{\text{Pr}_i} \times P_i$	Dispersion $D = \sum_{i=1}^{f} (\overline{\text{Pr}_i} - a)^2 \times P_i$
1	2	3	4
1	78.5	2.2078	1.3977
2	79.5	3.6438	1.6774
3	80.5	5.0313	1.5936
4	81.5	7.2161	1.4520
5	82.5	11.8594	1.3369
6	83.5	12.3163	0.6196
7	84.5	12.6750	0.1652
8	85.5	13.3594	0.0004
9	86.5	9.3708	0.0979
10	87.5	5.1042	0.2219
11	88.5	2.7656	0.2720
Total		A = 85.5496	D = 8.8347

For example, probability of profit will deviate from the most expected value (a = 85.5496 thous. dollars) by 2*SD* to a larger side, i.e. by 5.9446% (= 2 × 2.9723%), and is 2.2775%, and deviation proper is determined in the following way:

$$P_r = \alpha \times \left(1 + \frac{2\alpha}{100}\right).$$

Initial data for plotting the line of probability distribution to empirically obtain certain profit level (on the basis of frequency and correction coefficients calculation) were given in columns 6 of Table 4 and 2 of Table 5. Table 6 lists initial data for plotting probability distribution by statistical method (cum *SD* and a).

Table 6. Initial data for plotting statistical probability distribution line to obtain certain profit level

Event No.	Pr_i	P_i	Event No.	Pr_i	P_i
1	75.9500	0.0001	10	86.6900	0.1721
2	77.1800	0.0010	11	88.0900	0.1487
3	77.9200	0.0014	12	90.5300	0.0500
4	79.0000	0.0100	13	90.6400	0.0228
5	80.4600	0.0228	14	92.1000	0.0100
6	80.5700	0.0500	15	93.1800	0.0014
7	83.0100	0.1487	16	93.9200	0.0010
8	84.2000	0.1721	17	95.1500	0.0001
9	85.5500	0.1880	Sum:	–	1

Attention should be paid to the fact, that in columns 8, 9 and 10 probability values were chosen with regard to probabilities sum of all discrete distribution outcomes equals one, as well as accounting for the fact, that maturity of mathematical profit expectation (column 9 in Table 6) is most probable. Both lines are shown in Fig. 2.

It should be pointed out that distribution curves will never cross abscissa axis, though infinitely approach it. It cannot be said that both distributions have coincided, but lines are spaced close to each other and, as profit approaches mathematical expectation, probabilities of such outcomes practically coincide.

It makes sense to transform these 2 lines into one line by finding mean probability values in each profit interval. When combining 2 plots, particular attention should be paid to the section of the plot which is to mathematical expectation' left (organization is still more interested in deviation towards decrease, rather than profit deviation towards increase against an expected profit).

The right section of distribution is assumed as equal to the left part. The plot is given in Fig. 3. Region of loss is up to the right from the mathematical expectation, region of gain is up to the left.

According to central limit theorem of Chebyshev, parameters distribution is reduced to normal (irrespective of initial distribution type), if a great number of independent causes effect this parameter (Дубров 2000).

Hence, one can assume that in Fig. 3 we have a normal profit distribution. No matter what distribution is, Chebyshev inequity states, that not less than 88% of its values will be within ±*3SD range*, which in our case makes 73.8–89.7 thous. dollars range. In distribution shown in Fig. 3, 98.58% of values are included in this range.

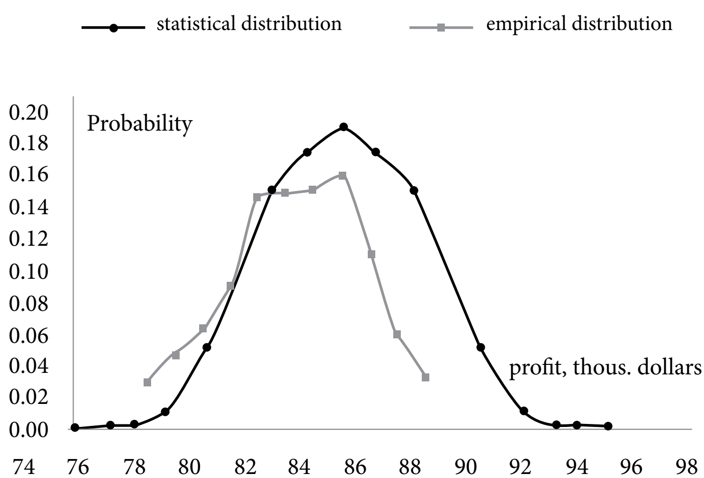

Fig. 2. Discrete probabilities distribution for obtaining certain profit level

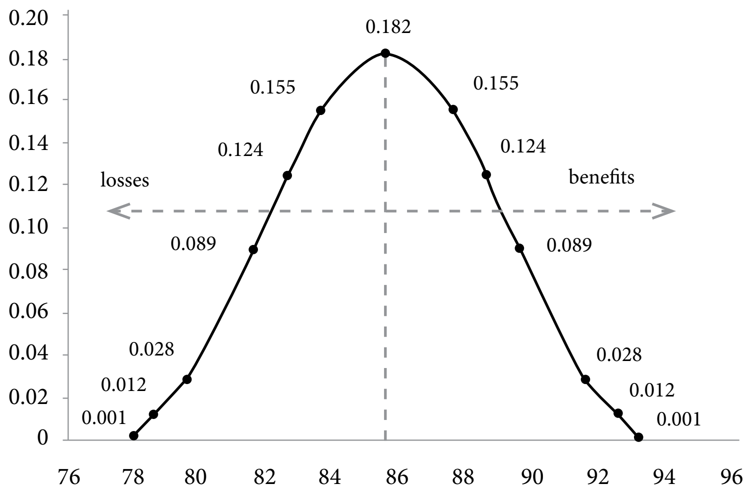

Fig. 3. Summarized curve of probabilities distribution

Important indices are possibilities of certain loss levels, they allow to judge of the expected risk and its acceptability, so the curve plotted in Fig. 1 can be qualified as a *risk curve*.

Methodology of plotting the curve of possible loss probability, or at least determination of regions and indices for acceptable, critical and catastrophic risk, is seen as quite an efficient tool of management decision-making by an organization. Examples of risk curve use are given below.

Suppose, a catastrophic loss probability is approximated by an index, which shows substantial threat to the whole property loss (for example, when its value is 0.2). Prudent organization/entrepreneur will abandon such case and will not run such a risk in advance. Even when to assess the risk of entrepreneur's activity, not the whole curve of risk probability is plotted, and only 4 representative points are determined (most probable risk level and probabilities of allowable, critical and catastrophic loss), the problem of such assessment can be considered as solved successfully. Values of these indices are in principle enough to take a reasonable risk in majority of cases.

For an entrepreneur who is estimating the risk, not the point, but the interval approach is more appropriate. Its important for him not only to know, that probability of loosing 10 000 dollars in the future transaction is, say, 0.1 or 10%.

He will also be interested in how probable is to loose the amount within certain boundaries (for example, in the range of 10 000–15 000 dollars) (Hizrich and Peters 1999). The loss probability curve allows to answer this question by finding mean probability value in the given loss interval.

Quite possible is also another manifestation of the interval approach in the form of "semi-interval", which is quite characteristic namely for entrepreneural risk. In the process of decision-making on weather, the risk is acceptable and reasonable, an entrepreneur has to estimate not so much the probability of certain loss level, but rather that probability of losses won't exceed a certain level. According to logic, namely this is the principal risk index. Probability of losses not exceeding a certain level is the index of reliability and confidence. Indices of risk and security in entrepreneural business are obviously closely intertwined (Bernstain 2000).

Suppose, an entrepreneur managed to determine that probability of loosing 20 000 dollars equals 0.1%, i.e. is relatively small, and he is ready to run the risk. What is principally important in this case is not that an entrepreneur is careful not to loose exactly 20 000 dollars. He is ready to accept any smaller loss and is never ready to agree to a larger amount. This is the natural psychology of an entrepreneur's behaviour under risk conditions.

The knowledge of risk indices (*Pc*, *Pa*, *Pcr*, *IC*) allows to shape the judgement and make decision on transaction. But to make such decision is not sufficient to estimate values of indices (probabilities) of acceptable, critical and catastrophic risk.

Limit magnitudes, over which they should not increase, have yet to be determined and apprehended, to avoid being entrapped in excessive unacceptable risk zone. Let's denote limit values of acceptable, critical and catastrophic occurrence probabilities as *Ka, Kcr, Kkt*, correspondingly.

In principle, magnitudes of these indices should be established and recommended by the applied theory of entrepreneural risk. Still, the entrepreneur himself can determine his own limit risk level, he is not intending to exceed. The present work is dedicated to the following limit risk values: $Ka = 0.1$, $Kkr = 0.01$, $Kkt = 0.001$, i.e., 10, 1 and 0.1%, correspondingly. It means that entrepreneural deal should not be taken, if one can loose all profit in 10 cases out of a hundred, loose income in one case out of hundred, and loose property even in one case out of one thousand.

Summing it up, if an organization has values of 3 risk indices and limit risk criteria, it can formulate the most general terms of acceptability of a deal being considered, or activity under analysis.

3. Conclusions

Any investment to business for deriving profit involves into management account the question of risk and potential revenue correlation (this correlation should be enough attractive for investor). Risk is the uncertainty while achieving the enterprise aims. That's why risky management obtains the growing actuality.

Being a dynamic process, risk management presupposes regular updating in order to analyse the development of the project risks continuously (Johnstone 2007). Only knowledge of the risk structure and of the dates, when risks occur during the project sequence, make it possible to initiate definite measures for minimizing risks (Лапуста 1998). Considering problems of making decisions under uncertainty requires engaging the financial mathematics apparatus.

In spite of it, there is no suitable method for different theoretical and practical cases of quantitative estimation of generalized risk criteria.

Analysis of accumulated experience in research of risk has shown the absence of scientifically substantiated limits of risk level acceptability for concrete situations.

This paper proves the risk which can be estimated quantitatively, but making decisions with assistance of risk curve will also require working out estimation parameters of concrete operation risk acceptability. Application of the suggested method of integral risk level estimation allows the organization to consider the situation objectively.

Further research must provide a great diversity of criteria, which influence the shape of risk curve (meaning that plenty parameters can remove the top of the curve to the left, and so decrease the mathematical expectation of loss). This way of research provides the great opportunity of working out the optimizing strategy of such categories as risk and revenue.

Appendix 1. Table of probability values for occurrence of event P versus mathematical expectation and standard deviation (is used for constructing the statistical distribution curve)

Standard deviation quantity	Probability of event realisation, %	Positive deviation value, thous. dollars	Positive deviation value, thous. dollars
1SD	14.870	84.409	79.118
1.96SD	5.000	86.949	76.578
2SD	2.278	87.055	76.472
2.576SD	1.000	88.579	74.949
3SD	0.135	89.701	73.827
3.291SD	0.100	90.470	73.060
3.774SD	0.010	91.750	71.780

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RIZIKOS KREIVĖS TIPO PARINKIMAS

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Santrauka

Rizikos ir grąžos kategorijų dialektika tampa vis svarbesnė versle. Informacija apie rizikos rodiklius leidžia įvertinti ir priimti sprendimą. Siūlomas rizikos valdymo metodas leidžia priimti protingesnius ir tinkamesnius sprendimus. Straipsnyje aprašoma, kaip atlikti įmonės rizikos lygmens integralinį vertinimą. Sukurtas metodas, kuriuo galima nustatyti įmonės finansinių nuostolių lygmens tikimybės kreivę. Pateikti rizikos kreivės naudojimo pavyzdžiai. Metodologija, leidžianti grafiškai pavaizduoti galimų nuostolių tikimybės kreivę ar bent jau nustatyti priimtinos, kritinės ir katastrofiškos rizikos sritis ir rodiklius, yra gana efektyvus įrankis priimant efektyvius sprendimus organizacijoje.

Reikšminiai žodžiai: neapibrėžtumas, rizikos kreivė, tikimybė, normalinis pasiskirstymas, nuostolio lygmuo, reprezentatyvūs taškai.

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