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METHOD OF ASSESSING THE LEVEL OF ECONOMIC SECURITY OF INDUSTRIAL ENTERPRISES APPLYING HARRINGTON DESIRABILITY FUNCTION

The article offers a methodological approach to the assessment of the economic security level. The expediency for application of Harrington desirability function as a tool in complex estimation of economic security level of industrial enterprise on the basis of its functional components is grounded. Key stages in the assessment of economic security of the enterprise using Harrington desirability function are identified.

Keywords: *economic security; Harrington desirability function; scale of desirability.*

Артем Л. Шатохін

МЕТОДИЧНИЙ ПІДХІД ДО ОЦІНЮВАННЯ РІВНЯ ЕКОНОМІЧНОЇ БЕЗПЕКИ ПРОМИСЛОВОГО ПІДПРИЄМСТВА ІЗ ЗАСТОСУВАННЯМ ФУНКЦІЇ БАЖАНОСТІ ХАРРІНГТОНА

У статті досліджено методичний підхід до оцінювання рівня економічної безпеки підприємства. Обґрунтовано доцільність застосування функції бажаності Харрінгтона як інструменту комплексного оцінювання рівня економічної безпеки промислового підприємства на основі її функціональних складових. Виділено основні етапи оцінювання економічної безпеки підприємства з використанням функції бажаності Харрінгтона.

Ключові слова: *економічна безпека; функція бажаності Харрінгтона; шкала бажаності.*
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Артем Л. Шатохин

МЕТОДИКА ОЦЕНКЕ УРОВНЯ ЭКОНОМИЧЕСКОЙ БЕЗОПАСНОСТИ ПРОМЫШЛЕННОГО ПРЕДПРИЯТИЯ С ПРИМЕНЕНИЕМ ФУНКЦИИ ЖЕЛАТЕЛЬНОСТИ ХАРРИНГТОНА

В статье исследован методический подход к оценке уровня экономической безопасности предприятия. Обоснована целесообразность применения функции желательности Харрингтона как инструмента определения комплексной оценивания уровня экономической безопасности промышленного предприятия на основе ее функциональных составляющих. Выделены основные этапы оценивания экономической безопасности предприятия с использованием функции желательности Харрингтона.

Ключевые слова: *экономическая безопасность; функция желательности Харрингтона; шкала желательности.*

Introduction. The current state of Ukrainian economy significantly changed the conditions of conducting economic activity of enterprises, which led to the emergence of various risks, both internal and external, thus requiring the adoption of a number of urgent measures aimed at economic stabilization. These problems include the estimation of economic security level of enterprises. The relevant problem for management in this case is the methodology choice for assessing the level of economic security.

Latest research and publications analysis. The most significant contribution to the development of methodical approaches to the assessment of economic security

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level have been made by such scientists: O.I. Baranowski (2004), M.A. Bendikov (2002), S.B. Dovbnya (2008), K.S. Goryacheva (2006), M.M. Iermoshenko (2001), G.V. Kozachenko and V.P. Ponomarev (2001), G.V. Kozachenko et al. (2003) and many others. However, finding the most effective methods for assessing the level of economic security still continues.

The purpose of the study. To investigate the possibility of applying the desirability function by Harrington as a tool for complex estimation of economic security level at industrial enterprises on the basis of its functional components.

Key research findings. Today in scientific literature there is no generally accepted approach and methodology for assessing the economic security of enterprises, due to uncertainty of the criteria and methodology of calculation of the related indicators. Scientists offer a variety of indicators with limit values, mostly borrowed from the world experience. Common in most of these methodologies, is the comprehensive approach to the determination of the integral index, while they differ in quality composition of evaluation indicators and in various mechanisms of information generalizing. Given the previous experience of researchers, we will note the main conditions, which the generalized (integral) index must meet:

- to have fixed boundaries for assessment;
- a simple calculation method, which would use the available data and be flexibile in application;
- to be able to assess the levels of economic security of different security components of the same enterprise, as well as economic stakeholders within various industries.

From our point of view, the best instrument to meet the requirements here is the desirability function by Harrington. The relevance of its use is justified in the scientific papers of E.C. Harrington himself (1963), L.A. Zadeh (1965), Y.P. Adler et al. (1976), V.D. Sekerin et al. (2005), T.S. Bezborodova (2014) and others. This desirability function has been used in many industries. For example, in ecology, economics, medicine and technology, it is used to assess: the quality of water; the level of socioeconomic development of a region; competitiveness; efficiency of investment projects; effectiveness of treatment; rationality of constructive-technological and geometrical layout of solutions etc. (Harrington, 1965; Koltunov and Belinska, 2010; Fedulova, 2011; Zakharkina, 2011).

The essence of this method lies in the fact that all selected indicators calculation (in different units of measurement, including quality, aesthetic, psychological or personal characteristics) are reduced to a single dimensionless one, based on which the integral indicator is calculated (Harrington, 1963). Therefore, from both theoretical and practical points of view, the Harrington desirability function is used to assess the level of economic security under the conditions of adaptation of calculations to required requirements.

Enterprise economic security is a fairly complex multivector system, the effective management of which depends, to a large extent, from the qualitative assessment of the state of its components. Note that when calculating the level of economic security of enterprises it is necessary to consider several elements from the point of view of their impact on the enterprise in two broad groups: internal and external orientation. The relevance of such differentiation is well explained by (Shatokhin and Ignashkina, 2014). Let us consider how to use effectively the Harrington desirability

function for the assessment of economic security level for industrial enterprises on the basis of its elements. Let's take a closer look at the essential principles of this approach.

It is well known that the first step in the calculation of the desirability function is the choice of assessment metric scale on the interval from 0 to 1. There are two variants of the desirability scale: one-way and two-way restriction. The first of them specifies only one "critical" value of the indicator (CVI), for example, with regard to our topic of study, the minimum acceptable level of any measure of economic security (Figure 1). In this case, if the value of the index will be less than the minimum (MN), the level of economic security will be unsatisfactory, if more or close to the minimum (MoM) – satisfactory level of economic security. Criteria for "satisfactory" or "unsatisfactory" are taken for example; every researcher can aet own limits and interpretation for them.

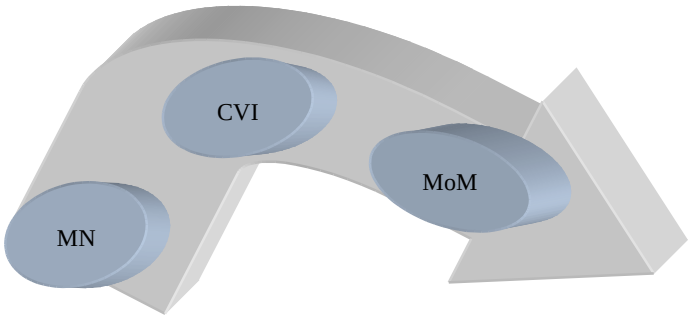

Figure 1. **The desirability scale with one-way restriction,** *developed by* (Bezborodova, 2014)

For most indicators to set the scale on one-way restriction is difficult, in this case the minimum (min) and maximum (max) values are defined (Figure 2). The matter is that almost all technical and economic indicators of enterprise activity can precisely align with unilateral constraint, they can vary higher or lower, that is, they have "max" and "min" values. Determination of values depends on the selected evaluation metrics. Usually taken normative values of these parameters are calculated on the statistical basis or recommended values for each industry.

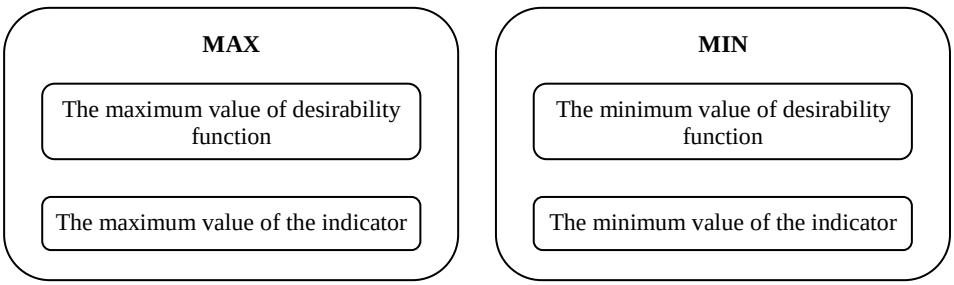

Figure 2. **The scale of desirability with two-way restriction,** *developed by* (Rybintsev et al., 2005)

Note that the scale of desirability belongs to psychophysical scales. Its main task is the establishment of correlations between physical and psychophysical parameters. Physical, aesthetic and statistical parameters include the potential assessments that characterize the functioning of an object under study. Psychological factors include subjective assessment of the desirability posed to scientists on the basis of experience or experiments. The majority of researchers in various fields of science (physics, economics, medicine etc.) regardless of the nature of comprehensive assessment are using a ready-made scale of desirability with the developed tables of relationships between physical and psychological parameters (Table 1).

Table 1. **Interpretation of the estimated desirability function** (Sekerin et al., 2005)

Assessment desirability function	Interpretation
1.0 < D < 0.8	Very good
0.63 < D < 0.8	Good
0.37 < D < 0.63	Satisfactory
0.2 < D < 0.37	Unsatisfactory
0 < D < 0.2	Very unsatisfactory

The literature describes several methods of creating desirability function, each has its practical use depending on the type of analysis to be conducted:

1) for providing most of the desired value based on the empirical distribution function of the estimated value.

Desirability function for the empirical distribution is calculated on the basis of providing the most desirable value. Let $x \to Femp(x)$, the experimental distribution function of a random variable x. Let us denote $y(z)$ function for z: [0;1].

$$y(z)=\begin{cases}\exp\left(\dfrac{(z-z_{opt})^2}{z(1-z)}\right),\\ 0,\ z=0,\quad z=1.\end{cases} \tag{1}$$

Then the desired desirability function is the value of the function $G(x) = y(F_{(exp)}(x))$. The only parameter specified by this way of constructing the desirability, is the set of z_{opt} within the range [0; 1]. The choice of a certain z_{opt} is based on the empirical distribution function x. The meaning of this transformation is to standardize the desired variable. Note that the closer the desirable value approaches 1, the smaller is the deviation of x from a certain value taken as the optimum;

2) on the left and the right border of the desired values.

Desirability function on the left and right bounds of the range of desirability is based on two constraints (min and max). Let the value of x_{min} and x_{max}xmax define the range of desired values of the magnitude of the indicator. Using $z(x)$ define the helper function from $x \to z(x) = \dfrac{2x - x_{min} - x_{max}}{x_{max} - x_{min}}$. The desirability at the point x will be calculated by the formula $F(x) = \exp(-z^2(x))$;

3) the right or the left side and the place of optimal distribution of desirability. Building a desirability function on the right border and the place of optimal distribution of desirability (x_{opt}) is based on the auxiliary functions $x \to z(x) = \dfrac{(x - x_{opt})}{x_{opt} - x_{right}}$.

In this case, the desirability values of x is determined as $F(x) = \exp(-z^4(x))$. Building a desirability function at the left boundary follows the same principle as that of the right one; the difference lies in the replacement of function x_{right} by x_{left}.

Calculating the level of economic security it is better to use, in our opinion, the second way to build the desirability function with left and right limits. The left limit is the smallest value of a single indicator for the period under analysis, the right has the maximum value. If the index of economic security is decreasing, in this case the left limit is defined as the maximum, and the right as the minimum value.

After choosing the method for constructing the desirability function we calculate the distribution function of the considered variables according to the data obtained for each indicator of economic security. Harrington desirability function has its mathematical form:

$$d = e^{-e^{(-x_i)}}, \quad (2)$$

where d is the unit rate of desirability function; e – the base of natural logarithms; x_i – the value of evaluation index, converted to dimensionless scale.

Graphically the desirability function of Harrington is shown in Figure 3. The x axis has the values of the dimensionless quantity of the assessed indicator, the axis of ordinates corresponds to the dimensions of desirability. On the chart of distribution, the researcher can clearly define the value of the desirability function and its variable x.

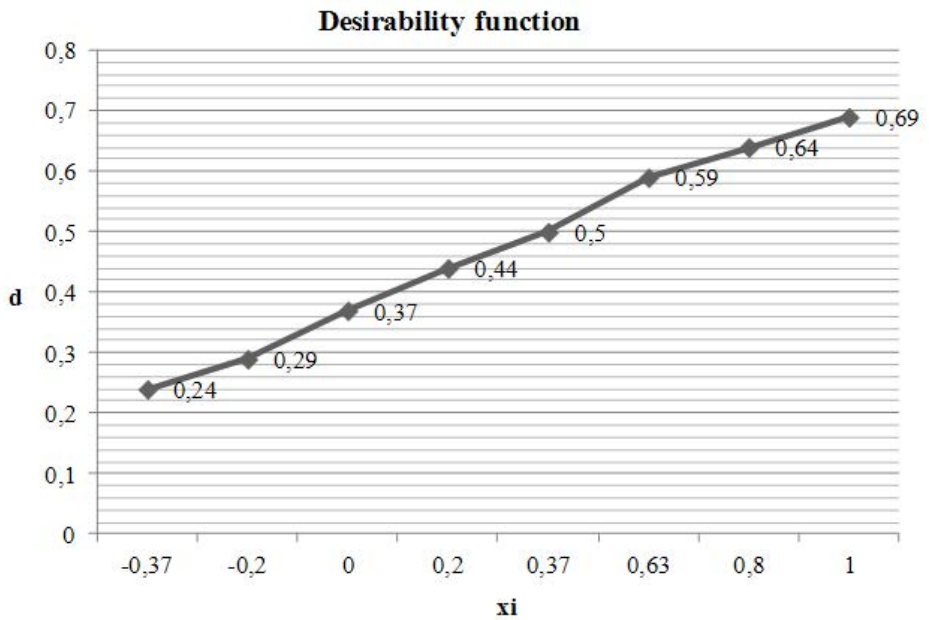

Figure 3. **The graph of desirability function,** *developed according to* (Puryaev, 2007)

After finding the unique indicators of the components of economic security on a dimensionless scale we turn to comprehensive assessment of economic security level in all its components.

The distinction between the calculation of the components of the security is necessary for a more detailed analysis in order to identify the problem areas that require a program of actions to improve the situation.

Combining individual indicators into a single integral indicator can be done in various ways. For example, the arithmetic mean is the most common medium for calculation of the integral indicator. Academic economists use mainly those methods in which the sum of individual values of relative indicators is obtained with weighting. However, after analyzing the essence of various techniques, it is advisable, in our opinion, to determine the integral index formula for geometric average. Our choice can be explained by the fact that the geometric average gives the most accurate result of averaging (Yeliseyeva et al., 2001). Also, giving preference to geometric average is required when the individual values are relative. Therefore, Harrington desirability function (meaning, the level of economic security components) will be presented through the geometric average of individual parameters and taking into account the above values as follows:

$$D = \sqrt[n]{P_{i-1}^{n} d_i} = \sqrt[n]{P_{i-1}^{n} e^{-e^{\frac{2x_i - x_{\min} - x_{\max}}{x_{\max} - x_{\min}}}}}, \quad (3)$$

where D is the overall desirability (the level of economic security components); P – product sign indicators; n – the number of combined indicators.

In our opinion, at the stage of finding the general indicator of economic security level it is advisable to take into account the weight of internal and external constituents. This will help more accurately determine the overall level of security, because internal and external security have different impact on company's activities. So, the overall index of economic security due to components arrangement is determined as:

$$les = D_{\text{int}}^{a} \times D_{ext}^{b}, \quad (4)$$

where les – the overall level of economic security of an enterprise; D_{int}^{a} – the level of economic security of enterprise's internal components; D_{ext}^{b} – the level of economic security for external components; a and b are the weighting factors of internal and external security, respectively ($0 < a(b) < 1$)).

To determine the coefficients a and b the literature describes many techniques, including the expert method.

On the basis of mentioned above, we can describe the main stages in the assessment of economic security level of the enterprise with the use of Harrington desirability function (Figure 4).

Conclusions and prospects for further research. According to the results of this study, the relevance of Harrington desirability function is doubtless for comprehensive assessment of economic security level and its constituents.

The practical use of this technique is based on Harrington desirability function as a psychophysical scale, allowing to compare the level of economic security of enterprises, regardless of their specificity. Calculations of economic security level will help top managers to identify the most problematic areas in enterprise functioning. Further important stage in the research is the formation of a system of individual indicators for each component.

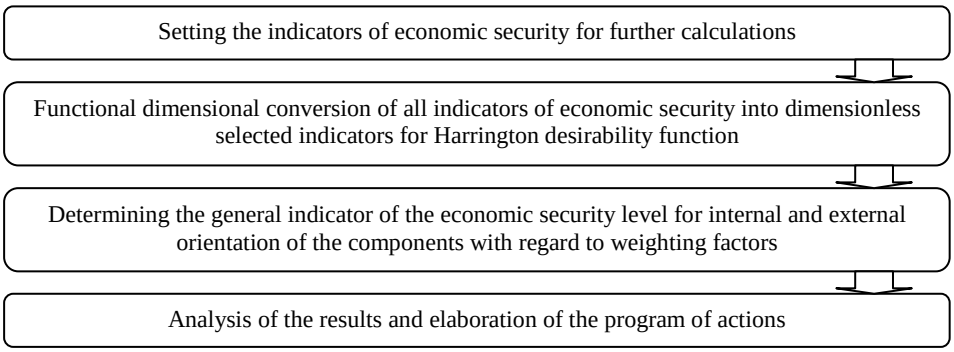

Figure 4. **Scheme for assessment of the economic security level,** *author's*

References:

Адлер Ю.П., Маркова Е.В., Грановский Ю.В. Планирование эксперимента при поиске оптимальных условий. – М.: Наука, 1976. – 280 с.

Ахназарова С.Л., Гордеев Л.С. Использование функции желательности Харрингтона при решении оптимизационных задач химической технологи: Учеб.-метод. пособие. – М.: РХТУ им. Д.С. Менделеева. – 2003.– 76 с.

Барановський О.І. Фінансова безпека в Україні (методологія оцінки та механізми забезпечення): Монографія. – К.: КНТЕУ, 2004. – 759 с

Безбородова Т.И. Использование функции Харрингтона при рейтинговой оценке деятельности организации в условиях антикризисного управления // Финансовая аналитика: проблемы и решения.– 2014.– №1. – С. 24–32.

Бендиков М.А. Экономическая безопасность промышленного предприятия в условиях кризисного развития // Менеджмент в России и за рубежом.– 2002.– №2. – С. 17–29.

Выбор материала с помощью функции желательности Харрингтона: Методические указания / Сост.: В.Д. Секерин, В.Н. Ясонов, Д.В. Секерин. – М.: МГУИЭ, 2005. – 21 с.

Горячєва К.С. Механізм управління фінансовою безпекою підприємства: Автореф. дис... канд. екон. наук: 08.06.01. – К.: НАУ, 2006. – 17 с.

Довбня С.Б., Гічова Н.Ю. Діагностика рівня економічної безпеки підприємства // Фінанси України.– 2008.– №4. – С. 88–97.

Єрмошенко М.М. Фінансова безпека держави: національні інтереси, реальні загрози, стратегія забезпечення: Монографія. – К.: КНТЕУ, 2001 // www.disslib.org.

Зазнобина Н.И. Оценка экологической обстановки в крупном промышленном центре с помощью обобщенной функции желательности (на примере города Нижнего Новогорода) // Вестник Нижегород. ун-та им. Н.И. Лобачевского.– 2007.– №2. – С. 115–118.

Захаркіна Л.С. Формування стратегії інноваційного розвитку машинобудівного підприємства (матричний підхід) // Економіка та управління підприємствами машинобудівної галузі: проблеми теорії та практики: Збірник наук. праць.– 2011.– №1. – С. 66–78.

Козаченко А.В., Пономарьов В.П., Ляшенко А.Н. Экономическая безопасность предприятия: сущность и механизм обеспечения: Монография. – К.: Либра, 2003. – 280 с.

Козаченко Г.В., Пономарьов В.П. Економічна безпека підприємств: сутність і передумови формування // Теорія та практика управління у трансформаційний період: Збірник наук. праць. – Донецьк: ІЕП НАН України, 2001. – Т. 3. – С. 3–7.

Колтунов В., Белінська Є. Обгрунтування ефективності збереженості редису методом Харрінгтона // Товари і ринки.– 2010.– №2. – С. 62–67.

Общая теория статистики / Под ред. И.И. Елисеевой, 2001 // www.stathelp.ru.

Пуряев А.С. Теория и методология оценки эффективности инвестиционных проектов в машиностроении: Моногорафия. – Набережные Челны: Камская госуд. инж.-экон. акад., 2007. – 180 с.

Рыбинцев В.А., Горюнов А.Н., Саламатова Н.С. Теоретические аспекты оценки качества и конкурентоспособности товаров народного потребления // Культура народов Причерноморья.– 2005.– №71. – С. 45–52.

Федулова І. Підходи до оцінки рівня готовності підприємства щодо інноваційного розвитку // Вісник Київського національного університету ім. Тараса Шевченка.– Серія: Економіка.– 2011.– №124/125. – С. 36–40.

Шатохін А.Л., Ігнашкіна Т.Б. Досконала структура економічної безпеки підприємства як запорука прийняття результативних управлінських рішень // Системи прийняття рішень в економіці та техніці: від теорії до практики: Колек. Монографія: У 2-х т. / За заг. ред. Л.М. Савчук. – Павлоград: АРТ Синтез-Т, 2014. – Т. 2. – С. 316–325.

Harrington, E.C. (1963). Chemical Engineering Program. Vol. 42, No 59.

Harrington, E.C. jr. (1965). The desirability Function. Industrial Quality Control, 21(10): 494–498.

Zadeh, L.A. (1965). Fuzzy Sets. Information and Control, 8: 338–353.

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