Abstract: Data Envelopment Analysis for risks assessment: This paper introduces the advantages of applying Data Envelopment Analysis (DEA) in the field of Risk Management. It describes the key functionality features of DEA for comparing the risks within a project and risk ranking process using DEA efficiency marks. It also points the specifics of using DEA as risk ranking method, its disadvantages and solutions for specific needs.

Key words: Data Envelopment Analysis (DEA), Risk Management, Risk Ranking.

И. Въведение

Data envelopment analysis (DEA) is a method evaluating a potential project, or aiding the process of making another management decision, using multicriteria assessment, which allows comparing indicators with diverse measuring units. For example, for a specific set of potential projects, the managers of the company need to assess the cash flows, to rank the
project availability to the available competences, to rank the project potential for building the desired future competences, the range of their technical feasibility and, finally, the range of attractiveness to consumers. Each of those indicators covers a part of the project, which is completely different from the others and the numbers, describing those indicators are different measurement units. In this case, the first indicator is a relatively constant value, while the second and the third are in fact, ranks, category values obtained as a result from comparing alternatives. This leads to difficulties in determining the differences between the separate levels of ranking. The last two indicators can be measured in points, obtained when applying a ranking system or different types of scales – for example, Likert scales (Zhu, 2009).

The aim of this paper is to prove theoretically the applicability of the data envelopment analysis as a method of assessment and prioritizing the risks, especially in the innovation activities.

For the achievement of the above-mentioned aim, the following objectives have been assigned: to clarify the essence of the method, to reveal its functional potential, advantages and disadvantages, as well as to make conclusions about its practical application.

II. Description of the method

The method Data Envelopment Analysis (DEA) is based on the term “decision-making unit” (DMU) in order to identify business operations, processes or objects, which are subjected to data envelopment assessment. Every DMU has a set of input and output parameters, which are multi-lateral measures of performance (Charnes, Cooper § Rhodes, 1978). To illustrate the method, a set of n observations of the units concerned is used. Each observation, \( DMU_j \ (j=1, 2, ..., n) \), uses m inputs \( x_{ij} \ (i=1,2,...,m) \) to produce s outputs \( y_{rj} \ (r=1,2,...,s) \).
Inputs (x_{ij}) Входове | Outputs (y_{rj}) Изходи
---|---
\( x_1 \) | \( y_1 \)
\( x_2 \) | \( y_2 \)
\( \ldots \) | \( \ldots \)
\( xm \) | \( ys \)

The empirical effective border, or good practices border is determined by those \( n \) observations. Two characteristics \( x_j \) and \( y_{rj} \) provide building a segment linear approximation of the effective curve, which possesses the following two properties (Zhu, 2009):

\[
\sum_{j=1}^{n} \lambda_j \cdot x_{ij}, \ (i=1,2,\ldots,m) \quad \text{and} \quad \sum_{j=1}^{n} \lambda_j \cdot y_{rj}, \ (r=1,2,\ldots,s)
\]

Convexity. Изпъкналост.

are possible inputs and outputs, achievable for DMU, where \( \lambda_j \ (j=1,2,\ldots,n) \) are positive numbers, fulfilling the condition

\[
\sum_{j=1}^{n} \lambda_j = 1
\]

Inefficiency. Неефективност. The same \( y_{rj} \) can be obtained by using \( \hat{x}_{ij} \), where \( \hat{x}_{ij} \geq x_{ij} \) (i.e. the same level of output indicators has been obtained, using larger input indicators); \( \hat{y}_{rj} \) can be obtained with the same \( x_{ij} \) where \( \hat{y}_{rj} \leq y_{rj} \) (i.e. the same input indicator produces a lower level of the output indicator).

If we take as an example the assessment of efficiency of different suppliers, then two input values can be total expenses and total time for the suppliers’ orders. For every specific \( x_i \ (i=1,2,\ldots,m) \) and \( y_r \ (r=1,2,\ldots,s) \), the following system can be written:

\[
\sum_{j=1}^{n} \lambda_j \cdot x_{ij} \leq x_i, \quad i=1,2,\ldots,m \\
\sum_{j=1}^{n} \lambda_j \cdot y_{rj} \geq y_r, \quad r=1,2,\ldots,s \\
\sum \lambda_j = 1
\]
The next step is to assess the empirical (linear by segment) curve of efficiency, described by the system (4). The Data Envelopment Analysis (DEA) presented initially by Charnes, Cooper and Rhodes, has proven a useful tool when such empirical borders and assessment of data envelopment are determined (Charnes, Cooper§Rhodes, 1978). DEA uses mathematical programming for implicit assessment of alternatives, lying within the borders of the empirical effective curve.

III. Functionality

All business operations and processes include a transformation – adding value as a result of the change of resources and transforming them into goods or services, sought by the customers. The transformation involves using input resources – labour, materials, energy, machines, and other resources for generating certain outputs – manufactured products, services, consumer satisfaction and other results. Risk management includes a similar process of transformation. For example, risk analysis uses the data available for events with a degree of uncertainty and transforms them into risk assessments. The risk management systems use the risk assessments, information about costs, necessary to influence these risks or digressing reserves to use as input indicators. The system receives data about the corrected risk indicators at the output (Kiryushkin & Larionov, 2009).

The managers are often interested in assessing the efficiency of different activities by taking into account the numerous performance indicators (inputs and outputs). A typical example of an innovation process is the manager to be interested in comparing several risk management strategies in view of the probability of risk, its weight in terms of damage, the financial means needed for the strategy, the expected outcomes. Eliminating or improving the inefficient strategies reduces the value of input indicators and improves performance. Performance assessment and comparative (reference) evaluation contribute to improving the productivity and efficiency of

Следващата стъпка е да се оцени емпиричната (посегментна линейна) крива на ефективност, описана чрез системата (4). Анализът на сравнителната ефективност (Data Envelopment Analysis - DEA) едъръвоначално от Чарнс, Купър и Родс е доказан приложим инструмент при определяне на подобни емпирични граници и оценка на сравнителната ефективност (Charnes, Cooper§Rhodes, 1978). DEA използва математическо програмиране за имплицитно оценяване на альтернативите, лежащи в границите на емпиричната ефективна крива.

III. Функционални възможности

Всички бизнес операции и процеси включват трансформация – добавяне на стойност в резултат на промяна на ресурсите и превръщането им в стоки или услуги, които клиентите търсят. Трансформацията представлява използване на входни ресурси - труд, материали, енергия, машини, други ресурси за генериране на определени изходи - произведени продукти, услуги, потребителска удовлетвореност и други резултати. Управлението на рискове включва подобен процес на трансформация. Например, анализът на риска използва наличните данни за събития с някаква степен на неопределеност и ги трансформира в оценки на риска. Системите за управление на риска използват оценките на риска, информация за разходите, необходими за въздействие върху тези рискове или отделение на резерви като входящи показатели. На изхода системата получава данни за коригираните показатели на рисковете (Kiryushkin & Larionov, 2009).

Мениджърите често са заинтересовани да оценяват колко ефективно протичат различните дейности като се отчитат многобройните показатели за производителност (входове и изходи). Типичен пример в един иновационен процес е менيدжърът да бъде заинтересован да сравни няколко стратегии за управление на рисковете с оглед на вероятността за риска, неговата тежест от гледна точка на щетите, необходимите финансови средства за стратегията, очакваният резултати. Елиминирането или подобряването на неефективните стратегии намалява стойността на входните показатели и подобрява производителността. Оценяването на производителността и сравнителното (еталонно) оценяване допринасят за подобряване
Operations and processes (Kiryushkin & Larionov, 2009).

Performance assessment is an important tool for continuous improvement, in order for the company to remain competitive, especially when it comes to business, carried out by high-tech industries. Comparative evaluation is a pre-requisite for every business unit to evolve, to improve, in order to survive and prosper in the surrounding business environment, facing global competition.

In contrast to optimization methods, where the efficient border is measured on the condition that the functional relationships between individual performance indicators are known, in data envelopment analysis the efficient border is obtained as a result of numerous indicator measurements, which are not necessarily related functionally. For example, the volume of waste and that of production are two interdependent variables, whose ratio reflects performance, but unfortunately, such information is not always accessible. Provided that the purpose of measuring performance is to evaluate a business process from within and to compare it to similar business processes from outside, in order to identify the best practices, such information can be obtained. The efficient curve can be determined empirically, based on observations on a business process/operation at different points in time, or on similar business operations in one specific time period (Camp, 1995). In any case, the performance of business units is a complex phenomenon, requiring more than one indicator to characterize it.

IV. Advantages and Disadvantages

Data envelopment analysis is characterized by certain characteristics and limitations, which determine its application. The researcher should take into account the following specifics of the method.

Being inherently an optimization method, data envelopment analysis carries the flaws of optimization tasks, related to finding the dominant weighted combination, i.e. the separate models indicate only the

на продуктивността и ефективността на операциите и процесите (Kiryushkin & Larionov, 2009).

Оценяването на производителността е важен инструмент за непрекъснато подобряване, с цел фирмата да остава конкурентоспособна, особено в условия на бизнес, осъществяван чрез високотехнологични производства. Сравнителното оценяване е предпоставка всяка бизнес-единица постоянно да еволюира, да се подобрява за да оцелее и да просперира в откръжващата бизнесреда, посрещайки глобалната конкуренция.

За разлика от оптимизационните методики, при които ефективната граница се измерва при условие, че са известни функционалните отношения между отделни показатели на производителността, при анализ на сравнителната ефективност, ефективната граница се получава в резултат на многобройни измервания на показатели, които нямат задължително функционална връзка помежду си. Например, обемът на отпадъците и обемът на произведената продукция са две взаимозависими променливи, чието съотношение отразява производителността, но за съжаление, подобна информация не винаги е достъпна. При условие, че целта на измерване на производителността е да се оценят дадените бизнес-процеси и да се противопостави на подобни бизнеспроцеси отвън за да се определят най-добрите практики, подобна информация би могла да бъде получена. Ефективната крива може да се определи емпирично, основавайки се на наблюдения на един бизнеспроцес/опeração през различни времеви точки или на сходни бизнесоперации в един специфичен времеви период (Camp, 1995). Във всеки случай, производителността на бизнесединиците е комплексен феномен, изискващ повече от един показател за характеризирането й.

IV. Преимущества и недостатъци

Анализът на сравнителната ефективност се характеризира с определени особености и ограничения, които обуславят и неговото прилагане. При оценяване на ефективността, изследователят трябва да се съобрази със следните специфични на метода.

Бидейки по своята същност оптимационен метод, анализът на сравнителната ефективност носи в себе си недостатъците на оптимизационните задачи, свързани с намирането на доминираща...
local optimums of the problem while there exists a more precise complex solution.

Besides, the methods for solving optimization problems are complex for manual calculation, which limits their use without specific computing technology.

DEA must have sufficient data for obtaining efficient results. For a small number of DMU or a very high number of observed parameters, DEA may not find inefficient DMU. The minimum requirement is the number of observed DMU to be at least double the number of the parameters observed.

DEA builds the efficient curve on the basis of the available prevailing DMU, irrespective of whether they reach the theoretical efficient curve or not. DEA identifies a point as effective although it may be technologically possible to increase efficiency – fig.1.

DEA forms the hypothetical DMU, drawing it by a weighted combination of real DMU. Nevertheless, there is no guarantee that such hypothetical combination could exist in real conditions. Comparing real DMU with the weighted combination, there exists probability for a situation, in which two efficient DMU, which have achieved high results in two separate parameters, can
form an efficient border that is physically unattainable for the other DMU, trying to achieve good results in both parameters simultaneously. The researcher should analyse carefully the nature of data. In some cases, such a problem can be avoided through the choice of an appropriate DEA model for different types of effects of scale.

The classical DEA model does not take into consideration the priority of parameters (Shen, Hermans, Da Ruan, Wets, Brijs § Vanhoof, 2011). The leading role (or ratio) of one parameter may ensure maximum efficiency evaluation, although a specific parameter (or ratio) in a specific case have low priority. Besides, the classical DEA models do not imply interval or inaccurate assessments. If the study implies the application of such assessments (Kuah § Wong, 2011), it is necessary to use the respective modifications of DEA (for example, Stochastic DEA (SDEA), Fuzzy DEA (FDEA), Imprecise DEA (IDEA) and others).

DEA cannot provide an answer as to which of the two efficient DMU has higher assessment – if they are both effective solutions, they have been evaluated with the maximum grade, equal to one. In this way, the efficiency assessments could be used for ranking only of inefficient DMU. For ranking the efficient DMU, it is necessary to use additional assessments.

The classical DEA model is not appropriate for evaluation of DMU efficiency as individual units in situations when they can combine and work together for the achievement of a common goal.

V. Conclusions

1. The data envelopment analysis is a multi-criterion assessment, using linear programming to combine indicators with different units of measurement and to build a hypothetical efficiency border, which determines the best performance of each indicator. This border can also be used to compare input data (e.g. costs) with the output data (expected benefits). Thus the distance of each alternative solution from this hypothetical efficiency border becomes a form of measurement that is physically unattainable for the other DMU, trying to achieve good results in both parameters simultaneously. The researcher should analyse carefully the nature of data. In some cases, such a problem can be avoided through the choice of an appropriate DEA model for different types of effects of scale.

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comes clear, and each of these solutions is assigned a certain value of efficiency.

2. The efficiency values are used for ranking alternative solutions for risk management, or for identifying them in some dominating order according to the probability of risk, its weight in terms of damages and the funds needed for implementing a specific strategy.

3. Some of the main advantages of the method in relation to risk management can be summarized as: its use to discover strengths and weaknesses of business operations, activities and processes; business being better prepared to meet consumer needs and requirements; awareness of opportunities for improving running operations and processes with the purpose of creating new products, services and processes.

Reference/Литература


