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Review paper

INFLUENCE OF INTRODUCING A NEW PRODUCT ON THE COMPANY'S SOLVENCY INDICATORS: TOPSIS METHOD ANALYSIS

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Abstract. *New product introduction is one of the most important processes for many companies, but at the same time one of the most difficult to consider. New product introductions may require significant market and engineering research and entail more significant changes in recources and manufacturing process, as well as a major marketing program. But at the same time, the introduction of new products is the main mechanism to increase market competitiveness and achieve higher profits. As the introduction of new products affects various indicators of solvency of a company, multi-criteria analysis algorithms can be successfully applied for the analysis of its effects. This paper presented the application of TOPSIS method in the analysis of the impact of the introduction of new product.*

Key Words: *New Product, Decision Making, Multi-Criteria Analysis, TOPSIS.*

INTRODUCTION

The aim of the management of a company is effective targeting and efficient use of available resources. Careful and prudent management of a company involves value anticipating of the company's future, the execution control of the set of plans and finally making individual business decisions.

Decision-making is incorporated into all phases of the management process. Thus, the planning phase consists of deciding on the goals, directions and global development strategies, determining the ways and means of achieving the goals and choosing the best alternative. At the organization stage, the decision to create the organizational structure is

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made, as well as the division of powers and responsibilities, etc. The control phase is a continuous process of decision making in order to achieve convergence of the plan or to correct the plan. Communication is the phase of the management process which involves the transfer of instructions and information relevant to the definition and implementation of certain decisions, from the decision-making levels to parts of companies, groups and individuals, and vice versa. Motivation is related to decision making about the construction of the system of motivation and reward in order to harmonize the goals of the parts and the whole enterprise.

The decision on the introduction of new products into production program requires relevant information relating to the costs and benefits of all possible products. Existing research criteria for the selection of new products (indicators of future success of the product) are mainly engaged in several separation ratio indicators and determine the intensity of their influence. According to these indicators, potential new products are compared and the product with the best ratings is adopted. A larger number of criteria is essential when making decisions referring to the use of multiple criteria and the TOPSIS method.

1. INFORMATION BASE FOR DECISION-MAKING

The management activity of individual decision-making is related to the cases of additional investment and cases of ongoing efforts to use available resources in the best way. Some of the typical decisions are:

- produce or buy a part,
- sell the product at market prices lower than the total cost,
- introduce a new product or not,
- reject or retain an existing product,
- processed or sold intermediate,
- change or keep the existing relations between the products in the range,
- install or not a new production line,
- leave the existing product line,
- add or eliminate functions within the organization,
- replace the equipment,
- invest in production equipment.

The next steps are essential in the process of decision-making (Novićević, 1997, p. 108):

- Identifying and defining the problem,
- The development and analysis of alternatives and
- Selection and implementation of decisions.

Comparing the current and the desired state of a company is generally defined problem which then, by identifying the factors that affect it, is defined in its specificity.

Developing alternatives is the process of proposing possible ways of changing the current situation in order to achieve the goals specified by defining the problem. Taking into account the new market opportunities, new technologies, competition, effective targeting and efficient use of available resources of the company can be performed.

Selecting the best alternative and creating the conditions for its achievement is the last stage in the decision-making process. Quantitative and qualitative information is necessary for this choice, and their combination finds the optimal solution.

Finding the optimal solution implies the existence of qualitative and quantitative information. Costs play a significant role in quantitative information.

In order for information to be relevant to a business alternative, it must meet the following requirements: it must be different from one to the other alternative (differential costs and benefits) and it must be related to the future.

Flexible set costing can help business decision-making in two ways (Stevanović, 2000, p. 436):

- Identification of business irrationality and referral to additional cost - benefit analysis and
- Providing specific information directly or by facilitating their obtaining by additional (non-routine) methods of analysis.

The quality of accounting information for decision-making relates to its relevance and reliability. Relevance indicates the appropriateness of the information to meet the particular needs of users in terms of content, scope and method of preparation. It is evaluated and assessed in terms of the ability to predict business trends, processes and relationships, possibilities of verification and correction, and in terms of timing. Reliability, as a quality of information, contains the truth of neutrality and the possibility of confirmation. An additional quality of information relates to the possibility of comparison in space and time and consistency (continuity) of the methods used in the process of creating information (Novićević, Antić, 2013, p. 18-19).

Out of the quantitative factors that influence business decisions, the most important are costs and benefits whose most common gross measure is income, but it is possible to express the cost savings. Costs vary from alternative to alternative, it is differential, and therefore must be taken into account in selecting the best alternative. In addition, the relevant costs are associated with the future, which means that the costs will only rise. All this applies to the relevant benefits also.

The aforementioned characteristics lead us to the concept of irrelevant (past, unavoidable) costs. They are the result of past decisions, the costs already incurred and which can not be avoided no matter which decision is made. Past costs are irrelevant in decision-making. Also, any current or future decisions can not change them. When it comes to projecting future costs, past costs can serve as an indicator of cost behaviour for a particular decision.

As part of future costs, variable costs are often relevant and fixed costs are irrelevant. Of course, the approach that all variable costs are relevant and all fixed irrelevant can not be fully accepted. Some variable costs may remain unchanged even after the decision, while the decision may still have an impact on some of the fixed costs.

Flexible standard costing has high ability to respond to the informational requirements of the business decision because the standard costs are future costs, and there is separation of variable and fixed costs.

It is worth adding that the decision will not be made by using only quantitative factors. "It is rather a product of thoughtful evaluation of all relevant factors by the decision maker, and therefore all the qualitative aspects of the alternative in question, which is sometimes given even greater significance" (Stevanović, 2000, p. 438).

2. INTEGRATED APPROACH TO THE USE OF FINANCIAL AND NON-FINANCIAL INFORMATION FOR DECISION-MAKING

Modern business can be successful only if it is accompanied by the introduction of new rules of behaviour within the management system. Accordingly, a new performance measurement system of production lines, manufacturing processes and responsibility centers is also necessary. Performance measurement systems are usually based on cost data, which are obtained from accounting. However, this may not always meet the information needs of the new business environment. This is because there is a growing need for "real time" information about the various indexes that traditional systems based on costs did not consider, such as, for example, the processing time of a specific product or different quality standards (Azzone, et al, 1989, p. 122).

One of the reasons that has caused fundamental changes in management accounting is that traditional cost accounting systems provide information that may lead to wrong decisions. The management accounting literature emphasizes that the full cost of a product, using the principles of financial accounting, is not adequate for the purposes of decision making. Instead, it advocates the use of additional costs (costs that can be avoided). In this regard, the decision to introduce a new product, the abandonment of a product, pricing, etc. should be made by monitoring only those additional costs and income that vary with respect to individual decisions. However, "in complex real-world situations where companies produce many different products, it may not be possible to determine only the relevant cost for each decision, because the set of possible solutions with which the managers are confronted is tremendous" (Drury, 1996, p. 264-275).

Kaplan says that the main reason for losing the relevance of management accounting is the use of the same system for decision-making regarding the product and the assessment related to various processes or organizations. The first type of problem (products) requires accurate information, which in not very frequent. In contrast, the control of the process requires very frequent (frequency) real time information. Therefore, Kaplan proposes a design of two different systems. Cost data should be used to measure the profitability of a particular product, while the process control would use mostly non-financial information (Kaplan, R., Cooper, 1998, p. 134-150).

Each of the two systems, if used separately, may produce false or misleading information. For example, the knowledge of the cost and value of a product is closely related to its non-financial characteristics, such as product quality and meeting deadlines. On the other hand, the non-financial indexes themselves can not provide full control of the process. There is a possibility that a decision results in an increase of one operational performance (e.g., quality), and simultaneously causes the reduction of another (for example, the fulfillment of time limits). The reduction of the preparation time, for example, can cause an increase in the size of individual series. This decision, in turn, may lead to increased production time.

We can conclude that the overall effect of a decision can only be determined in the case of defining the impact of each non-financial factor on the costs and revenues. So, only an integrated approach to the use of financial and non-financial information may be acceptable.

3. The Decision on the Introduction of New Products

Modern business conditions require a rational use of production and sales capacities, as a condition sine qua non for profitable business and maintaining the company as a business system. However, oversized capacity at the beginning of investment in production during the establishment of the company, as well as a permanent decline in demand for products from the existing range, can cause under-utilization of capacity in many companies. In this regard, the analysis of the possibility of introducing a new product based on the fact that the company has unused production capacity which it wants to employ. Among a large number of features that are then available to the company, it is necessary to choose the best.

The decision on the introduction of new products into the production program requires relevant information relating to the costs and benefits of all possible products. Thus, if a company wants to introduce a new product into production and sales range, and thereby have access to two or more products, information base for decision-making involves calculating the selling price and the cost of the product.

If a company has free capacities for the production of a certain quantity of products, and the introduction of any of the two products do not require additional investments in production capacity in the existing product range and does not cause a change in their relative profitability, the adoption of relevant decisions involves the calculation of the marginal and business results by products.

Based on the data about the marginal result of the product, it could be decided on the production of both products, as they are equally attractive. However, if the products require different investments in the sales capacity, the fixed costs of sale must be included in the analysis in order to make the relevant decisions. After identifying the direct fixed costs per product, the decision is on the introduction of that product in the production and sales range, which contributes more to the business result of the enterprise.

The decision to introduce the new product must take into account the costs of research and development which must occur before the introduction of any new product, and their write-off begins with the sale of a product that has been introduced in the production and sales range.

Research and development of products, intended for the broad market, takes place at the following stages (Görzig, Gornig and Werwatz, 2008):

1. Finding ideas and research needs of the market;
2. Review of production and marketing potential;
3. Defining of the project task;
4. Evaluation of the project task;
5. Collection of information;
6. Analysis of information;
7. The preparation of the technical proposal;
8. Evaluation of technical proposals;
9. Preparation of preliminary design and, if necessary, models;
10. Testing of the model and evaluation of the conceptual design;
11. Preparation of technical projects and, where appropriate, a functional model (or the so-called "sample" if a potential buyer requests so);
12. Examination of the functional model (or sample) and technical evaluation of the project;

13. Making workshop documentation for prototype and prototyping;
14. Testing and evaluation of the prototype;
15. Making workshop documentation for "zero" series and making of zero-series;
16. Testing and evaluation of the zero series;
17. Making workshop documentation for the test series and the development of a test series;
18. Testing and evaluation of the test series;
19. Making workshop documentation for the main series and making major series;
20. Testing and evaluation of the major series;
21. Making the part of the technical documentation which is intended for commercial use;
22. Evaluation of technical documentation intended for commercial use;
23. Promotion of products;
24. Promotion of products;
25. Monitoring products in the production and exploitation process (author surveillance)
26. Entry into the development of a new generation of products.

The objectives of introducing a new product can be (Lord, 2000):

- Primary: sales volume and profit growth;
- Secondary: maintaining the position of innovators, defending the existing position of market share, establishing a base for future new markets, winning the first market segment, developing technologies in new ways, etc.

4. MULTI-CRITERIA MODEL OF NEW PRODUCT IMPLICATION ANALYSIS

The description of the multi-criteria analysis problem can be given as selection problem, ie the problem of ranking of a set of m altrnatives A_i (i = 1, 2,..., m) considering n criteria C_j (j = 1, 2,..., n). Alternatives are defined as vectors $A_i = (x_{i1}, x_{i2},...,x_{ij},...,x_{in})$, ($i$ = 1, 2,..., m). The usual form of presenting the multi-criteria analysis problem is a decision matrix form:

$$\begin{array}{c} \\ A_1 \\ \vdots \\ A_m \end{array} \begin{array}{c} \begin{array}{ccc} C_1 & \dots & C_n \end{array} \\ \begin{bmatrix} x_{11} & \cdots & x_{1n} \\ \vdots & \ddots & \vdots \\ x_{m1} & \cdots & x_{mn} \end{bmatrix} \end{array}$$

The elements of the decision matrix are the extent to which the i^{th} alternative fulfils the j^{th} criterion and they can be quantitative or qualitative, depending on whether they are established by empirical measurements, or defined on the basis of past experience, or assessments of the decision maker. Precisely because it includes a multi-criteria analysis and qualitative assessment of the level of achievement, the criteria can be interpreted as a synonym for the level of benefits reaching the decision maker, estimated by their subjective perception (Stevanović, Stanković, 2012).

Multi-criteria analysis methods have evolved to accommodate various types of applications. Dozens of methods have been developed, with even small variations to existing methods causing the creation of new branches of research (Velasquez, Hester, 2013).

The problem of multi-criteria analysis of the new product implication, which the subject of this paper refers to, involves the following phases of problem solving (Vicenç, Narukaw, 2007):

i. Determination of relevant criteria for particular products on the basis of which the decision-making about their introduction can be preformed;
ii. Establishment of decision matrix;
iii. Determining the weights;
iv. Selection of an optimal solution based on the analysis.

Imagine a hypothetical problem in which it is necessary to perform an analysis of the implications of the introduction of one of the three potential products. The criteria in the model can be cost or benefit type, depending on their contribution to the utility of the decision maker. The relevant criteria for the hypothetical problem are:

C1: Selling price per product unit, expressed in monetary units - quantitative criterion, benefit type;
C2: Cost per product unit, expressed in monetary units - quantitative criterion, cost type;
C3: General liquidity ratio
C4: Net profit rate
C5: Turnover ratio of inventories
C6: Customer satisfaction with the quality of the product - a qualitative criterion, whose quantification is performed by Likert-type scale.

The information on the implications of the introduction of a new product is given in Table 1.

Table 1

Products	Working assets	Short term liabilities	The average inventories	The cost of realized products	Net profit	The value of net sales
Product 1	200,000	140,000	55,000	320,000	50,000	350,000
Product 2	230,000	95,000	60,000	300,000	45,000	340,000
Product 3	180,000	80,000	45,000	290,000	37,000	300,000

Based on the data in Table 1 it is possible to calculate the corresponding attribute values for C3-C5 criteria (Table 2).

Table 2

Criteria	Product 1	Product 2	Product 3
General liquidity ratio	1.43	2.42	2.25
Turnover ratio of inventories	5.82	5.00	6.44
Net profit rate	14.28%	13.23%	12.33%

According to the calculated attributes and other necessary data presented above, the decision matrix is formed (Table 3).

Teble 3

	Criteria					
	C1	***C2***	***C3***	***C4***	***C5***	***C6***
Data type	*Quantitative*	*Quantitative*	*Quantitative*	*Quantitative*	*Quantitative*	*Qualitative*
Criteria type	*Max*	*Min*	*Max*	*Max*	*Max*	*Max*
Product 1	320	250	1.43	14.28	5.82	7
Product 2	300	235	2.42	13.23	5	5
Product 3	290	260	2.25	12.33	6.44	3

The assumption is that all the criteria in the model are of equal importance, and therefore the value of the weights $w_j = 0.167$ (j =1,2,...6). For solving the problem defined above, the TOPSIS method will be used in the next section.

4.1. Application of TOPSIS method in evaluation of solvency indicators

Considering the fact that the problem of multi-criteria analysis can be interpreted as a geometric system of *m* points in *n*-dimensional space, Hwang and Yoon (1981) developed a method *Technique for Order Preference by Similarity to Ideal Solution* (*TOPSIS*). The TOPSIS method is based on the axiom that the optimal alternative, or point that represents it, should have a minimum separation measure from the positive-ideal and the maximum separation measure from the negative-ideal solutions in the geometric sense.

The ideal solution is defined as a set of ideal values of attributes for all criteria and ideal level at which the benefit of decision-makers is the highest possible. This is a solution where attributes have the maximum possible value for benefit type and minimum possible value for the cost type of criteria.

A formal definition of the positive-ideal solution is given through the following formula (Hwang C.L., Yoon, 1995):

$$A^* = \left(x_1^*, ..., x_j^*, ..., x_n^*\right) \tag{1}$$

Coefficient x^*_j is the best value of the j^{th} criterion of benefit type in the set of all alternatives, or x^*_j is equal to $max_i\, x_{ij}$. According to the preferences of the decision maker, for the cost type criteria, value x^*_j is equal to $min_i\, x_{ij.}$

Oposite to the positive-ideal solution, the negative ideal solution is calculated as:

$$A^- = \left(x_1^-, ..., x_j^-, ..., x_n^-\right) \tag{2}$$

The coefficient x^-_j the least preferred value of j^{th} criteria in all available alternatives. Therefore, for the benefit type criteria x^-_j is defined as $min_i\, x_{ij}$, while, for the cost type criteria, value x^-_j is determineted as $max_i\, x_{ij}$.

The assumptions for the application of the TOPSIS method are as follows:

i. Each Attribute in the decision matrix takes either monotonically increasing or monotonically decreasing utility according to the preferences of the decision maker
ii. It is possible to determine the set of weights;
iii. Any Outcome which is expressed in a non-numerical way should be quantified through the appropriate scaling technique.

Since the problem decribed in the section above meets all the assumptions, the TOPSIS method can be applied. The TOPSIS method applied in this paper is according to an algorithm described by Triantaphillou, E., 2000.

In the primary step of the TOPSIS algorithm, it is necessary to determine the normalized decision matrix R. The assessment of coefficients r_{ij}, is preformed using vector normalization defined by the equations:

$$r_{ij}^{+} = \frac{x_{ij}}{\sqrt{\sum_{i=1}^{m} x_{ij}^2}} \qquad r_{ij}^{-} = \frac{\frac{1}{x_{ij}}}{\sqrt{\sum_{i=1}^{m} \left(\frac{1}{x_{ij}}\right)^2}} \tag{3}$$

The r_{ij}^{+} are normalized values of benefit type attributes, and r_{ij}^{-} are normalized values of cost type attributes. Based on the formulas above, the coefficients of decision matrix have been transformed in the parameters of the interval (0,1], as it is presented in Table 4.

Table 4 Normalized decision matrix

	C1	*C2*	*C3*	*C4*	*C5*	*C6*
Product 1	0.608558609	0.57200881	0.397164	0.61971077	0.580995745	0.76834982
Product 2	0.570523696	0.608520011	0.672123693	0.574143802	0.499137238	0.5488213
Product 3	0.551506239	0.550008471	0.624908392	0.5350864	0.642888763	0.32929278

The coefficients v_{ij} of preferential normalized matrix V (Table 5) are defined as the product of normalized decision matrix coefficients r_{ij} and the weights. The coefficients v_{ij} can be calculated according to the relation:

$$v_{ij} = r_{ij} w_j \tag{4}$$

Table 5 Preferential normalized matrix

	C1	*C2*	*C3*	*C4*	*C5*	*C6*
Weights	0.167	0.167	0.167	0.167	0.167	0.167
Product 1	0.101629288	0.095525471	0.066326388	0.103491699	0.097026289	0.12831442
Product 2	0.095277457	0.101622842	0.112244657	0.095882015	0.083355919	0.091653157
Product 3	0.092101542	0.091851415	0.104359701	0.089359429	0.107362423	0.054991894

The third part of the TOPSIS method algorithm is the identification of positive-ideal and negative-ideal solutions, according to following relations:

$$A^{*} = \left\{v_1^{*}, v_2^{*}, ..., v_j^{*}, ..., v_n^{*}\right\} = \left\{ (\max_i v_{ij} \,\middle|\, j \in J_1) \wedge (\min_i v_{ij} \,\middle|\, j \in J_2), i = 1, 2, ..., m \right\} \tag{5}$$

$$A^{-}=\left\{v_1^{-},v_2^{-},...,v_j^{-},...,v_n^{-}\right\}=\left\{(\min_i v_{ij}\,\middle|\, j\in J_1)\wedge(\max_i v_{ij}\,\middle|\, j\in J_2),\ i=1,2,...,m\right\} \tag{6}$$

The set J_1 is a set of benefit criteria, while the set J_2 is a set of cost criteria. Positive and negative ideal solutions of the problem are presented in Table 6.

Table 6 Positive and negative ideal solutions

Positive ideal solution	0.101629288	0.101622842	0.112244657	0.103491699	0.107362423	0.12831442
Negative ideal solution	0.092101542	0.091851415	0.066326388	0.089359429	0.083355919	0.054991894

The two most significant steps in the TOPSIS method are to calculate separation measures, using the n-dimensional Euclidean distance, from the observed alternative to the positive-ideal and negative-ideal solutions. The separation measure from the positive-ideal solution for each alternative is calculated as:

$$S_i^{*}=\sqrt{\sum_{j=1}^{n}\left(v_{ij}-v_j^{*}\right)^2},\quad i=1,2,...,m \tag{7}$$

Separation from the positive ideal solution of the observed problem is given in Table 7.

Table 7 Separation from the positive ideal solution

	Value	Rang of alternative
S1*	0.04746052	2
S2*	0.044928983	1
S3*	0.076317397	3

Using the same analogy, the alternative separation mesure from the negative-ideal solution is calculated as:

$$S_i^{-}=\sqrt{\sum_{j=1}^{n}\left(v_{ij}-v_j^{-}\right)^2},\quad i=1,2,...,m \tag{8}$$

Separation measure of each alternative from the negative ideal solution of the observed problem is given in Table 8.

Table 8 Separation measures from the negative ideal solution

	Value	Rang of alternative
S1-	0.076596798	1
S2-	0.060005391	2
S3-	0.044976051	3

The results clearly indicate the existence of a situation where one alternative is closest to the positive ideal solution and the second furthest from the negative ideal solution.

Precisely for this reason, the TOPSIS algorithm involves calculating relative closeness to the ideal solution (C_i^*). The relative closeness of the alternative A_i with respect to A^* is defined as:

$$C_i^* = S_i^- \Big/ \left(S_i^* + S_i^- \right), \quad i = 1, 2, ..., m \tag{9}$$

Relative proximity index values are in the range $0 \leq C^*_i \leq 1$, where $C^*_i=0$ when the alternative A_i is equal to negative-ideal solution, or $A_i = A^-$ and $C^*_i = 1$ when the alternative A_i is equal to positive-ideal solution, when $A_i = A^*$. The index of relative proximity for this problem is given in Table 9.

Table 9 Relative closeness to the ideal solution

	Value	Rang of alternative
C1*	0.617430709	1
C2*	0.571837319	2
C3*	0.370803634	3

The final step of the TOPSIS method involves ranking the alternatives. From the above, it can be seen that the first alternative, or Product 1, is the one that should be introduced in production.

CONCLUSION

Continually finding new products or changes to the existing represent the preconditions for growth, development and survival of the organization in the modern businessman environment. The importance of new products is reflected in stimulating benefits of difference, maintaining sales growth, creating large profits, enabling diversification, increasing distribution efficiency, technological development, responding to varying demands of consumers.

New products significantly affect the parameters of company solvency and efficiency of its operations. In this regard, the adoption of efficient decisions on the introduction of new products requires an appreciation of modern scientific methods and their application, and especially methods of operations research. The TOPSIS method, as very efficient and accurate, represents an adequate tool for making this type of a decision.

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UTICAJ UVOĐENJA NOVOG PROIZVODA NA INDIKATORE BONITETA PREDIZEĆA: ANALIZA TOPSIS METODOM

Uvođenje novog proizvoda je jedan od najvažnijih procesa za mnoge kompanije, ali u isto vreme jedan od onih koje je najteže sagledati. Uvođenje novih proizvoda može zahtevati značajna tržišna i tehnološka istraživanja i podrazumeva važne promene u resursima i proizvodnom procesu, kao i veliki marketinški program. Ali istovremeno, uvođenje novih proizvoda je osnovni mehanizam za povećanje konkurentnosti na tržištu i ostvarivanja većih profita. Kako uvođenje novog proizvoda utiče na različite pokazatelje boniteta preduzeća, to se za analizu njegovih efekata uspešno koristiti algoritmi višekriterijumske analize. U ovom radu biće prezentovana primena TOPSIS metoda u analizi uticaja uvođenja novog proizvoda.

Ključne reči: novi proizvod, donošenje odluka, višekriterijumska analiza, TOPSIS.