*Revista Gestão & Tecnologia*
*e-ISSN: 2177-6652*
*revistagt@fpl.edu.br*
*http://revistagt.fpl.edu.br/*

# FORECASTING THE COMPONENTS OF THE PRODUCT COMPETITIVENESS INDICATOR

**FORECASTING THE COMPONENTS OF THE PRODUCT COMPETITIVENESS INDICATOR**

**PRONÓSTICO DE LOS COMPONENTES DEL INDICADOR DE COMPETITIVIDAD DEL PRODUCTO**

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Editor Científico: José Edson Lara
Organização Comitê Científico
Double Blind Review pelo SEER/OJS
Recebido em 10.05.2021
Aprovado em 13.03.2022

**ABSTRACT**

The purpose of the study is to conduct an analysis of theoretical developments and propose an economic and mathematical search model that allows modeling and analyzing the process of forecasting the indicator of product competitiveness. The the model allows to determine the components of the competitiveness indicator of both the useful effect and the total costs for the full life cycle of products. The results of the analysis of forecasting methods showed that for their use in solving the problem of quantifying the useful effect of an object (product) and the total costs of its acquisition and use, in most cases, additional data of the parameters of the base sample are required, which are unknown quantities that cause the greatest difficulties in calculating them.

**Keywords:** Product Competitiveness Indicator, Useful Effect, Total Costs.

**RESUMO**

O objetivo do estudo é realizar uma análise dos desenvolvimentos teóricos e propor um modelo de busca econômica e matemática que permita modelar e analisar o processo de previsão do indicador de competitividade do produto. O modelo permite determinar os componentes do indicador de competitividade tanto do efeito útil quanto dos custos totais para o ciclo de vida completo dos produtos. Os resultados da análise dos métodos de previsão mostraram que para seu uso na solução do problema de quantificar o efeito útil de um objeto (produto) e os custos totais de sua aquisição e uso, na maioria dos casos, dados adicionais dos parâmetros da base são necessárias amostras, que são quantidades desconhecidas que causam as maiores dificuldades em calculá-las.

**Palavras-chave:** Indicador de Competitividade do Produto, Efeito Útil, Custos Totais.

**RESUMEN**

El propósito del estudio es realizar un análisis de los desarrollos teóricos y proponer un modelo económico y matemático de búsqueda que permita modelar y analizar el proceso de pronóstico del indicador de competitividad del producto. El modelo permite determinar los componentes del indicador de competitividad tanto del efecto útil como de los costos totales para el ciclo de vida completo de los productos. Los resultados del análisis de los métodos de pronóstico mostraron que para su uso en la resolución del problema de cuantificar el efecto útil de un objeto (producto) y los costos totales de su adquisición y uso, en la mayoría de los casos, datos adicionales de los parámetros de la base se requieren muestras, que son cantidades desconocidas que causan las mayores dificultades para calcularlas.

**Palabras clave:** Indicador de Competitividad del Producto, Efecto Útil, Costos Totales.

## 1. INTRODUCTION

To use the results of forecasting competitiveness in the development of new product modifications, it is necessary to forecast data not only the value of their level and competitiveness indicator, but also its main components – the quality (useful effect) that the consumer should receive from using products for their standard service life, as well as the total costs for the full life cycle, including manufacturing and consumption costs. At the same time, information on the quantitative assessment of the competitiveness indicator and its components is of particular importance, which should be considered as a tool for adapting products to the market and one of the elements of functioning. In this regard, the next step of the algorithm of the developed economic and mathematical model of forecasting the competitiveness of products is to solve the problem, the essence of which is to determine the numerical values of its constituent parameters based on the known forecast value of the competitiveness indicator.

## 2. MATERIALS AND METHODS

The analysis of existing methods for quantifying the indicator of the competitiveness of goods has shown that the dependence based on the ratio of the useful effect of its use for the standard service life to the total costs for the full life cycle meets the market requirements to the greatest extent. This dependence makes it possible to obtain the most objective and reliable quantitative assessment of the competitiveness indicator and develop a methodology for determining the constituent parameters based on its forecast value (Lifits, 2004; Suslenkov, 2018; Basovskij; Protas'ev, 2017).

To calculate the forecast values that make up the competitiveness indicator, the functional expression of the variable parameters will take the form:

$$CI_2 = \frac{UE_2}{PC_2 + UC_2} = \frac{UE_2}{TC_2}, \tag{1}$$

where $CI_2$ is an indicator of the competitiveness of products in the forecast period, which is determined by the calculated dependence previously obtained by us; $UE_2$ is the total useful effect from the use of products in the future; $TC_2 = PC_2 + UC_2$ is the total costs in the forecast period for the purchase of $PC_2$ products and their use for the entire service life of $UC_2$.

The analysis of equation (1) shows that the forecast value of the product competitiveness indicator $CI_2$ can be achieved with different ratios of the numerical values of the useful effect unknown to us and the total costs for the purchase and use of the product in the future. Equation (1) contains two unknown parameters, which complicates the solution.

So, with a known forecast value of the product competitiveness indicator $CI_2$, it is necessary to determine the numerical values of its constituent parameters: the useful effect and total costs (Zakharova et al., 2018). The solution of this problem is possible if one of the known parameters is numerically determined, for example, by some known forecasting method, then the second parameter is found from equation (1) with a known forecast value of the competitiveness indicator.

## 3. RESULTS

We propose a geometric interpretation of equation (1) for different ratios of its components. To do this, we construct a coordinate field (Figure 1), where the coordinate axis is the useful effect, and the abscissa axis is the total costs. At the same time, the useful effect and the total costs are expressed in monetary terms. In the adopted coordinate system, based on equation (1), the competitiveness indicator is an angular coefficient that can be written in terms of the tangent function of the angle α:

$$CI = \tan \alpha = \frac{UE}{TC} , \tag{2}$$

Each point of the coordinate field with the axes *UE* and *TC* corresponds to a certain numerical value of the competitiveness indicator. To determine the value of this parameter, for example, at the point $A_1$ of the coordinate field, it is necessary to connect this point of the line with the point of origin, then the tangent of the angle of inclination between the direction of the drawn line $OA_1$ and the axis of the abscissa $OTC_1$ will be equal to the competitiveness index at this point, i.e. $\tan \alpha_1 = CI_1$. In this case, the lines drawn through this point parallel to the coordinate axes will show on the corresponding axes the numerical values of the useful effect of *UE* and the combined costs of the *TC*. Moreover, it should be noted the characteristic points in Figure 1 lying on the abscissa and ordinate axes, where the competitiveness indicators are respectively equal to $CI_2 = 0$ and $CI_2 = \infty$, and at the points corresponding to the bisector of the right angle between *UE*, *O*, and *TC*, the parameter under consideration is equal to one ($CI = \tan 45° = 1$). With an increase in tan α in absolute value, the slope of the straight lines, based on the origin of coordinates, increases, which corresponds to a large numerical value of the competitiveness indicator. Consequently, the competitiveness indicator on the coordination field can vary from 0 to ∞ and each point with corresponding numerical values of quality parameters (useful effect) and consumption prices shows the position of the analyzed product in relation to the competitor's product.

In relation to the problem under consideration, Figure 1 shows the competitiveness indicator $CI_1 = \tan \alpha_1$, the useful effect of $UE_1$ and the total costs of $TC_1$ reflect the state of the product in the current period, and $CI_2 = \tan \alpha_2$, $UE_2$ and $TC_2$, respectively, in the future, i.e., the forecast period (Vasin, 2016; Varzhapetjan et al., 2017).

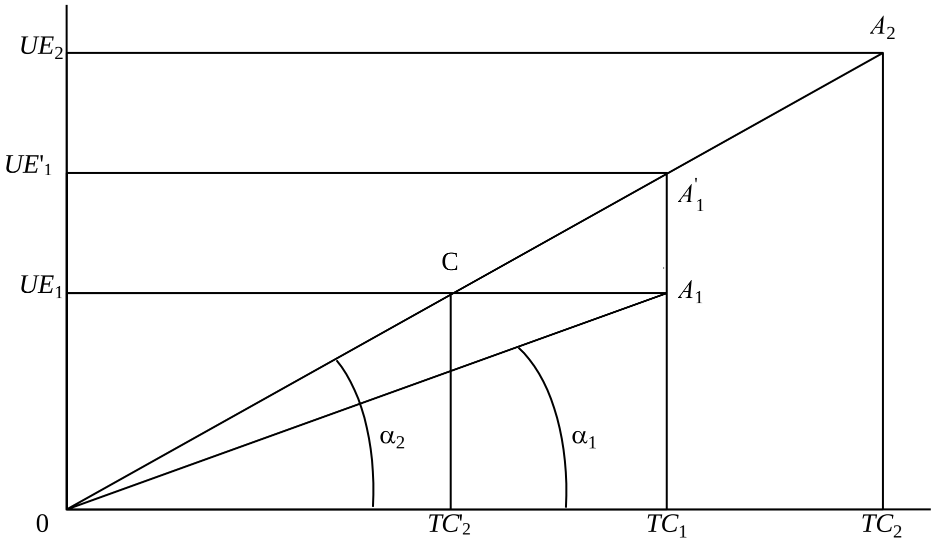


**Figure 1.** Scheme of geometric interpretation of the product competitiveness indicator
**Source:** Authors

Consequently, lines $OA_1$, $OA_2$ in Figure 1 have a certain substantive meaning, which is expressed in the fact that the coordinates of any points lying on these lines characterize the numerical values of the variable parameters $UE_i$ and $TC_i$, which ensure equality $CI = \tan \alpha_i = UE_i / TC_i$.

Let's consider the first option of achieving the forecast value of the competitiveness indicator $CI_2$, when it is necessary to reduce the total costs relative to their achieved values in the current period and maintain a constant value of the beneficial effect. The essence of the first option is to increase the competitiveness indicator $CI_2 = \tan \alpha_2$ by reducing costs from the value of $TC_1$ to $TC'_2$ while maintaining a constant value of the useful effect of $UE_1$. In this case, the reduction of production costs of the enterprise is achieved by the introduction of new energy-saving and resource-saving technologies, as well as through the effective use of organizational management. The initial moment from which it is possible to implement this ratio of *UE* and *TC* is reflected on the straight line $OA_2$ (Figure 1) by point *C*. The analyzed product at this point is characterized by the value of the useful effect of $UE_1$ and the total costs of $TC'_2$. Moreover, the point *C* is the lower bound of the implementation of the relation $CI = \tan \alpha_2 = UE_1 / TC'_2$ in the future. To implement the forecast value of the competitiveness indicator to the left of point *C* on the straight line $OA_2$, the value of the useful effect that was achieved in the current period is required. Quantitatively, the value of the total costs of $TC'_2$ at point *C* is determined from the ratio:

$$TC'_2 = \frac{UE_1}{CI_2}, \qquad (3)$$

Consequently, at the point C, all the components of equation (1) become known: $CI = \tan \alpha_2$, $UE_1$ and $TC'_2$.

When moving along a straight line $OA_2$ from point *C* to point $A'_1$, the value of the useful effect and the total costs increase. The value of the useful effect at point $A'_1$ is found from the expression:

$$UE'_1 = TC_1 \cdot CI_2, \qquad (4)$$

where $UE'_1$ is the value of the useful effect of the product, which should be achieved in the forecast period, provided that the total costs in the future will remain at the level of the current period, i.e. equal to $TC_1$ at $\tan \alpha_1 = CI_1$. The state of the product at point $A'_1$ is characterized by the parameters $CI_2 = \tan \alpha_2$, $UE_1$ and $TC_1$, which are quantitatively determined. It should be noted that the point $A'_1$ corresponds to the second variant of the possible ratios of *UE* and *TC* when the forecast value of the product competitiveness indicator is reached. The essence of the second option will be that the company should improve the quality of the goods, using various innovations and giving the product novelty while maintaining the achieved level of total costs (Bergman; Feser, 1999; Steiner; Hartmann, 2001;). This approach of increasing the competitiveness of goods corresponds to the strategy of differentiation, i.e. finding methods to increase the value of products for the consumer due to its new properties that are absent with that of competitors' products (Agarkov, 2015; Bernovskij, 2017; Dzhuran, 2020). This option of increasing competitiveness can be called maximizing the quality of products at a given level of costs.

With known parameters of $UE$ and $TC$ at points $C$ and $A'_1$ on the straight line $OA_2$, the absolute value of the increase in the useful effect on the section $CA'_1$ is equal to:

$$\Delta UE = UE'_1 - UE_1, \tag{5}$$

and the same amount of reduction in total costs on the same site is:

$$\Delta TC = TC_1 - TC'_2, \tag{6}$$

Let's write down in relative terms the corresponding values of increasing the useful effect and reducing the total costs:

$$\Delta UE'_1 = \frac{UE'_1 - UE_1}{UE_1} = \frac{\Delta UE}{UE_1}, \tag{7}$$

$$\Delta TC'_1 = \frac{TC_1 - TC'_2}{TC_1} = \frac{\Delta TC}{TC_1}, \tag{8}$$

Thus, with a known value of the competitiveness indicator in the future $CI_2$, given the value of the reduction in total costs at any point of the segment $CA_1$ of the straight line $OA_2$ (Figure 1) within its change from zero to the maximum value of $\Delta TC$, it is possible to determine the necessary value of the useful effect in the forecast period by the formula:

$$UE_i = TC_i \cdot CI_2, \tag{9}$$

where $TC_i = TC'_2 + \Delta TC_i$ – the current value of the total costs on the segment $CA'_1$; $UE_i$ – the current value of the useful effect on the same segment $CA'_1$ of the straight $OA_2$.

It should be noted that at the point $C$ of the segment $CA'_1$ of the straight line $OA_2$ (Figure 1), the total costs are minimal. In this case, $CI_2$ is achieved only due to the maximum reduction in total costs and with the value of the useful effect equal to the value achieved in the current period, i.e. $UE_1$. At all subsequent points of the segment $CA'_1$ value $CI_2$ is achieved with an increase in the value of the useful effect and a reduced value of the total costs relative to the value that was achieved in the current period, i.e. $TC_1$. Thus, the second variant of the ratio of the useful effect and the total costs is realized at point $A'_1$ of the segment $CA'_1$, where the useful effect is achieved by the value of $UE'_1$, and the total costs remain at the level of $TC_1$, i.e. at $CI_1 = \tan\ \alpha_1$.

Next, we will consider the third variant of the ratios of the components of the competitiveness indicator, when its forecast value is achieved while simultaneously increasing the useful effect of the product and the total costs, due to an increase in its purchase price (Antokhina, 2017; Taver, 2020; Afanas'ev et al., 2017; Krylova, 2004).

According to the third option, the company should improve the quality of products (goods), but strive to get a higher price for it. This is also a variant of the differentiation strategy. The success of such a strategy is determined by three factors (Andersson et al., 2014; Prahalad; Hamel, 1990; Schmitz, 1992):

1) marketing – the presence of buyers on the market who are ready to pay an increased price for a better product;

2) financial – the income from the sale of goods at an increased price should exceed the costs of achieving high quality;

3) advertising – the need to show and prove to the buyer that the increase in the usefulness of the product is adequate to increase the price.

This variant of the solution of the problem in Figure 1 corresponds to the segment $A'_1A_2$ on the line $OA_2$. From the geometric model of figure 1, it can be seen that the useful effect and the total costs at point $A_2$ are the upper boundary of the segment $A'_1A_2$, their numerical values that need to be determined are also unknown. In this case, the solution of the problem is possible if one of the two unknown parameters $UE_1$ or $TC_2$ is determined, for example, by some known forecasting method or can be set, then the second one is found directly from equation (1).

The results of the analysis of existing forecasting methods show that the parametric method is the most acceptable for solving this problem, for the practical use of which the working equations are known (Antonova; Smirnov; Antonov, 2016; Semenov et al., 2017).

Let's consider a variant of the initial determination of the value of the useful effect by the method of parametric forecasting and write down an equation where the useful effect of the product in the future can be determined by the specific indicators of the base product:

$$UE_2 = \frac{UE_B}{CH_B} CH_{12} \cdot K_{12} \cdot K_{22} \cdot K_{32}, \quad (10)$$

where $UE_2$ is the useful effect of the product in the forecast period; $CH_B$ is the most important characteristic (main function) of the base product; $UE_B$ is the average annual useful effect of the base product, similar to the one under consideration; $CH_{12}$ is the most important characteristic of the product in the forecast period; $K_{12}$ is the coefficient that takes into account the increase in the reliability of the designed product in the future compared to the base one; $K_{22}$ is the coefficient that takes into account the change in the organizational and technical level of production of the consumers of the designed product in the forecast period compared to the level of production of the consumers of the base product; $K_{32}$ is a coefficient that takes into account changes in the organizational and technical level of production of the repair organization of the designed product in the forecast period compared to the base product.

After determining the useful effect in the future, the second unknown parameter of equation (1) is the total costs, we find as follows:

$$TC_2 = CI_2 \cdot UE_2, \quad (11)$$

Using the parametric forecasting method, it is similarly possible to initially determine the total costs in the forecast period, and then find a useful effect from equation (1). To do this, we will write down the total costs in a general form, as the sum of the purchase price of $PC_2$ and the cost of operating $OC_2$ product:

$$TC_2 = PC_2 + OC_2, \quad (12)$$

R.A. Fatkhutdinov (2000) considers the possibility of using several methods of price forecasting at the stage of strategic marketing. Without stopping at their detailed analysis, we note that the most acceptable method from the point of view of practical use is the method of forecasting the prices of the designed products based on the establishment of the profit standard, which ensures the break-even of the enterprise, provided that the production costs are optimal:

$$PC_2 = SC_2 + P_S, \tag{13}$$

where $PC_2$, $SC_2$, and $P_S$ are, respectively, the price, self-cost and profit standard in the forecast period.

The operating costs of the product under consideration by the method of specific indicators can be determined by the formula (Brun; Georgi, 2018).

$$OC_2 = \frac{OC_B}{CH_B} CH_{12} \cdot K_{12} \cdot K_{22} \cdot K_{33}, \tag{14}$$

where OC2 is the cost of operating the designed product in the forecast period; OCB is the average annual cost of operating the base product; CHB is the most important characteristic of the base product (the main function); CH12 is the most important characteristic of the designed product in the forecast year; K12, K22, K33 are coefficients similar to equation (10) where their essence is revealed.

Thus, in the section A'1A2 of the straight OA2 of Figure 1, determining one of the two unknown parameters of the useful effect or total costs by the forecasting method, we find the second one from equation (1).

## 4. DISCUSSION

The known forecasting methods can be used in the future in combination with other solution methods. In this regard, it is necessary to research and develop new approaches and methods for solving this problem.

The essence of the proposed method for determining the forecast values of the component parameters of the competitiveness indicator is that the calculation of the useful effect and total costs is carried out based on the functional relationship and the known forecast value of the competitiveness indicator itself, which has its functional dependencies on many other factors, i.e. equation (1) contains two unknown parameters and the function $CI_2 = f(UE,TC)$ is a complex function of two variables.

The forecast value of the product competitiveness indicator $CI_2$ from equation (1) can be obtained at different ratios of the values of the useful effect *UE* and the total costs *TC* in the forecast period. At the same time, each variant of *UE* and *TC* ratios should be considered as a strategy for ensuring the competitiveness of the product. The analysis of the interrelationships of the variable parameters of *UE* and *TC*, which determine the regularity of changes in the competitiveness indicator, allows us to identify three main, most acceptable for practice, variants of their combinations, in which it is possible to achieve the forecast value of $CI_2$ at:

–reducing the total costs and maintaining a constant value of the beneficial effect;

–an increase in the useful effect at a constant value of the total costs, i.e. when the total costs in the forecast period remain at the level of the current period;

–simultaneous increase of the useful effect and total costs.

Therefore, the solution of the problem of achieving the predicted value of the competitiveness indicator is possible based on the results of the implementation of three variants of the ratio of the useful effect and total costs. At the same time, the optimal solution can be chosen based on the results of their analysis.

## 5. CONCLUSION

Taking the minimum total costs as the optimization criterion, the results of the three variants of the *UE* and *TC* ratios show that on the segment $CA'_1$, including the boundary point $A'_1$, the forecast value of the competitiveness indicator is achieved at costs not exceeding the values that were achieved in the current period. Therefore, this range is the most optimal for achieving the forecast value of the competitiveness indicator and the implementation of the *UE* and *TC* ratios.

Thus, the analysis of equation (1) and its geometric interpretation made it possible to identify the most likely options for implementing the relations of the useful effect and the total costs, to establish the boundaries of their optimality and to determine the numerical values within these boundaries. It should also be noted that the proposed method of geometric interpretation when predicting the components of the competitiveness indicator makes it possible to present more clearly the possible variants of their relationship.

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