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PRODUCTION FUNCTION APPLICATION IN DETERMINING THE OPTIMAL PARAMETERS IN THE DEVELOPMENT OF HOSPITALS

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ABSTRACT
The health reform in Bulgaria brought about the emergence of competition among hospitals. Their managers are now urged to choose a new competitive behavior for the future strategies of the institutions run by them. One of the primary tasks is to find the optimal proportion among resources so that social needs for healthcare be satisfied better.
The article is aimed at proposing a way to implement the production function as a means to determine the major parameters of the competitive behavior of hospitals. A model has been developed attempting to find an effective combination of the production factors at the extremity of the function. The problem with the comparability of the various quantities measurements has been solved with the use of a multiplier. With the deduced optimal values of the arguments hospital managers will be in a condition to determine the capacity, that is, the supply of hospital service on the market.
The model which has been developed is standardized enough to allow to prepare and use appropriate software. This will invariably facilitate hospital managers in making strategic decisions about the future.
The testing of the model has been accomplished at the Varna Eye Hospital, Bulgaria, which has sponsored it and will use it for its strategic purposes. The results of the study are reflected in the present article.

Key words: production factors, number of patients served, Varna Eye Public Hospital

INTRODUCTION

The healthcare system in Bulgaria is currently undergoing reforms aimed at the provision of quality and affordable medical service in accordance with international standards. New relationships and interdependencies specific for the market economy are being established. The competition which has arisen among hospitals is intensifying constantly. Therefore, the choice of competitive behavior that hospitals should make as well as the determination of its parameters are very important issues in the new market conditions. They contribute substantially to the survival and future development of Bulgarian hospitals.

We agree with the some scholars who have articulated the existence of a production process in hospitals [1] when various strategic decisions are made and we suggest in the present article the application of certain methods and models used by other sectors of the economy.

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MATERIALS AND METHODS

At it is well known in science, production as an activity and a process in the different spheres of society is compliant with certain technological and economic laws. This implies that the various production factors have been combined in a particular way leading to a concrete result - a product or a service.

In this sense, the dependencies among the possible combinations of production factors and the range of opportunities for the production of a maximum quantity of produce with these factors could be expressed with a production function of the following type:

$$Y = f(X) = f(x_1,x_2,...,x_n), \qquad /1/$$

where:

Y is the quantity of the product produced and

n - number of factors of production included (j = 1, 2, n)

x_j ca unknown quantities of the different factors of production (resources)

Along with this, the presumption is that the vector of production factors $X = (x_1, x_2, \quad x_n)$ belongs to a convex range K of non-negative n-dimensional vectors, where Xj is the quantity of the j-factor.

Just like in firms, operating in the production sphere, in hospitals there are processes in which resources are being combined in a particular way for the provision of specific health services. These services are the intermediate product of healthcare, whereas the achieved results of the activities constitute its final product. Since the improvement or the aggravation of someone's health tend to be more influenced by external factors, we will take health services as the product of clinic activity. The references in the field of health economics indicate two approaches to determining the health product of hospitals [2]:

a) using the set of services provided (service-mix);
b) using the number of patients served (case-mix).

We consider both approaches to be appropriate due to the fact that they reflect comprehensively the outcomes of hospital service and the various combinations of production factors in this process. The *mix of the services provided* could be determined most precisely after the introduction in the healthcare system of diagnostic related groups (DRG) as the units of analysis, reporting, and forecasting. Before and after that the second approach could be used, since *the number of patients* aided is being used as an indicator in the hospitals for several years. Both approaches will help us in the correct reporting of the results of hospital service.

Because economic literature recognizes resources as the production factors, it is necessary to underline their diversity in hospitals. This will allow us to identify the input of the production system. The resources infused in the production process of hospitals are specific which is associated with the peculiarities of healthcare. They are, essentially, production factors which can be divided in two categories - labor and capital. This set of internal resources of hospitals is also subject to certain dependencies and interrelationships existing in the production sphere, too. In hospitals they can generally be grouped as:

x_1 - long-term assets — buildings, medical and non-medical equipment, transportation means, furniture, etc.;

x_2 - short-term assets - medicines, medical supplies, food, etc.;

x_3 - labor (human) resources - physicians, nurses, hospital attendants, administrators, economists, etc. performing the medical and the administrative activities in the hospital, i.e. the labor of personnel;

x_4 - financial resources - money in the bank accounts held by the hospital as well as cash, shares, securities, loans, etc.;

x_5 - informational resources - information systems set up and the assisting software;

x_6 - technological resources such as patents, licenses, brands, scientific products, etc.;

x_7 - organizational resources including the conditions in the hospital aiding the continuous production process.

It is possible to consider other factors which we would like to optimize at the extremity of the production function. Some of them will greatly help the hospital management when making strategic decisions.

Following the market principles valid in healthcare, every hospital will be striving to optimize the input production factors with the precise technological relationship reflecting the diagnostics and the treatment of human health. At the same time one major condition should be the appropriate minimization of costs for each of the services offered by hospitals in their being producers in this process.

In other words, **the production function of hospitals** as health producers *is the technological link and dependence among their resources participating in the provision of health services in the diagnostics and treatment of patients.*

The application of production functions in healthcare faces tremendous difficulties. They evolve from the intangible nature of the product of hospitals - health service and its relation to the most precious human good, that is, health. In order for the product to be created, a great number of various production factors need to be involved. Other than that, there could be no substitutability between labor and capital. The prices of health services are exceptionally high compared to other products of the material sphere but, nevertheless, they have to be provided. The market principles which have been established in healthcare, too, demand that hospital management follow adequate behavior in order for the hospitals to survive and prosper in the competitive environment. This inextricably means that revenues should exceed costs and the needs of the people for the particular health service should be met.

This is the reason for the authors, who are fully aware of all the difficulties and risks, to set as their goal in the present article the proposition of a specific mathematical construction (formulation) of the production function. The function should be suitable for the analysis of condition of hospitals and the determination of the parameters of their behavior in the competitive environment.

In order to avoid the above-mentioned limitations, as common practice dictates, we will set the following conditional restraints: Firstly, the production function should pertain to a homogeneous and sometimes hypothetical health service Y.

Secondly, the various health resources transformed in specific health services should be combined and grouped in two main factors - capital and labor. This also requires the divisibility of the factors of production which leads to the assumption that not the very factors are being used but their material inputs. Even with such limitations as these, there are still essential difficulties such as the incomparability of the inputs of production factors, the differences in the units of measure, and others. The existence of such sometimes insuperable difficulties is the main reason why many economists express doubts about the possibility of constructing a correct production function in the social sphere and achieving realistic and significant results by analyzing it. Some scholars in the field of health economics indicate that the function could be used. However, they have failed to work out concrete models of its application in hospitals [3].

Evidently, the particular type of production function plays a decisive role not only from the theoretical and methodological point of view but also from the view point of the immediate practical orientation of analyses, conclusions, and prognoses. In this sense, the production function should not only approximate some available information precisely enough, but it should quite accurately reflect the nature and essence of the processes in question, while meeting a number of requirements. When describing and studying the production and technological processes in hospitals, the production function should:

a) be continuous just like the very production and technological process of healthcare;
b) have only non-negative values when the values of the arguments are positive and arbitrary;
c) provide for the restriction and simplicity of the possible values of the arguments;
d) have continuous derivatives of first and second order compliant with the following condition:

$$\frac{d\,f}{d\,x_j} > 0 \quad (j = 1, 2, \ldots, n); \qquad /2/$$

e) be convex from above (or its form or position should properly reflect the characteristics of the substitutability of the production factors):

$$\frac{d^2 f}{d\,x_j^2} < \quad (j = 1, 2, \ldots, n); \qquad /3/$$

f) be suitable enough for immediate use and allow to determine realistically the parameters and the economic and mathematical characteristics on the basis of the existing information.

Conditions /2/ reflect the laws of the enlarged number of health services or of cases with the increase of any of the production resources, while keeping the quantities of all other factors the same. Conditions /3/ confirm the validity of the economic law of diminishing returns of each varying production factor in that there is a decrease in the growth of cases when the input of at least one other production resource increases, the necessary diagnostics and treatment of the individual patient being invariably same.

Although all the production function requirements mentioned are formally expressed in a mathematical way, they are purely economic in their essence and meaning and respond to the real production, technological, organizational and economic processes in hospitals. As a result of this the analyses of each production function depicting realistically the specific features of production allow to discover a number of significant and interesting characteristics and regularities. They could be used in setting the parameters of hospital behavior while taking the demand for hospital service into consideration. In this respect, it is necessary to emphasize the following:

First, we should consider the marginal rate of technical substitution (MRTS) measuring the proportion in which one production resource could be substituted with another within the given technology of diagnostics and treatment, the number of patients being the same. By determining the values of the MRTS we, in effect, characterize quite precisely the technologies used in relation to the substitutability of the production resources. On this path, the technologies could be divided in three groups:

a) technologies with a perfect (absolute) substitutability of the production resources where the MRTS is constant. There is a specific case when MRTS = 1, since the production resources could be substituted 1:1;
b) technologies with a perfect (absolute) substitutability of the production resources where the MRTS cannot be determined, that is, the production resources cannot substitute one another and they are combined at a constant rate independent of the number of cases.

Second, the quantitative influence of the MRTS over the rate of combining the production factors (σ) which is defined as the relation between the proportional change in the ratio of the production factors and the proportional change in their technical substitution. The easier it is to substitute production factors, the smaller the proportional change of the MRTS and the greater the absolute value of the elasticity of substitution. For example, when there is perfect substitutability of the production factors, the MRTS will not change at · all and the substitution elasticity will be closer to infinity. The Cobb - Douglas production function is being characterized with a constant elasticity of substitution with a value of 1 which leads to the conclusion that the proportion in which production factors are combined is constant no matter the selected mode of diagnostics and treatment (i.e., the technological variant of production) of patients and no matter the type of returns from the number of patients treated (i.e., the scale of production).

Third, the production elasticity of the production factors defined as the ratio of the marginal and the average product and expressed with the percentage change of the number of cases at a 1 per cent change of the input of a particular production factor.

The production elasticity of production factors is directly related to the returns from the number of cases and appears to be one of its concrete characteristics. Thus, for example, when the production function is homogeneous and is of first order, with the concurrent increase of the input of production factors by 1 per cent, the production expands by 1 per cent exactly which implies constant returns to scale. In such a situation the sum of the production elasticity of labor and capital equals 1. If in any section of the production function the production elasticity of some of the production factors is higher than 1, then the production elasticity of the other factor is negative. This indicates that undoubtedly there is a need for an immediate change of the technological variant of production expressing the relationship and the dependencies among the resources used in the diagnostics and treatment of patients, because the production factor with a negative elasticity is not being used efficiently. In this sense, in such condition the hospital should try to implement an innovative strategy. It should opt for a long-term approach in choosing a competitive behavior.

The above-mentioned dependency has been deduced on the basis of Oyler's theorem of the homogeneous first-order production function stating that the sum of the multiplications of the quantities and the marginal products of the production factors is always equal to the total product produced, that is, the number of cases. This regularity takes a central place in the analysis of the markets of production factors which are very developed in healthcare and the competition intensity in which is very high. They are the fundament of the theory of income distribution in correspondence with the marginal product which is interesting as an object of study, since this problem has not been solved in hospitals yet.

As to the homogeneous production functions of the K-order, very often it is just the order-indicators in them which characterize the production elasticity of production factors. This is the case with the Cobb - Douglas production function [4]. However, the returns to production scale in it could be different depending on the value of the sum of the production elasticity of production factors.

Fourth, the returns to production scale or the number of cases which is the most essential part of analyzing production process in hospitals in a longer period of time. In fact, with the help of these returns a thorough characteristic of the technical and technological efficiency in setting up production can be made allowing to determining its optimal technological size.

Clearly, when analyzing each production function reflecting on the real conditions, a lot of other objective laws can be drawn especially when the analysis involves the respective cost function and the motives behind the market behavior of hospitals.

Our study of bibliographic sources has convinced us that not every function of the f (X) type satisfies the criteria mentioned, nor it allows to discover important characteristics and laws. It turns out that in such cases the most suitable function is the transcendent function, because it captures the projected trends best:

$$Y = \delta \prod_{j=1}^{n} x_j^{\lambda_j} e^{-\mu_j x_j} \qquad /4/$$

where:

Y is the number of patients;

n - number of factors of production included

x_j is the quantity of input of the j-production factor (j = 1, 2, ..., n);

δ, λ_j, μ_j are parameters subject to determination (j = 1, 2, ... , n).

In order to find the adequacy of this function to the interrelationships between the dependent variable Y and the independent variable x_j, correlation coefficients and a correlation ratio are used. The homogeneity of the choice could be checked with the help of a variability coefficient, whereas the significance of the correlation with the help of Student's t-criterion.

The analytical indicators established on the basis of the production function proposed are quite an efficient means to determine the impact of the change of production factor inputs on the change in the number of cases. In this context, without being aimed at completeness, the current article attempts to deduce the mathematical expressions of the main analytical parameters of the function /4/.

First, for the marginal product (MP) of the j-production factor characterizing the growth of the dependent variable Y (number of cases) when changing the input of a particular production factor, the other production factors in the function Y (or the technology) being the same. As it is known, the MP of a particular production factor can be found as the first derivative of the function /4/:

$$w_j = \frac{dY}{dx_j} = \delta \prod_{j=1}^{n} x_j^{\lambda_j} . e^{-\mu_j . x_j} (\lambda_j . x_j^{-1} - \mu_j)$$

$$(j = 1, 2, \ldots, n) \qquad /5/$$

for x_i = const., i = 1, 2, ..., n - 1, $i \neq j$

The parameter Xj is, in fact, the *initial elasticii* (i.e., a coefficient of elasticity of productio with respect to the input of the relevai production factor) of the j-production factor c it is the probability of change in the number c cases resulting from the input of a particuk production factor.

It is necessary to stress that the law of tb diminishing returns from the varying factor c production is valid for at least on unchangeable (fixed) production factor in tb function or given that same technology is use< Along with this, some interesting dependenck can be detected when analyzing the return from each of the changing production factoi and the returns from the number of cases (thi is, the scale of production), while determinin the limits within which they are compatible.
Second, in terms of the production elasticity c production factors the coefficient of elasticít is deduced from equation:

$$v_j = \frac{dY}{dx_j} . \frac{x_j}{Y} = \lambda_j - \mu_j . x_j \ (j = 1, 2, \ldots, n); \qquad /6/$$

for x_i = const., i = 1, 2, ..., n — 1, $i \neq j$

Here the parameter μ, shows the increase (decrease) of the total elasticity of production with the increase (decrease) of the input of the j-production factor by 1, that is,

$$\mu_j = \frac{d\,v_j}{d\,x_j}, \qquad /7/$$

for x_i = const., i = 1, 2, ..., n - 1 $i \neq j$

Third, for the MRTS. In the function /4/ it is a positive quantity

$$\mu_{ij} = \frac{d\,Y}{d\,x_i} : \frac{d\,Y}{d\,x_j} \qquad /8/$$

x_k = const.,k= 1,2,…,n-2 $k\neq i, k\neq j$

This quantity is practically positive because it shows by how many units the input of the i-production factor should be increased (reduced) when reducing (increasing) the j-production factor by one unit, given that the number of cases (i.e., the value of the production function in /4/) is the same. Other than this, it is also presumed that all other factors of production are fixed and that the proportions in which the analyzed factors i and j are combined are being studied.

The multiplier δ before the multiplication sign in the function reveals the various measurements (or measures) of the components (number of patients and production factors used). The multiplier is determined with the help of the following formula:

$$[\delta] = \left[\frac{\delta}{\prod_{j=1}^{n} \delta_j^{\lambda_j}} \right] \qquad /9/$$

where:

δ_0 are the units of measure of the Y parameter (number of patients served);

δj are the units of measure of the j-production factor.

With the help of the multiplier one of the primary problems associated with production function is solved, that is, the problem of compatibility of measurements, the problem of comparing the number of patients and the different production factors used.

The applied production function is very convenient for the analysis of specific situations in that it gives an opportunity to determine the major parameters by implementing well known methods. Thus, for instance, with the help of logarithms the production function in /4/ can be transformed into a linear function with respect to the parameters:

$$\ln Y = \ln\delta + \sum_{j=1}^{n} (\lambda_j . \ln x_j - \mu_j . x_j) + \varepsilon_y, \qquad /10/$$

which, on the other hand, allows to find these parameters through the least square method.

We have introduced a random error term in the final term ε_γ of equation /10/ which points out that the method used does not dispose of some errors. Here, the random error term should be considered as a random quantity having a probability distribution with zero expected values and standard deviation $\sigma_{\varepsilon y}$.

When constructing and finding a solution to the production function in /4/, most vital is the problem of choosing its arguments identified as the range of the production factors involved in it. Meanwhile, with respect to the analytical and technological point of view, as well as in terms of essence, it is possible, proper and obligatory not to reflect on absolutely all production factors used in the diagnostics and treatment of patients. They should demonstrate the most essential interdependencies and reveal the most important aspects influencing production, while having the greatest significance in terms of impact on it.

The measure of the strength and the direction of interdependencies between production and production factors as a rule is detennined by the correlation coefficient. It characterizes the availability and the strength of statistical dependence (relation) between production and production factors without determining the magnitude of the very influence of arguments (i.e., the production factors) upon the dependent variable (i.e., the production). The latter has been achieved in the production function suggested in /4/ through the parameters (or characteristics) introduced, that is, w_j /5/ and v_j /6/.

In conclusion we need to emphasize that when the concrete construction of the suggested transcendent function is significant and when related analyses of hospital activity are made, relevant optimal solutions can be derived as well as sufficiently accurate projections. The function reaches its extremities in the points in which

- for the maximum $\lambda_j > 0$ and $\mu_j > 0$
- for the minimum $\lambda_j < 0$ and $\mu_j < 0$.

This is exactly:

$$x_j^o = \frac{\lambda_j}{\mu_j}$$

The authors are fully aware that one article solely cannot give a comprehensive characterization of the production function proposed especially in its direct application in determining the parameters of hospital behavior in the competitive environment. But it will designate the possible combinations of production factors necessary to accomplish a certain level or least inputs of resources per patient.

The methodology discussed could serve as a method of establishing and analyzing the laws and interdependencies among the variables studied. It can provide a quantitative measurement of the impact on the final result, in this case the number of patients aided, depending on the factors chosen and affecting it. This methodology can be applied in formulating precise projections in other spheres of the economy as well.

RESULTS AND DISCUSSION

In order to demonstrate the suggested model, we have used statistical data for the period 1998-2007 of the Varna Eye Public Hospital's four departments - children's, retinal detachment, glaucoma, and keratoplasty. Considering the information processed, we aim to construct a production function of the type in /4/, which determines the dependence of the number of patients served on the factors picked:

x_1 - long-term tangible assets, thousand levs;
x_2 - short-term tangible assets, thousand levs;
x_3 - financial resources, thousand levs;
x_4 - number of physicians;
x_5 - number of nurses;
x_6 - other types of service personnel;
x_7 - information resources, thousand levs;
x_8 - expenditure per patient, thousand levs.

By using the suggested production function we can carry out an additional analysis of the influence exercised by the separate factors on the global indicator. We have considered one more factor in the approbation which, in our view, is quite important in making utmost decisions. This is the expenditure per patient. With the help of the multiplier shown in /9/ we make it responding to the other factors.

After the primary information is processed in the relevant statistical and mathematical way using the production function in /4/, the following equation of the resources is reached:

$$\ln Y = 0{,}058 + 0{,}235 \ln x_1 - 0{,}00032\, x_1 + 0{,}168 \ln x_2 - 0{,}000732\, x_2 + 0{,}768 \ln x_3 - 0{,}00023\, x_3 + 0{,}0121 \ln x_4 - 0{,}006722\, x_4 + 0{,}0324 \ln x_5 - 0{,}000675\, x_5 + 0{,}0112 \ln x_6 - 0{,}000432\, x_6 - 0{,}0112 \ln x_7 - 0{,}000132\, x_7 + 0{,}00023 \ln x_8 - 0{,}000537\, x_8 + \varepsilon_y$$

The random error term ε_y is herein considered as a variable connected with a roulette wheel where the whole numbers from -10% to + 10 % are evenly arranged. This means that there are 21 possible outcomes during the outcome wheel rotation, each of them equiprobable. Thus, when there is a given set of numbers, the arithmetic mean (expected value mathematical expectation) of the random error terms is equal to zero:

$$(-10.\frac{1}{21}) + (-9.\frac{1}{21}) + \ldots + (9.\frac{1}{21}) + (10.\frac{1}{21}) = 0$$

We should note that this calculation is a product sum of all expected values of the probabilities for their appearance. Now it becomes obvious that the standard deviation of this given random error term is equal to 6, 06 %.

$$\sqrt{[(-10-0)^2.\frac{1}{21} + (-9-0)^2.\frac{1}{21} + \ldots + (9-0)^2.\frac{1}{21} + (10-0)^2.\frac{1}{21}} = 6,06$$

The regression coefficients in the equation are the parameters of the production function:

$$/5/ \quad Y = \delta \prod_{j=1}^{n} x_j^{\lambda j} e^{-\mu_j x_j} = 1{,}06\, x_1^{0{,}235} e^{-0{,}00032\, x_1} x_2^{0{,}168} e^{-0{,}000732\, x_2} x_3^{0{,}768} e^{-0{,}00023\, x_3} x_4^{0{,}0121} e^{-0{,}000231\, x_4} x_5^{0{,}0324} e^{-0{,}000675\, x_5} x_6^{0{,}0112} e^{-0{,}000432 x_6} x_7^{0{,}0112} e^{-0{,}000732 x_7} x_8^{0{,}00023} e^{-0{,}000532 x_8}$$

The correlation coefficient and its error then are equal to:

$$R \pm \Delta R = 0,\ 87 \pm 0{,}069$$

Following Fisher's criteria (F-distribution) [5], we have g (t, n_b n_2) = 8,78 with a table g = 210 and a degree of variability (frivolity) nj = 7 and n_2 = 33. The parameters are statistically significant according to Student's t-criterion with a table $t_{0,05}$ = 1,66 and a level of significance of p = 0,05 (fifth and sixth row of **Table 1).** The slack term of this criterion is included in column Y of the fifth row. The indicators found characterize the statistical plausibility of the constructed function representing the number of patients at the Varna Specialized Eye Hospital's four departments using the chosen factors. The first three indicators (the arithmetical mean, the mean square deviation, and the variability coefficient) were computed on the basis of the processed information. The other four regression coefficients (the correlation coefficient, the coefficients t_a. and t_p. of the Student's criterion for regression, the marginal efficiency of the factor and the production coefficient of elasticity) resulted from the production function in /5/ using the mean values of Y and the factors of the sample.

As Table 1 shows, the mean square deviations demonstrate a substantial hesitation of the indicators for the years and departments observed around the respective mean values the result of which is the fluctuation of the number of patients. This, unfortunately, is a fact, since in the last there years there is a magnificent decrease in relation to this indicator due to the existence of strong competition in the sector. To compare the levels of activity of the hospital, we can analyze the variation coefficient. The greatest differences observed are in the short-term tangible assets, the financial, and information resources (13% on average). This reveals that these resources have not been determined appropriately and, hence, the final results and the quality of service have aggravated. Logically, the main reason for that is that until recently these resources have been provided by the state.

Table 1. Economic and Mathematical Characteristics of the Influence Exercised by the Number of Cases in Dependence on the Production Function

N	Indicator	Y	x_1	x_2	x_3	x_4	x_5	x_6	x_7	x_8
1	Y' and x'	2479	551	176	443	16	41	36	33,6	0,2
2	Mean square deviation S	1,2	1,3	0,98	1,4	0,048	0,482	0,032	0,628	0,124
3	Variability coefficient V_s	2,7	4,3	14	12	5,2	5,78	0,35	12,8	1,48
4	Net correlation coefficient r		0,17	0,14	0,11	0,42	0,32	0,36	0,14	0,24
5	Parameters of the function according to the Student criterion $t\alpha_j$ and $t\beta_j$	1,18	2,18	2,09	4,08	3,26	1,12	2,14	3,12	2,82
7	ω_j		0,2637	3,09	3,72	1,3	1,59	-0,27	0,406	0,003
8	v_j		0,05868	0,039168	0,66611	0,008404	0,02625	-0,004358	0,0067648	0,0002038

The measure of the magnitude and the direction of dependency between the number of cases and the factors is represented by the correlation coefficient. The strongest correlation is between the number of cases and the service personnel, that is, the number of physicians, the paramedical staff with vocational education as well as the other types of personnel. The weakest correlation is between the number of cases and the financial resources. The correlation coefficient expresses the existence and the strength of the statistical link between the number of cases and the factors but is not indicative of the scale of the very influence of the dependent variable on its arguments. As we have already stated, this is done through the two characteristics w_j and v_j (row 7 and 8 of Table 1). The highest growth of the number of cases responding to an increase of the factor (differentiated productivity) by one and, hence, the highest elasticity coefficient, can be observed for the financial resources ($w_3 = 3{,}7$ and $v_3 = 0{,}66611$) and the short-term tangible assets ($w_2 = 3{,}09$ and $v_2 = 0{,}039168$). This could be explained with the fact that these two factors vary a lot for the different years and departments.

The introduced transcendent function /4/ can be applied in finding an optimal solution to the formulated problem. The function has an extreme value for those values of the independent variables for which $\lambda > 0$ and $\mu > 0$ (a maximum) and $\lambda < 0$ and $\mu < 0$ (a minimum). In other words,

$$x_j^0 = \frac{\alpha_j^0}{\beta_i^0}$$

Specifically for the present research the results are the following (see **Table 1):**

$x_1^0 = 734$; $x_2^0 = 229$; $x_3^0 = 3339$; $x_4^0 = 18$; $x_5^0 = 48$; $x_6^0 = 26$; $x_7^0 = 85$; $x_8^0 = 0{,}43$

These values of the factors are real and significant. They reflect the need for more financial resources for the purchase of long- and short-term tangible assets and information resources with the aim to respond to the customer requirements for a modem equipment and medication. To improve the quality of service, it is necessary to enlarge slightly the medical staff at the expense of the other service personnel which should be reduced and later on employed through outsourcing. It is understandable that the better conditions will bring up the expenditure per patient. The changes, however, will urge more clients to choose the hospital despite the serious competition of the other three hospitals in the Varna region. These are the Naval and Military Hospital, Associate Professor D. Georgiev Private Eye Hospital and Saint Petka Private Eye Hospital.

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