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Original Article

Dynamic profitability threshold of a sports equipment selling enterprise

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Abstract:
The increase in household wealth, observed at the beginning of the 21st century in Poland, results in dynamic development of sport infrastructure. Playing fields, bicycle paths, swimming pools and recreation centers emerge in publicly accessible places. This generates great demand for sports equipment, which is also fostered by the sport successes achieved by Polish athletes in many disciplines. The subject of this study entails the profitability threshold of an enterprise selling sports equipment on the Internet. Profitability threshold is an enterprise characteristic that does not belong to the categories analyzed via econometric tools. The literature, therefore, lacks studies addressing empirical determination of profitability threshold in an enterprise. This necessitates a model comparison of the company's total costs against the sales revenues. The purpose of this article is to describe the variability mechanism of the total costs in an enterprise, using a stochastic econometric model. Sales revenues have been included in the model equation. This will allow to determine the level of the company's fixed costs as well as calculate the increase in the variable costs the per revenue unit. Positive verification of the empirical model allowed indication of the sales revenues level at which the total costs are covered. This requires comparison of an empirical equation of the cost with a hypothetical equation that assumes equal costs and revenues. By solving such a system of equations, the company's profitability threshold is obtained. Exceedance of the profitability threshold results in the appearance of profit in an enterprise. A procedure for determining the dynamic profitability threshold of an enterprise has been presented as well. This procedure is necessary when a trend occurs in the empirical equation of the total costs. Information on the profitability threshold becomes an important decision-making tool in an enterprise. It indicates the point at which profit on sales can be expected in a period under observation. Additionally, it suggests the use of marketing tools that allow the company to exceed the profitability threshold.
Key Words: **econometric model, cost analysis, profit analysis, production, e-commerce.**

Introduction

The increase in household wealth, observed at the beginning of the 21st century in Poland, results in dynamic development of sports infrastructure. Playing fields, bicycle paths, swimming pools and recreation centers emerge in publicly accessible places. This generates high demand for sports equipment, which is also fostered by the sport successes achieved by Polish athletes in many disciplines.
The subject of this study will be the profitability threshold of an online seller of sports equipment. The literature on the subjects lacks econometric models that would enable determination of a company's profitability threshold. Only works addressing optimization models, with profit functioning as an objective, exist [Archibald. G. Ch. (1989), Chen. J. T. (1980), Junankar. P. N. (1980), Pando, Valentín. Juan García-Laguna, and Luis A. San-José (2012)]. Stochasticity in profit analysis can be encountered as well [Chaiho Kim (2007)]. Works addressing profitability of a given company's operations are popular as well, for example: Skvarciany. V.. Simanaviciute. J. (2018), Tassis, C.D. (2013). In the past year, works on econometric modeling and forecasting of profit and costs were published [Wiśniewski J. W. Sokołowska E. (2020), Wiśniewski J. W. (2020a), Wiśniewski J. W. (2020b)]. The most recent publications are still dominated by works on the methodology of measurement and analysis of profit and costs [see: Gaughan P. A. (2020), Kupriyanova, L.M., Schneider O.V. (2020), Reid W., Myddelton D.R. (2020)].

Materials and methods

The subject of the study entails statistical information on the costs and revenues in an enterprise that sells sports equipment via the Internet. The statistical data comes from the website: https://www.biznesradar.pl/raporty-finansowe-rachunek-zyskow-i-strat/INTERSPPL,Q. In addition, information on the average enterprise-sector pay in the years 2006 – 2020 was used, found at: https://wynagrodzenia.pl/gus/dane-kwartalne. As such, 58 statistical observations from the following quarters were used: from 2006.01 to 2020.02. The company sells online. As a result, the company's clients are located throughout Poland.

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The tool used to determine the company's profitability threshold is a linear model of costs, in which the volume of production, measured, for example, by the value of the sales revenues, is the explanatory variable. As such, the following linear econometric model will be discussed:

$$C_t = \alpha_0 + \alpha_1 P_t + \eta_t, \quad (1)$$

where:
C_t – total cost in an enterprise (thousands PLN),
P_t – the value of net sales revenues (thousands PLN),
α_0, α_1 – structural parameters of the equation,
η_t – the equation's random component.
The equation (1) parameters will be estimated using the ordinary least squares method. It is important to obtain high accuracy of the description of costs by the sales revenues, i.e. to obtain a coefficient of determination at least at the level of $R^2 > 0.9$. This will result in an empirical equation of costs:

$$\hat{C}_t = a_0 + a_1 P_t, \quad (2)$$

where $\hat{C}_t$ denotes the theoretical values of costs, obtained from the empirical equation, a_0 and a_1 are the assessments of structural parameters α_0, α_1 in the model (1). In a classic approach, a_0 represents the level of the company's fixed costs, while a_1 represents the increase in variable costs resulting from the increase in the value of sales revenues per unit.
Let us additionally consider the following equation:

$$\hat{C}_t = P_t. \quad (3)$$

which assumes that the total costs and revenues in the enterprise are equal [see: Wiśniewski J.W. (2009), pp. 96-99]. The solution to the system of equations (2) and (3), with regard to P_t and $\hat{C}_t$,will indicate the values of Pr i $\hat{C}_r$, which determine the company's profitability threshold [Wiśniewski J. W. (2002), pp.36-39]. Figure 1 shows the profitability threshold in this case.

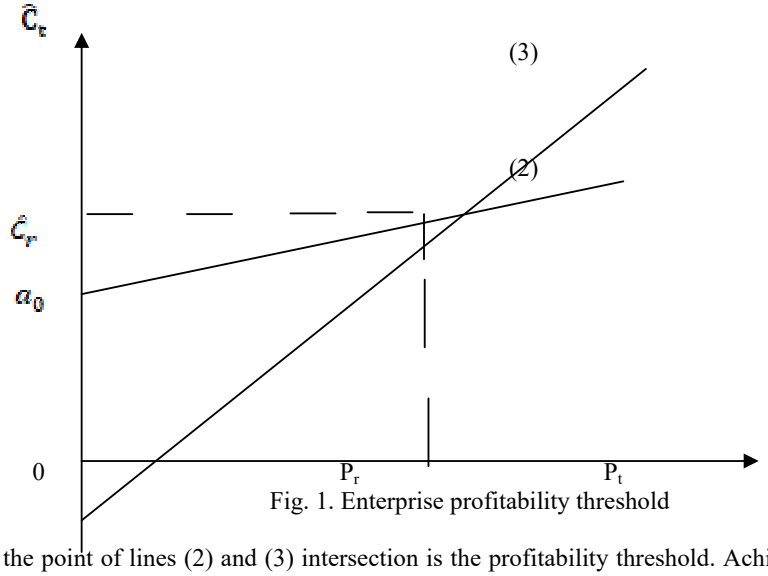


Fig. 1. Enterprise profitability threshold

In Fig. 1, the point of lines (2) and (3) intersection is the profitability threshold. Achievement of sales revenues at the level of $P_t > P_r$ results in the company's transition from the area of loss to the profit zone. The duration of the period for which the empirical model of type (2) is to be determined: whether it is a year, a quarter or a month, needs to be resolved. It can be assumed that it will be most rational to search for profitability threshold at the level of quarterly and monthly data.

Results

The possibilities of empirical analysis will be limited to annual and quarterly data. In large enterprises, such time intervals are most useful for analyzes. Let us begin with an empirical cost-to-revenue equation based on annual data. This equation is presented in Table 1. Figure 1 illustrates the empirical and theoretical relationship between the company's total costs and the sales results.

The negative value of the constant term and the statistical insignificance of parameter α_0 suggest a lack of a fixed-costs level, which seems illogical. This results from the high dynamics of the company's total costs, significantly exceeding the sales revenues dynamics. It is evidenced by the value of parameter a_1=1.03279. This means that along with an increase in the value of the sales revenues by 1 thousand PLN, the total costs increase by an average of PLN 1 032.79. Such situation should alarm the company's management and trigger a reaction aimed at healing the company in the area of the costs incurred in various groups of costs.

An empirical model of costs that is based on annual observations does not, therefore, allow for rational determination and analysis of the company's profitability threshold. Determination of quarterly profitability threshold should thus be considered.

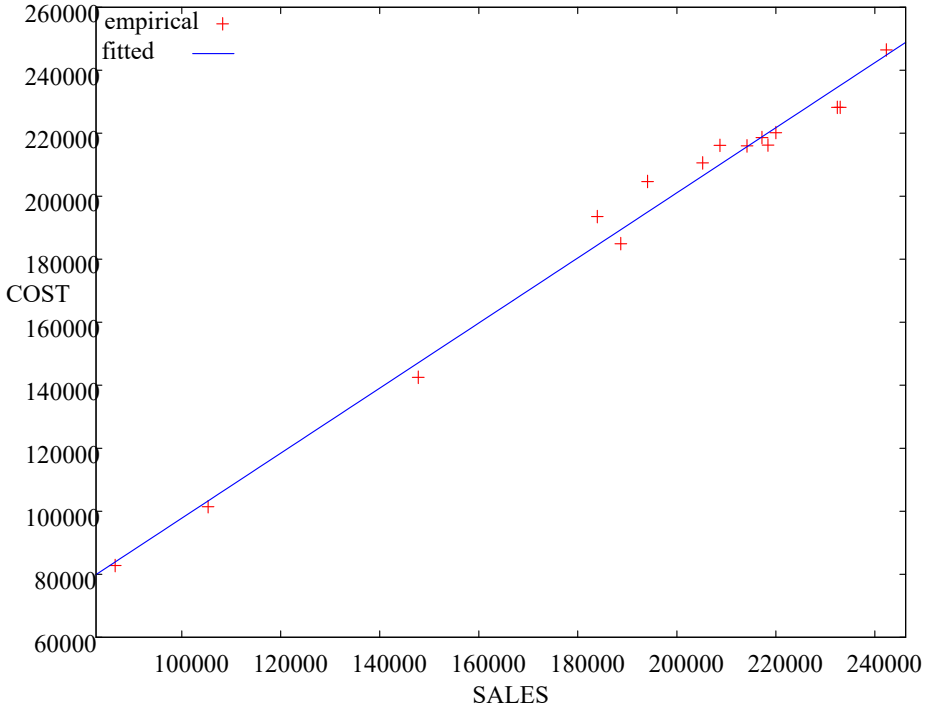
Table 1 Dependent variable (Y): COST, observations used 2005-2019 (N = 15)

Variable	*Coefficient*	*t-Statistic*	*Prob. P*	*Significance*
const	−5477.61	−0.8733	0.3983	
SALES	1.03279	32.64	<0.0001	***

Mean dependent var.	194041.5	S.D. dependent var.	47739.64
Sum squared resid.	3.85e+08	S.E. of regression	5439.498
R-squared	0.987945	Adjusted R-squared	0.987017
F(6, 43)	1065.372	Prob(F-statistic)	7.35e-14
Log likelihood	−149.2325	Akaike info criterion	302.4649
Schwarz criterion	303.8810	Hannan-Quinn criterion	302.4498
Autocorrel. Coeff. (rho1)	0.052379	Durbin-Watson Stat.	1.805292

Source: Own calculations using the GRETL package

Fig. 1 Empirical and fitted values COST versus SALES



Source: Own calculations using the GRETL package

Table 2 presents an empirical model of costs for the quarterly sales revenues generated. The equation fits well with the empirical data (R^2=0,94265). What is more, no autocorrelation of the random component occurs. Figures 2 and 3 show the variability of the variable COST.

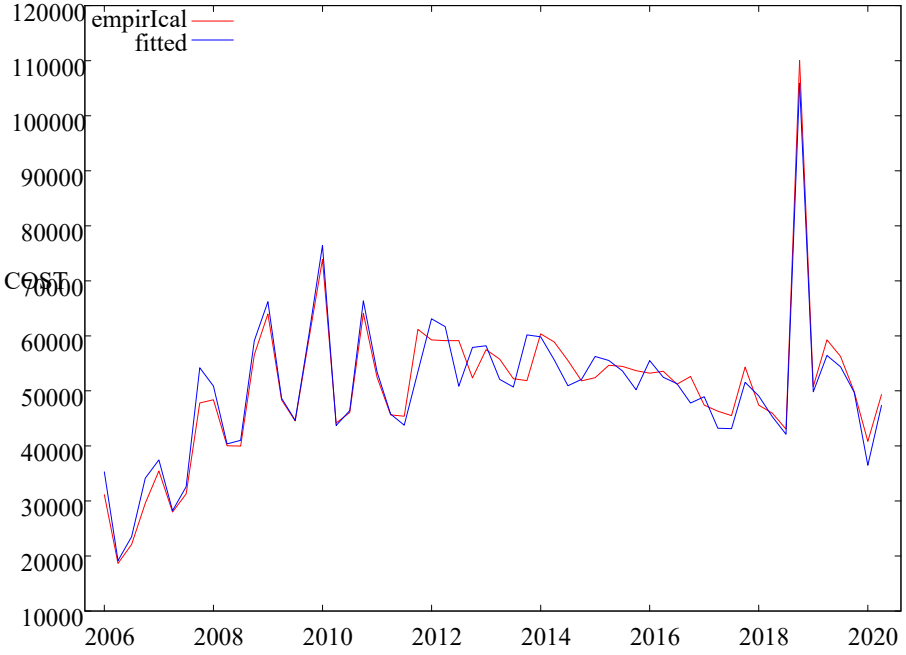
Table 2 Dependent variable (Y): COST, observations used 2006:1-2020:2 (N = 58)

Variable	*Coefficient*	*t-Statistic*	*Prob. P*	*Significance*
const	2976.80	1.840	0.0710	*
SALES	0.950994	30.34	<0.0001	***

Mean dependent var.	50413.34	S.D. dependent var.	13072.52
Sum squared resid.	5.59e+08	S.E. of regression	3158.425
R-squared	0.942650	Adjusted R-squared	0.941626
F(6, 43)	920.4551	Prob(F-statistic)	1.89e-36
Log likelihood	−548.6348	Akaike info criterion	1101.270
Schwarz criterion	1105.391	Hannan-Quinn criterion	1102.875
Autocorrel. Coeff. (rho1)	0.009930	Durbin-Watson Stat.	1.942463

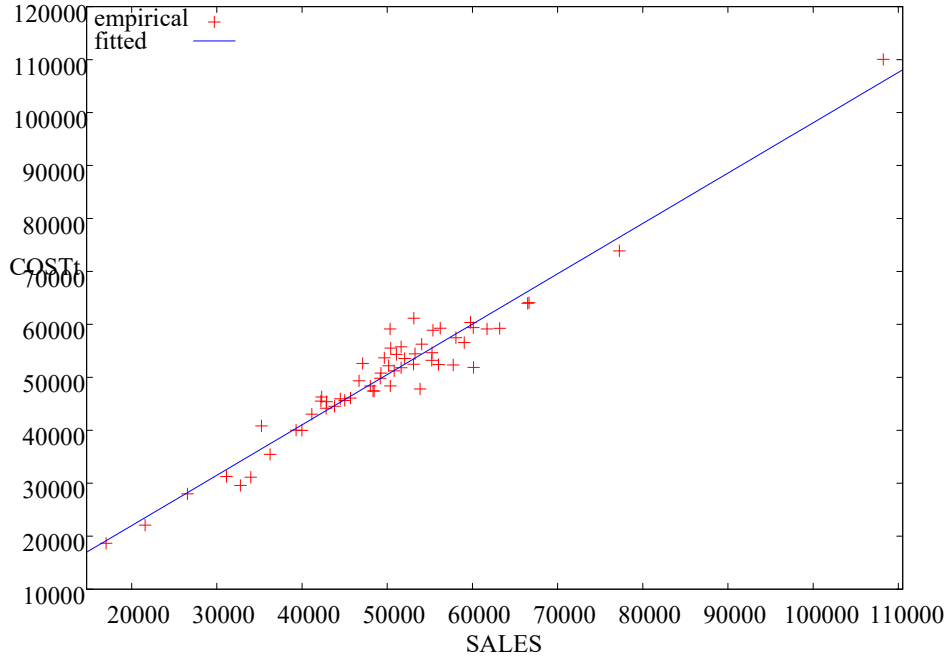
Source: Own calculations using the GRETL package

Fig. 2 Empirical and fitted value of variable: COST



Source: Own calculations using the GRETL package

Fig. 3 Empirical and fitted value of COST versus SALES



Source: Own calculations using the GRETL package

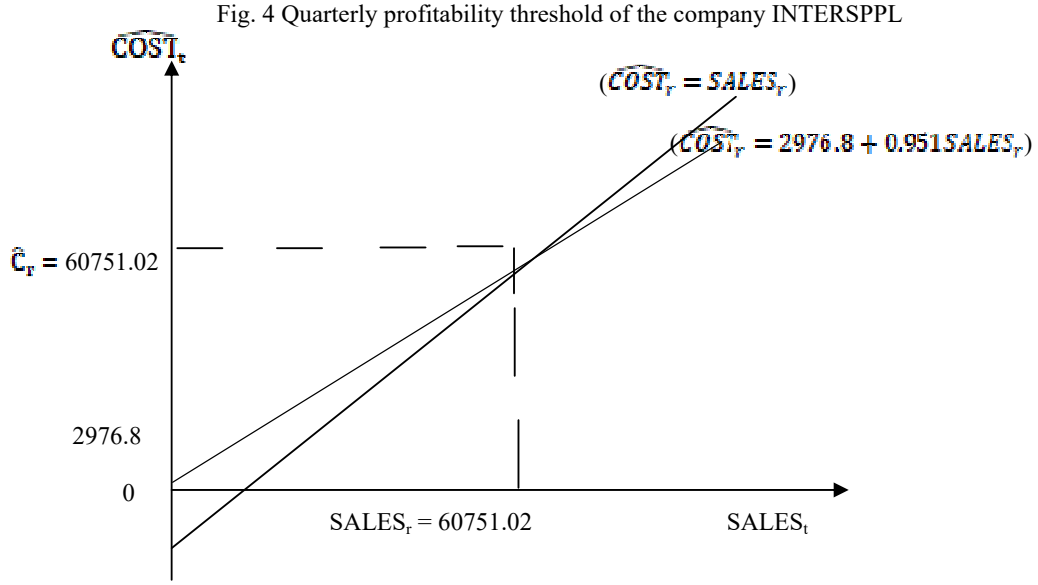
Having an empirical cost-to-sales equation allows the system of the following equations to be solved with respect to the COST and SALES variables:

$$\widehat{COST}_t = 2976.8 + 0.951 SALES_t , \quad (4)$$

$$\widehat{COST}_t = SALES_t , \quad (5)$$

The solving of the system of equations results in $SALES_r = 60751.02$. This means that by generating sales revenues of PLN 60 751.02 thousand PLN, the costs become equal to the sales revenues. The total costs in the enterprise will then reach the level of PLN 60 751.02 thousand PLN. Exceedance of the profitability threshold ($SALES_r = 60751.02$) will result in a surplus of revenues over the total costs, i.e. appearance of profit.

Fig. 4 Quarterly profitability threshold of the company INTERSPPL



The enterprise's profitability threshold was established, assuming stability of the dependency mechanism between the variables $\widehat{COST}_t$ and $SALES_t$, as illustrated in Fig. 4.

Discussion

The above-presented calculation results indicate that the search for the profitability threshold based on annual data may turn out to be overdue and resulting in negative financial results in the enterprise. The model presented in Table 1 should provoke reflection. Coefficient a_1 = 1.03279 signifies an excessive rate of the increase in the total costs, in relation to the increasing sales revenues.

This prompts examination of the quarterly mechanism of costs, in relation to the sales volume. It may turn out that the variable SALES is not the only significant reason behind the increase in the total costs. It should therefore be checked whether an additional trend occurs in the total costs. The results of the calculation for the variable COST model, under the impact of the variable SALES and a linear trend, are shown in Table 3. Figure 5 shows the empirical and theoretical values of the total costs, in relation to the sales revenues. The empirical model under consideration is characterized by high description accuracy of the variable COST.

Table 3 Dependent variable (Y): COST, observations used 2006:1-2020:2 (N = 58)

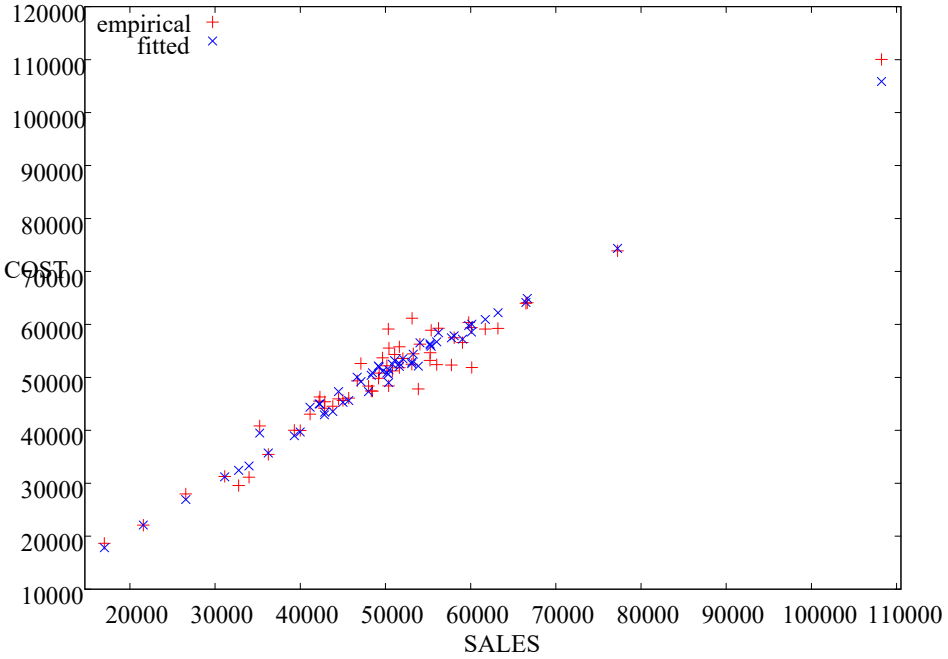
Variable	*Coefficient*	*t-Statistic*	*Prob. P*	*Significance*
const	2077.59	1.417	0.1621	
SALES	0.915739	31.05	<0.0001	***
time	90.0924	3.865	0.0003	***
Mean dependent var.	50413.34	S.D. dependent var.		13072.52
Sum squared resid.	4.39e+08	S.E. of regression		2826.249
R-squared	0.954899	Adjusted R-squared		0.953259
F(6, 43)	582.2367	Prob(F-statistic)		9.78e-38
Log likelihood	−541.6672	Akaike info criterion		1089.334
Schwarz criterion	1095.516	Hannan-Quinn criterion		1091.742
Autocorrel. Coeff. (rho1)	−0.198393	Durbin-Watson Stat.		2.384771

Source: Own calculations using the GRETL package

Based on the empirical model of costs presented in Table 3, it can be seen that a linear trend appeared in the costs. This signifies an autonomous quarterly increase in the variable COST, averagely by approximately 90.09 thousand PLN. At the same time, the value of the constant term decreased from a_0 = 2976.8 thousand PLN to the level of a_0 = 2077.59 thousand PLN.

This allows a conclusion that the profitability threshold in the enterprise examined changes over time. Quarterly, it increases by the value of PLN 90.09 thousand PLN on average. It therefore becomes necessary to determine a rolling profitability threshold.

Fig. 5 Empirical and fitted value of variable COST versus SALES



Source: Own calculations using the GRETL package

A changing profitability threshold necessitates the solving of the following system of equations

$$\widehat{COST}_{rt} = 2077.59 + 0.916SALES_{rt} + 90.09t, \quad (6)$$

$$\widehat{COST}_{rt} = SALES_{rt}. \quad (7)$$

(where a time variable appears t = 1,…, 58) due to the changing values of the profitability threshold $\widehat{COST}_{rt}$ and $SALES_{rt}$. As such, the company's profitability thresholds will be determined for the last four quarters of the period under analysis, i.e. for t = 55, 56, 57, 58. The results of the calculations are presented in table 4. It is also possible to determine the quarterly increase in the profitability threshold.

Using the following equation written by the symbols:

$$\widehat{COST}_{rt} = a_0 + a_1 SALES_{rt} + a_2 t, \quad (8)$$

quarterly increase in the value of the profitability threshold can be determined as follows:

$$SALES_{rt} - SALES_{rt-1} = \frac{a_2}{1-a_1} = \frac{90.09}{1-0.916} 1072.50. \quad (9)$$

Table 4 The company's dynamic profitability threshold for the quarters 2019:03 – 2020:02

Period	$\widehat{COST}_{rt} = SALES_{rt}$	$SALES_{rt} - SALES_{rt-1}$
2019:03	83720.714	1072.50
2019:04	84793.214	1072.50
2020:01	85865.714	1072.50
2020:02	86938.214	1072.50

Source: Own calculations

A glaring difference in the volume of the profitability threshold, depending on the method of determination, can be noticed. Rational decisions that are based on the profitability threshold determined can be made when as many as possible circumstances affecting the final result are taken into consideration. The occurrence of a trend in the total costs necessitates the use of a rolling method of profitability threshold determination. A dynamic profitability threshold emerges in this way. Knowledge of the changing volumes of $\widehat{COST}_{rt}$ and $SALES_{rt}$ will enable the management to undertake many activities that meet the needs associated with many preparations, including adjustment of the sales potential and adequate marketing procedures.

Conclusions

Knowledge of a company's profitability threshold is an elementary essentiality in enterprise management. A traditional approach entails determination of a static profitability threshold, which is a correct solution under the conditions of regular changes in the total costs. The empirical equation describing the relationship between the costs and the sales revenues does not include any additional mechanisms, particularly it

does not include a trend. In such case, classic determination of a static profitability threshold is acceptable and effective in terms of decision making. In large and medium-sized enterprises, it is necessary to employ quarterly data, which enables determination of a quarterly profitability threshold.

When an additional trend appears in the empirical model of the total costs dependent on the sales revenues, the classic approach fails, leading to wrong business decisions. An autonomous increase in the costs causes an increase in the volume of the profitability threshold. It is then necessary to determine a dynamic profitability threshold, which changes over time. In each subsequent period, a new profitability threshold must be determined, the increase of which, in terms of the cost model's linearity, is constant, identical in subsequent quarters. Application in an enterprise of the procedure propounded in this work for indication of a dynamic profitability threshold may increase the enterprise's economic security.

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