Original Article

Econometric forecasts of costs in a sports equipment trading enterprise

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Abstract:

The sport infrastructure in Poland has been dynamically developing after 2000. Sports fields, bike paths, swimming pools, recreation centers are being built in parks and housing estates. There is a great demand for sports equipment. This demand is favored by the sporting successes achieved by Poles in many disciplines. What is more, the wealth level of households has been increasing. The subject of this study will entail the costs incurred by an enterprise selling sports equipment via the Internet. A recursive mechanism will be considered, beginning with the average pay in the enterprise sector in Poland, which is characterized by an increase in the citizens' wealth. The result of the increase in the population's wealth may entail an increase in the sales revenues of the company offering sports equipment. The consequence of the growing revenues will entail a corresponding increase in the company's total costs. This mechanism will be described by an econometric model. The cost forecasts will follow the path of changes in the value of the sales revenue forecasts. They will therefore also result from the assumptions about the future values of the variables generating company revenues. Effective business management requires the use of forecasts. Forecasts of important company characteristics, including sales revenues and prime costs, allow preparation of a system for the upcoming events. An appropriate response to the anticipated costs and revenues may improve the results of the company's operations. The forecasts indicate that revenues higher than costs can be expected only in the fourth quarters of 2019 and 2020. What is noteworthy is the forecasted volume of the revenues from sales in 2020 at the level of just over PLN 361 million, while the forecasted value of costs may reach the amount of 397.5 PLN million. This signifies excessive costs, requiring remedial actions on the part of the management, primarily aimed at reduction of the prime costs. Continuation of the current trends threatens the enterprise with bankruptcy. The forecasts thus should be of a warning nature. It is necessary to undertake measures that will prevent the negative scenario contained in the forecasts from materializing. Corrective actions are therefore becoming an urgent task for the management board.

Key Words: econometric forecasts, costs analysis, trade in sports equipment, recursive prediction

Introduction

The sport infrastructure in Poland has been dynamically developing after 2000. Sports fields, bike paths, swimming pools, recreation centers are being built in parks and housing estates. There is a great demand for sports equipment. This demand is favored by the sporting successes in many disciplines achieved by Poles. Moreover, the wealth level of households has been increasing. Moreover, the wealth level of households has been increasing. In view of the above, it can be expected that the trading companies offering sports equipment can expect a good economic situation. The subject of this study will entail the costs incurred by an enterprise selling sports equipment on the Internet. A recursive mechanism will be considered, beginning with the average pay in the enterprise sector in Poland, which is characterized by an increase in the citizens' wealth. The result of the increase in the population's wealth may entail an increase in the sales revenues of the company offering sports equipment. The consequence of growing revenues will entail a corresponding increase in the company's total costs. This mechanism will be described by an econometric model. Econometric models of costs are constructions not commonly presented in economic literature. In Poland, first such works appeared in the late 1960s. A. Barczak was a pioneer of such research [Barczak A. (1968), Barczak A. (1971), Barczak A., Dziembała L. (1969), Wiśniewski (2010)]. This issue was also addressed by Z. Pawłowski (1976), chapter 8. In the 21st century, more papers on econometric cost analysis appeared [Wiśniewski J. W. (2010), Juszczak M., Zima K., Lelek W. (2019)]. In this paper, the purpose of constructing such an empirical model will entail construction of econometric forecasts of enterprise costs. Availability of cost forecasts can support business management [Dobrodolac T. (2011)], making it more effective.

Materials and methods

The subject of the study entails statistical information on the costs and revenues in an enterprise that sells sports equipment on the Internet, found at: <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 -

2019 was used, found at: <https://wynagrodzenia.pl/gus/dane-kwartalne>. As such, 54 statistical observations from the following quarters were used: from 2006.01 to 2019.02. The company sells online. As a result, the company's clients are located throughout Poland.

The subject of the analysis and the forecasting will entail a recursive sequence:

$$\text{APAY} \rightarrow \text{SALES} \rightarrow \text{COSTS} \quad (1)$$

where:

APAY – the average gross monthly pay in the quarter t ($t = 1, \dots, 54$) expressed in PLN,

SALES – quarterly revenues from the sale of sports equipment, expressed in thousands PLN,

COSTS – quarterly total costs in the enterprise, expressed in thousands PLN.

One fundamental cost factor, indicated in the literature [e.g. Pawłowski (1976), p. 177 et seq.] is the scale of production. The scale of production in commercial enterprises is measured by the sales revenues (SALES). The recursive sequence begins with the average pay in the enterprise sector (APAY), which is a measure of consumer wealth. It influences the volume of the sales revenues, which in turn generate the prime costs in an enterprise. The study will incorporate linear stochastic econometric equations in the following form:

$$y_t = \sum_{j=0}^k \alpha_j x_{tj} + \sum_{i=1}^4 \beta_i y_{t-i} + \sum_{l=1}^4 \sum_{j=1}^k \lambda_{lj} x_{t-l,j} + \alpha_{k+1} t + \sum_{h=1}^3 \gamma_h dq_h + \eta_t, \quad (2)$$

where:

y_t – observations on the dependent variable ($t = 1, \dots, n$),

x_{tj} – observations on exogenous variables,

t – the time variable,

dq_1, dq_2, dq_3 – the dummy variables, taking the value of 1 in the distinguished quarter and 0 in the remaining quarters,

η_t – the random component of the equation,

$\alpha_j, \beta_i, \lambda_{lj}, \dots, \gamma_p$ ($j = 0, 1, \dots, k, i = 1, \dots, 4, l = 1, \dots, 4, p = 1, 2, 3$) – the structural parameters of the equation,

$n = 54$ – the number of statistical observations.

The model's equations will therefore include direct and delayed causal conditions and an autoregression with a trend and seasonal fluctuations. The structural parameters and the stochastic structure of each equation were estimated using the ordinary least squares method. The Student's t -test was used to eliminate statistically insignificant variables.

Empirical equations were used to recursively (chain) estimate the forecasts, in the following order: APAY_{Tp} , SALES_{Tp} , COSTS_{Tp} . The symbol T signifies the forecast periods covering subsequent quarters, starting from 2019: 3 and ending in 2020: 4. The forecasts have been equipped with average forecast errors and relative forecast errors evidencing their accuracy. The forecast admissibility limit was set at $V_G^* = 5\%$. As such, if the relative forecast error V_T^* does not exceed the relative limiting error, the forecasts can be considered acceptable, i.e. sufficiently accurate from the perspective of a forecast user.

Results

The empirical equations describing the variables COSTS, SALES, APAY are presented in Tables 1, 2, 3. Figures 1, 2, 3 show the theoretical values of the respective variables, obtained from empirical equations, as well as their actual values. This allows visual assessment of a given empirical equation's accuracy.

Table 1 Dependent variable (Y): COSTS, observations used 2006:3-2019:2 (N = 52)

Variable	Coefficient	Std. Error	t-Statistic	Prob. p	Significance
const	926.434	2217.43	0.4178	0.6781	
SALES	0.918542	0.0338607	27.1271	<0.0001	***
SALES_1	0.259085	0.124566	2.0799	0.0433	**
SALES_2	0.403237	0.128118	3.1474	0.0029	***
time	152.746	37.1202	4.1149	0.0002	***
COSTS_1	-0.282223	0.134011	-2.1060	0.0408	**
COSTS_2	-0.38526	0.13637	-2.8251	0.0070	***
Mean dependent var.		51637.58	S.D. dependent var.		12635.77
Sum squared resid.		3.63e+08	S.E. of regression		2840.921
R-squared		0.955398	Adjusted R-squared		0.949451
F(6, 45)		160.6528	Prob(F-statistic)		1.08e-28
Log likelihood		-483.5236	Akaike info criterion		981.0473
Schwarz criterion		994.7060	Hannan-Quinn criterion		986.2837
Autocorrel. coeff. (rho1)		-0.021569	Durbin h-statistic		-0.604831

Source: Own calculations using the GRETl package

Source: Own calculations using the GRETl package

Table 2 Dependent variable (Y): SALES, observations used 2007:1-2019:2 (N = 50)

Variable	Coefficient	Std. Error	t-Statistic	Prob. p	Significance
const	-45614.6	25931.3	-1.7591	0.0857	*
APAY_2	29.4293	9.942	2.9601	0.0050	***
EFFECT	52675	6382.34	8.2532	<0.0001	***
time	-1173.48	370.129	-3.1705	0.0028	***
dq2	-7038.51	2657.98	-2.6481	0.0113	**
dq3	-8525.5	2628.13	-3.2439	0.0023	***
SALES_4	0.570512	0.0922924	6.1816	<0.0001	***
Mean dependent var.		52053.16	S.D. dependent var.		12160.37
Sum squared resid.		1.50e+09	S.E. of regression		5897.647
R-squared		0.793587	Adjusted R-squared		0.764786
F(6, 43)		27.55342	Prob(F-statistic)		3.15e-13
Log likelihood		-501.2918	Akaike info criterion		1016.584
Schwarz criterion		1029.968	Hannan-Quinn criterion		1021.680
Autocorrel. coeff. (rho1)		0.060576	Durbin-Watson Stat.		1.821773

Source: Own calculations using the GRETl package

Source: Own calculations using the GRETl package

The equation describing the variable SALES includes the exogenous variable EFFECT, which takes the value of 1 in the fourth quarter of 2018 and zero in other periods. As such, the so-called "peak" effect can be distinguished in this period, resulting from many combined factors (the beginning of the academic year, the effect of holidays and the 500+ program).

Forecasts of the variables forecasted were obtained in accordance with the chain of links between endogenous variables, beginning with $APAY_{Tp}$, through $SALES_{Tp}$, to $COSTS_{Tp}$. It was necessary to follow the rule of sequential forecasting, which resulted from the occurrence of delayed endogenous variables in individual empirical equations. Tables 4, 5 and 6 present forecasts of $APAY_{Tp}$, $SALES_{Tp}$ and $COSTS_{Tp}$, along with their average and relative forecast errors.

Table 3 Dependent variable (Y): $APAY$, observations used 2006:2-2019:2 (N = 53)

Variable	Coefficient	Std. Error	t-Statistic	Prob. p	Significance
const	119.365	66.1884	1.8034	0.0776	*
dq1	-148.018	29.83	-4.9621	<0.0001	***
dq2	-272.605	29.2237	-9.3282	<0.0001	***
dq3	-147.879	29.6455	-4.9882	<0.0001	***
$APAY_{-1}$	1.02051	0.0176928	57.6796	<0.0001	***
Variable	Coefficient	Std. Error	t-Statistic	Prob. p	Significance
Mean dependent var.		3674.000	S.D. dependent var.		616.1007
Sum squared resid.		274019.7	S.E. of regression		75.55623
R-squared		0.986117	Adjusted R-squared		0.984960
F(4, 48)		852.3828	Prob(F-statistic)		6.48e-44
Log likelihood		-301.7963	Akaike info criterion		613.5927
Schwarz criterion		623.4441	Hannan-Quinn criterion		617.3810
Autocorrel. coeff. (rho1)		-0.123281	Durbin h-statistic		-0.905040

Source: Own calculations using the GRETl package

Fig. 3 Empirical and fitted value of variable: $APAY$

Source: Own calculations using the GRETl package

Table 4 Quarterly forecasts of the average monthly pay for the periods of 2019: 3 to 2020: 4

Forecasted period (T)	Forecasts ($APAY_{Tp}$)	Average prediction error (V_T)	Relative prediction error (V_T^*) (%%)	Forecast range at a confidence level of 95%
2019:3	5217.94	75.5562	1.45	(5066.02; 5369.86)
2019:4	5444.34	107.954	1.98	(5227.28; 5661.39)
2020:1	5527.36	133.588	2.42	(5258.76; 5795.96)
2020:2	5487.50	155.866	2.84	(5174.11; 5800.89)
2020:3	5571.55	176.096	3.16	(5217.48; 5925.61)
2020:4	5805.20	194.946	3.36	(5413.23; 6197.16)

Source: Own calculations using the GRETl package

Fig. 4 Quarterly forecasts of the average monthly pay for the periods of 2019: 3 to 2020: 4

Source: Own calculations using the GRETl package

Table 5 Quarterly forecasts of the average monthly sales revenues for the periods of 2019: 3 to 2020: 4

Forecasted period (T)	SALES _{TP}	Average prediction error (V_T)	Relative prediction error (V_T^*) (%)	Forecast range at a confidence level of 95%
2019:3	52378.5	5897.65	11.3	(40484.8; 64272.2)
2019:4	154388	5897.65	3.8	(142494; 166282)
2020:1	69165.5	5897.65	8.5	(57271.7; 81059.2)
2020:2	71571.8	5897.65	8.2	(59678.1; 83465.6)
2020:3	69162.9	6789.94	9.8	(55469.7; 82856.2)
2020:4	186240	6789.94	3.6	(172547; 199933)

Source: Own calculations using the GRETl package

Table 6 Quarterly forecasts of the total costs for the periods of 2019: 3 to 2020: 4

Forecasted period (T)	Forecasts (COSTS _{TP})	Average prediction error (V_T)	Relative prediction error (V_T^*) (%)	Forecast range at a confidence level of 95%
2019:3	55571.3	2840.92	5.1	(49849.4; 61293.2)
2019:4	149011	2951.89	2.0	(143065; 154956)
2020:1	70822.0	3076.92	4.3	(64624.8; 77019.3)
2020:2	78307.1	3126.39	4.0	(72010.2; 84603.9)
2020:3	70516.2	3131.46	4.4	(64209.1; 76823.3)
2020:4	177870	3142.54	1.8	(171541; 184200)

Source: Own calculations using the GRETl package

Fig. 5 Quarterly forecasts of the average monthly sales revenues for the periods of 2019: 3 to 2020: 4

Source: Own calculations using the GRETl package

Fig. 6 Quarterly forecasts of the total costs for the periods of 2019: 3 to 2020: 4

Source: Own calculations using the GRETl package

Discussion

The hypothesis about the reccursiveness of the econometric model of enterprise costs in some of the links has been confirmed, since the revenues are simulataneously significantly affected by the company's revenues (SALES COSTS). There was no simultaneous impact of the average pay on the revenues. The dependence of t is characterized by a delay: an increase in the average pay causes a reaction of the company's revenues after two quarters. The company's costs are positively dependent on the simultaneous and the delayed by 1 and 2 quarters revenues. Negative first- and second-order autoregressions and a positive linear trend occur as well. The equation of costs is characterized by high description accuracy, since R^2 exceeds 0.95.

In the empirical equation describing the variable SALES, it was necessary to introduce the variable EFFECT taking the value of 1 in the fourth quarter of 2018 and 0 in other periods. This resulted from the appearance of an atypical observation with the nature of a positive peak. Without this variable, description accuracy of the sales-revenue equation was low (R^2 was around 0.4). The variable EFFECT caused the sales-revenue equation to be characterized by the R^2 value close to 0.8, resulting in an increase of sales in the fourth quarter of 2018 by PLN 52675000. The volatility of the variable SALES is characterized by a positive fourth-order autoregression, a negative linear trend, and negative seasonal fluctuations in the second and the third quarters. In addition, the average pay delayed by two quarters turned out to be a factor favoring sales.

The equation describing the average pay in the enterprise sector was assumed to be of an autoregressive-trend nature with seasonal fluctuations. It is characterized by the best fit to real data, since R^2 exceeds 0.98. Empirically, the autoregression in the variable APAY has eliminated the positive trend. The value of the first-order autoregression coefficient is about 1.021. This signifies a rapid increase in the average pay, amounting to nearly 2.1% in a given quarter, compared to the pay in the previous quarter. Moreover, statistically significant seasonal fluctuations in the variable APAY appear in each of the four quarters. Seasonal fluctuations in the average enterprise-sector pay add up to zero and individually amount to:

in the first quarter: -5,89 PLN,
in the second quarter: -130,49 PLN,
in the third quarter: -5,75 PLN and
in the fourth quarter: +142,13 PLN.

Particularly, the higher pay in the fourth quarter of the year is conducive to increased purchases of goods and services, including sports equipment.

Empirical equations of the model under consideration are accurate sufficiently. They also possess appropriate stochastic properties, which qualify them to become the predictors enabling estimation of forecasts in the order of the chain of links, i.e. $APAY_{T_p}$, $SALES_{T_p}$ or $COSTS_{T_p}$. It is necessary to only observe the sequentiality of the procedure resulting from the delays of endogenous variables. The $APAY_{T_p}$ forecasts are presented in Table 4 and Figure 4. It can be expected that - while maintaining the current volatility mechanism - the average gross enterprise-sector pay in the fourth quarter of 2020 will exceed PLN 5800 per month. These forecasts are characterized by high accuracy, as evidenced by the magnitude of the relative forecast errors, which ranged from 1.45% in the third quarter of 2019 to 3.36% in the fourth quarter of 2020. They are clearly smaller than the relative limiting error, which was assumed at 5%.

Availability of the $APAY_{Tp}$ forecasts allows estimation of subsequent $SALES_{Tp}$ forecasts, which are presented in Table 5 and Figure 5. When estimating the $SALES_{Tp}$ forecasts, appearance of the peak effect in the fourth quarters of 2019 and 2020 was assumed. This means that the value of the exogenous variable EFFECT in the fourth quarters of 2019 and 2020 was set at the level of 1. This assumption results in the sales-revenues forecasts for the fourth quarters at levels of over PLN 154 million in 2019 and above PLN 186 million in 2020. The $SALES_{Tp}$ forecasts are characterized by precision at a lower level, in relation to the assumed limiting error, exceeding it in the third quarter of 2019 and in the first, the second and the third quarters of 2020. The forecasts in the fourth quarters of 2019 and 2020 turn out to be acceptable. The assumptions at which the forecasts were estimated should be kept in mind though. A change in the assumptions may result in different forecast values and different accuracy.

The consequence of previous assumptions regarding the revenues from the sale of sports equipment will entail the cost forecasts, which are presented in Table 6 and Figure 6. The $COSTS_{Tp}$ forecasts will follow the path of the changes in the $SALES_{Tp}$ forecast values. As such, they will also result from the assumptions about the future values of the variable EFFECT. Five of the six $COSTS_{Tp}$ forecasts are acceptable. The cost forecast for the fourth quarter of 2020 is the most accurate one, with the relative forecast error $V_{2020:4}^* = 1.8\%$. By changing the value assumptions of the variable EFFECT in such a way that in subsequent forecasted periods the variable will assume the values of zero, both forecasts will change: $SALES_{Tp}$, and $COSTS_{Tp}$.

Conclusions

Effective business management requires the use of forecasts. Forecasts of important company characteristics, including sales revenues and prime costs, allow preparation of a system for the upcoming events. An appropriate response to the anticipated costs and revenues may improve the results of the company's operations.

In the case under consideration, many forecast options should be taken into account: $SALES_{Tp}$ and $COSTS_{Tp}$. Analysis of various future scenarios allows preparation, from the company's perspective, for both positive and negative circumstances. In the forecasts presented above, an effect of a shifting the relation of past revenues and costs can be seen. The forecasts indicate that revenues higher than costs can be expected only in the fourth quarters of 2019 and 2020. What is noteworthy is the forecasted volume of the revenues from sales in 2020, at the level of just over PLN 361 million, while the forecasted value of costs may reach the amount of 397.5 PLN million. This signifies excessive costs, requiring remedial actions on the part of the management, primarily aimed at reduction of the prime costs. Continuation of the current trends threatens the enterprise with bankruptcy. The forecasts estimated should therefore be of a warning nature. It is necessary to undertake measures to prevent the negative scenario contained in the forecasts from materializing. Corrective actions are therefore an urgent task for the management board.

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