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MODELING AND FORECASTING FINANCIAL PERFORMANCE OF A BUSINESS: STATISTICAL AND ECONOMETRIC APPROACH

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Abstract

By employing statistical methods, econometric modeling and forecasting financial indices this study attempts to analyze financial performance of a typical Russian company operating in consumer goods industry. Financial data for analysis has been obtained in the statements of the company for 2016-2018 and are presented as monthly time series. The approach to empirical research adopted for this study is a mixed time series methodology based on methods to detect trends and abnormal observations, tests for stationarity, graphical analysis of autocorrelation function and partial autocorrelation function, methods of constructing and assessment of econometric models, and the comparison of forecast capabilities of constructed models. This research offers multiple regression model of dependence of profit on other financial indices. To forecast profit and other indices autoregressive moving average model is also examined in this study. Constructed models were applied to test forecasts of profit. The findings demonstrated the advantages of forecasting based on multifactor linear regression model. The point and interval forecasts for upcoming period are presented. The findings of this study demonstrate that there is no positive dynamics of monthly profit, however, there is no risk of bankruptcy as well. The second major finding was that the negative influence of increased net cost, decreased production and sales volumes could cause the decrease in profit during the period forecasted.

Keywords: Financial performance, profit, econometric model, forecasting, time series.

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1. Introduction

Russian businesses have faced the whole range of challenges: harsh competition, imperfect tax system, financial instability, and risk of bankruptcy. This environment is where a business "bears full responsibility for its activities to its shareholders, employees, banks and investors" (Sakayeva, Iremadze, & Grigorieva, 2010, p. 78). Thus, there is an urgent need for any business to constantly monitor its financial status and the efficient use of its resources.

Monitoring events depend on a business type and on the system of indices that characterize its financial status (Strokovych & Mykolenko, 2018; Dikareva & Kankhva, 2016) or financial resilience (Bidzhoyan & Bogdanova, 2016; Khudyakova & Shmidt, 2015), on bankruptcy probability assessment (Temchenko & Kryshtopa, 2017), on economic sustainability assessment methods (Khudyakova & Shmidt, 2015), and on competiveness assessment (Borodin, 2015), etc.

2. Problem Statement

Profit is the major indicator that characterizes financial result of business activities. Having profit allows a firm to pay its investors and suppliers, to pay taxes, to expand the range of products, and to upgrade its equipment (Sakayeva, Iremadze, & Grigorieva, 2010).

An application of econometric and statistical methods to a thorough analysis of profit could enable a business to adjust its plans and take rational managerial decisions.

This paper analyzes the financial indices of a limited liability company 'Samarsky Trikotazh'. This company is listed in Russian small and medium size company register. The company is listed as a micro business and is seen as a typical company of a consumer goods industry. The core activity of the company is production and wholesale of knitted and jersey goods.

The data for the research in question were taken from financial statements of the company. The indices analyzed illustrate financial resilience of the company. Preliminary statistical analysis allowed us to select the following indices (thousands of rubles): Y- monthly profit, X1 - production price, X2 - general and administrative expenses, X3 - revenue. The data represent monthly time series dynamics for the period from January 2016 to April 2018. Statistics and data were analyzed with MS Excel, Gretl, Eviews software.

3. Research Questions

The research attempts to fulfill the following tasks:

- to carry out preliminary statistical analysis of financial resilience indices;
- to construct econometric models of profit and other indices under research;
- to compare forecasting potential of the models constructed;
- to make a point forecast and an interval forecast of profit for upcoming periods.

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4. Purpose of the Study

The aim of this paper is to construct econometric models of financial resilience indices and to forecast profit through the best selected model. The profit is seen as a financial result of a firm's operational activity.

5. Research Methods

There are a number of studies which utilize different approaches towards economic indices modeling and forecasting. Among others profit indices have been explored. Gadelshina and Aksyanova used multitrend models to forecast profit (Gadelshina & Aksyanova, 2013). Sukhova (2012) explored profit forecasting based on autoregression models and adaptive expectation models. In (Klebanova & Rudachenko, 2015) to forecast bankruptcy adaptive models were used.

The methodological approach taken in this study is a mixed methodology based on time series of selected financial indices: methods for detection trends and abnormal observations, stationarity tests, graphical analysis of autocorrelation function and partial autocorrelation function, methods of econometric models construction, model residuals tests for heteroscedasticity and autocorrelation, and methods for comparison the forecasting resources of econometric models.

6. Findings

The construction of econometric models was preceded with the statistical analysis of all the indices under study.

Analyzing time series of financial indices it is important to identify the pattern of their time dynamics and their development trends.

Time series graph of the indices revealed instability in the dynamics of the changes. Figure 01 illustrates fluctuations of series levels with some marked values. As it can be seen from the graph the monthly profit declined toward the end of 2017 whereas the simultaneous growth in the revenue and net cost was observed. The graph also demonstrates a slight increase in profit in the beginning of 2018.

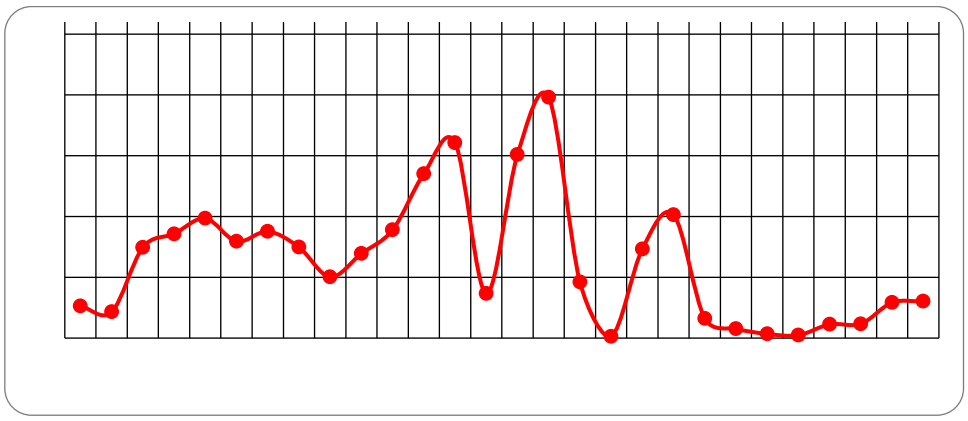

Figure 01. Monthly profit dynamics (*Y, thousands of rubles*) from January 2016 to April 2018

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Foster-Stuart test was applied to reveal the trend of financial indices presence in time series. The results are shown in Table 01. Data from this table demonstrate that there were no indices under study within time series. The absence of positive dynamics within profit (*Y*) and revenue (X_3) time series illustrates stable low pace of the firm's development.

Table 01. Foster-Stuart test results

Variable	***t*-statistic**	**Critical value *t* (0,05; 54)**	**Findings**
Y	1,69	2,00	No trend
X_1	0		No trend
X_2	0,42		No trend
X_3	-0,43		No trend

Source: Authors.

To test the homogeneity of index sets their statistical characteristics were calculated. In comparison to 2016 in 2017 an average monthly profit (*Y*) decreased. From September the values of that index levelled off rapidly. In 2016 the profit was an average 10% of the revenue whereas in 2017 it was only 8%. Thus, starting from February 2016 to April 2018 the company was profitable on average but with no positive dynamics.

The analysis revealed that the *Y* aggregate is not homogeneous during the period under study (in contrast to other aggregates) with the variation coefficient of v = 48, 5%. To improve the quality of data under analysis abnormal observations were revealed on *Y* criteria. For that purpose Irwin methodology was adopted (Trofimenko, Marshalov, Grib, & Kolodeznikov, 2014). The methodology is based on λ_t - statistics concept:

$$\lambda_t = \frac{|y_i - y_{i-1}|}{\sigma_y}, \quad (1)$$

where, y_i - current value of time series under study, y_{i-1} - previous value of time series under study, σ_y - standard deviation of time series under study.

Test values λ_t, were calculated for time series *Y*. Test values were then compared to critical value for n = 28 and for predetermined significance level (λ (0,05; 28) = 1,2). If test value is less than critical value, then the corresponding value is abnormal. Abnormal observations were revealed and replaced with the arithmetic average of two neighboring observations.

After the conversion of *Y* time series the variation coefficient was 41%. Thus, applying Irwin criteria homogenized the aggregate on *Y* (monthly profit).

Testing for time invariance is an essential stage when a time series econometric model is developed. Initial data graphs were analyzed to test the time invariance of indices under study. The graphs of autocorrelation function (ACF) and partial autocorrelation function (PACF) were also studied. The results of augmented Dickey-Fuller test (ADF-test) were considered (Derunova, Ustinova, Derunov, & Semenov, 2016). Table 02 shows experimental values of *t*-statistics from *ADF*-test and corresponding *p*-

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values. There was invariance of time series on their initial levels (all *p*-values are lower than 5% level of significance. Thus, null hypothesis on nonstationarity of time series was rejected.

Table 02. *ADF*-test results on invariance of financial indices time series

Variable	ADF-test, *t*-statistic	*p*-value
Y	-6,63	0,0000
X_1	-3,38	0,0431
X_2	-3,51	0,0156
X_3	-5,74	0,0214

Two types of econometric models were constructed in this study. First, the model was adjusted to the time series of every index. Time series of all indices under study were invariant and were described with autoregression processes and moving average (*ARMA* (*p*,*q*) models were used, where *p* - order of autoregression, *q* - order of moving average) (Sukhanova & Shirnaeva, 2015). To define the possible orders of *p* and *q* ACF and PACF were constructed for time series of every index. The Akaike criterion (AIC) and Schwarz criterion (SC) were also applied. It was concluded that the best models to describe *Y* time series (monthly profit) are autoregression model and first order moving *ARMA* (1,1):

$$Y_t = \delta + \varphi_1 Y_{t-1} + \theta_1 \varepsilon_{t-1} + \varepsilon_t . \quad (2)$$

Time series of other indices are best described with *ARMA* (1,0) model - first order autoregression model:

$$X_{i,t} = \delta + \varphi_1 X_{i,t-1} + \varepsilon_t . \quad (3)$$

In models (2) and (3): Y_t, Y_{t-1}, $X_{i,t}$, $X_{i,t-1}$ - current and lagged values of variables under; δ, φ_p, θ_q - are parameters to estimate; ε_t - random errors of "white noise", $t = \overline{1, 28}$, $i = \overline{1, 3}$.

The results of time series modeling are shown in Table 03.

Table 03. *ARMA* models of indices under study

Variable	Model	Parameter	Parameter estimate	Standard error	*p*-value
Y	*ARMA*(1,1)	δ	61,81	13,05	<0,0001
		φ_1	−0,19	0,04	0,0105
		θ_1	0,79	0,17	<0,0001
X_1	*ARMA*(1,0)	δ	601,52	74,72	<0,0001
		φ_1	0,75	0,12	<0,0001
X_2	*ARMA*(1,0)	δ	215,88	15,11	<0,0001
		φ_1	0,32	0,13	0,0443
X_3	*ARMA*(1,0)	δ	851,47	79,91	<0,0001
		φ_1	0,77	0,11	<0,0001

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Thus, for *Y* index, according to modeling results *ARMA* (1,1) model has the form:

$$\hat{Y}_t = 61{,}81 - 0{,}19\, Y_{t-1} + 0{,}79\, \varepsilon_{t-1}. \quad (4)$$

The constructed *ARMA* models were then applied to forecasting the monthly profit.

Having a good forecasting capability, which their major task is, *ARMA* models do not take into account the influence of external indices. To examine the correlation of monthly profit (*Y*) and financial indices (X_1, X_2, X_3) a multifactor linear regression model was applied:

$$Y = b_0 + b_1 X_1 + b_2 X_2 + b_3 X_3 + \varepsilon. \quad (5)$$

Tentatively, to find and exclude multicollinearity from the model (5) a matrix (Table 04) of paired correlation coefficient of residuals (*e*) in *ARMA* models was generated.

Table 04. Matrix of paired correlation coefficient of residuals in *ARMA* (*p*,*q*) models

	e_Y	e_{X_1}	e_{X_2}	e_{X_3}
e_Y	1			
e_{X_1}	-0,3342	1		
e_{X_2}	-0,1544	0,4432	1	
e_{X_3}	0,3621	0,6289	0,5133	1

Source: Authors.

From the matrix it is apparent that there is no multicollinearity among the explanatory variables (indices X_1, X_2, X_3).

To assess the parameters of the model (5) least squares method (LSM) was applied. The results are shown in Table 05.

Table 05. Model of multiple linear dependency of monthly profit from financial indices (X_1, X_2, X_3)

Variable	**Parameter**	**Parameter estimate**	**Standard error**	***t*-statistic**	***p*-value**
Const	b_0	37,64	44,78	0,84	0,4089
X_1	b_1	-0,96	0,21	-4,57	0,0001
X_2	b_2	-1,13	0,24	-4,71	0,0000
X_3	b_3	0,99	0,23	4,30	0,0003
$R^2 = 0{,}59$					
$F(3, 24) = 11{,}71$					

Thus, the constructed model of monthly profit has the form:

$$\hat{Y} = 37{,}64 - 0{,}96 X_1 - 1{,}13 X_2 + 0{,}99 X_3. \quad (6)$$

According to the simulation results, model parameter estimates are significant at 5% significance level (except the intercept). In general the model is also significant (the experimental value of *F*-statistic,

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equal to 11,71, is higher than critical value $F(0,05; 3; 24) = 3,01$). The coefficient of determination equal to 0,59 demonstrates that an average 59% monthly profit variation is determined by variations in net cost of production, revenue, and general and administrative expenses.

The constructed model shows that one thousand rubles increase in net cost is followed by an average 0,96 thousand rubles decrease in profit; 1 thousand rubles growth of general and administrative expenses decreases monthly profit by 1,1 thousand rubles; the revenue growth increases monthly profit by 0,99 thousand rubles on average.

Regression residuals analysis of the constructed model (6) demonstrated their stationarity (*t*-statistic value of augmented Dickey-Fuller test was - 3,81, *p*-value was 0,0077); no autocorrelation (experimental value *Q*-statistic of Ljung-Box test was 8,05 at *p*-value equal to 0,529) (residuals graphs ACF and PACF are illustrated in Figure 05); no heteroscedasticity (*F*-statistic experimental value of White test was 6,15 at *p*-value equal to 0,6301).

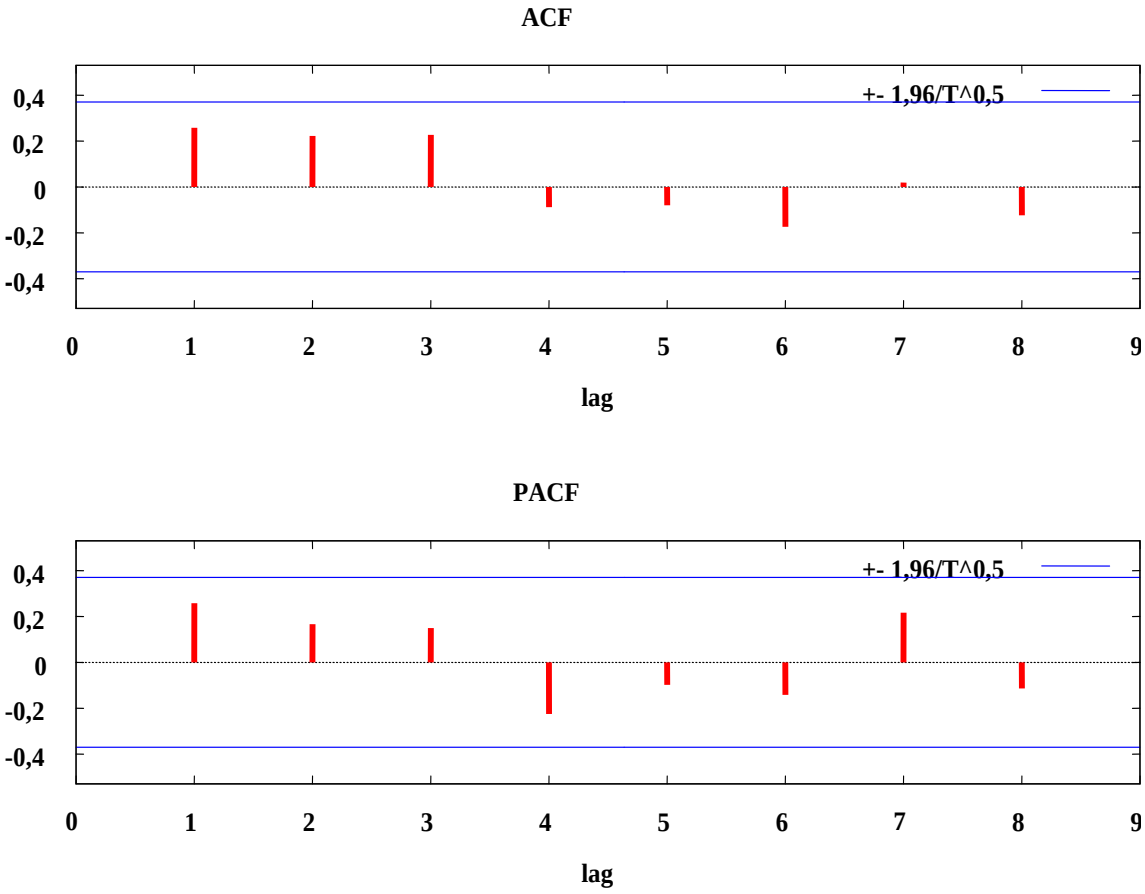

Figure 02. ACF and PACF graphs of residuals in model (6)

Test forecasting of *Y* index within the sample (Sukhanova, Shirnaeva & Mokronosov, 2016) was made to compare the forecasting capabilities of constructed models (4) and (6). Last values $m = 6$ of time series of *Y* index were chosen: Y_{23}, Y_{24},…, Y_{28}. Each model was assessed on the first $(n-m)$ observations ($n = 28$). Then they were applied to find the experimental value $\hat{Y}_{n-m+1}$. Each of both

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models was assessed on the first $(n-m+1)$ observations and the value $\hat{Y}_{n-m+2}$ was tested till the experimental value $\hat{Y}_n$ was found. Figure 06 illustrates the actual values (last six values for the period under study from November 2017 to April 2018), and forecast values for the same period that were found for Y index.

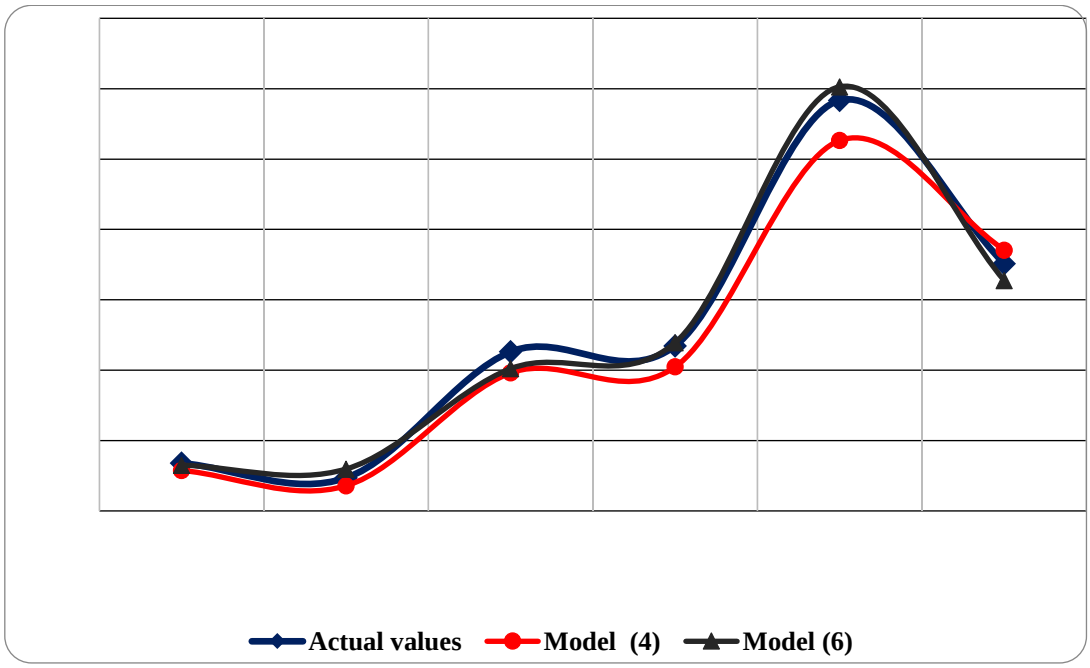

Figure 03. Test forecast for *Y* index (monthly profit, thousands of rubles)
Source: Authors.

To compare the accuracy of forecast among the models tested the mean relative forecast error was calculated:

$$\bar{\varepsilon} = \frac{1}{m}\sum_{t=n-m+1}^{n}\frac{\left|Y_t - \hat{Y}_t\right|}{Y_t}\cdot 100\%,$$

where Y_t , $\hat{Y}_t$ - respective actual and forecast values for Y ($t = \overline{23, 28}$; n = 28; m = 6). The results of calculations demonstrated that the forecast error for model (4) was $\bar{\varepsilon}_{(4)} = 12{,}5\%$, the forecast error for model (6) was $\bar{\varepsilon}_{(6)} = 8{,}9\%$. Minor mistakes made it possible to conclude that models generated have decent forecast capabilities. The preference should be given to forecasting that is based on multifactor linear regression model. It should be noted that practical application capabilities of those models are higher than those of *ARMA* model, which are usually used to forecast and explain a single index.

Constructed multifactor regression model (6) was applied to develop point and interval forecasts (Wilke, 2018) for monthly profit of LLC 'Samarsky Trikotazh' for upcoming months of 2018. The first step of the profit forecast included the calculations of values for X_1, X_2, X_3 indices on *ARMA* model (Table 03).

The findings showed the following profit forecast values for October, November, and December

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2018: $\hat{Y}_{oct} = 56{,}47$; $\hat{Y}_{nov} = 55{,}81$; $\hat{Y}_{dec} = 55{,}16$. 95% confidence intervals for profit were calculated:

$$44{,}13 \le Y_{oct} \le 68{,}81;\ 43{,}41 \le Y_{nov} \le 68{,}23;\ 42{,}68 \le Y_{dec} \le 67{,}66.$$

The current research has revealed that the profit forecasted demonstrated the tendency to decline.

7. Conclusion

The findings of this study demonstrate that there is no positive dynamics of monthly profit, however, there is no risk of bankruptcy as well. The second major finding was that the negative influence of increased net cost, decreased production and sales volumes could cause the decrease in profit during the period forecasted. The research has also shown that the constructed models are reliable and their quality is sufficient to forecast monthly profit and other financial indices.

The research of company financial resilience would be a fruitful area for further work. Several questions still remain to be answered. Methods of assessing bankruptcy probability should be examined with logit models or other binary and multiple choice models.

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