Interval forecast of financial indicators of a company value based on a regression on principal components

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Abstract. The article emphasizes the need to forecast financial indicators in order to assess the value of a company in the interests of its owners and investors. This proves the need for using econometric models to measure quantitative economic interrelations of net profit as the main indicator of cash flow and internal factors of growth. The result of the study is an interval forecast estimate of the net profit of the trading company. The authors propose the construction of the forecast of net profit based on regression on the main components in the conditions of collinearity of regressors - indicators of the financial state of the company. Empirical results are obtained in Gretl's software environment in order to reveal the interrelationships of net profit and growth factors on the basis of specific economic data. The study confirmed the existence of a causal relationship between the net profit of the trading company and the turnover of inventory. In future research it is possible to apply the methodological approach presented in the article to obtain prognostic estimates of profit based on regression with non-financial indicators of the company and environmental factors, taking into account qualitative factors and territorial features of business.

Keywords: forecast, profit, multiple regression, multicollinearity, main components, confidence interval of a forecast

1. Introduction

The value of a company is the main criterion for assessing the effectiveness of the operation from the point of view of owners and managers, as well as potential investors and the state. Scientific publications emphasize that owners are increasingly interested in trends, the possibility of sustainable long-term growth in the value of the proportion of property they own [1, 2, 3]. World practice shows that the most competitive are those enterprises in which the criterion for evaluating the effectiveness of decisions is the further increase in the cost of business [4], the present value of future revenues, which are expected to bring use and possible further sale of property.

Depending on the cost factors that are the main variables in the algorithms, the evaluation methods are divided into methods of profitable, comparative and cost approaches [2, 5, 7]. Each approach is aimed at measuring and evaluating certain cost factors. The methods of the income approach connect the value of the valuation object and the magnitude of future cash flows. In other words, the income approach is the determination of the present value of future cash income, which is expected to bring use and possible further sale of the property. In this case, the calculation can be carried out through projected cash flows or other performance indicators, such as profit and dividends [5, 6]. Undoubtedly, the more the income, brought by the object of valuation, the greater the value of its market value [8]. Therefore, the purpose of the study is to forecast the company's profit as the main indicator of cash flow, identify the internal financial drivers of the company's growth directly associated with measuring net profit. Thus, it is obvious that econometric models should be used that measure the quantitative and qualitative economic interrelationships of gross profit and growth factors on the basis of specific economic data [9, 10, 11, 12]. Since the initial basis for calculating the

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aggregate of financial indicators of the company - regressors of net profit - is financial accounting reporting, the repeated use of its information to obtain various financial coefficients inevitably leads to collinearity of the regressors of net profit [13]. Therefore, in order to eliminate the consequences of collinearity of the regressors, the authors of the article use the method of main components to obtain the forecast model of the company's net profit.

2. Method
To forecast the net profit, we used the quarterly data of the trading company from 2012 to 2017: Y - net profit, thousand rubles; X1 - own capital, thousand rubles; X2 - debt to suppliers, million rubles; X3 - turnover of commodity-material values; X4 - liquid assets, thousand rubles. The classical least squares method was used to construct the initial net profit model, calculate the regression blow-up criterion - VIF for each predictor, then apply regression to the main components for estimating the parameters of the multifactorial linear regression model. The method of principal components under mulcollinearity conditions allows us to replace strongly correlated variables with a set of new variables, between which there is no correlation. In this case, the new variables are linear combinations of the original variables. The principal component method builds linear combinations of variables in order of decreasing their effect on the aggregate variance of the original data. In other words, the first main component is a linear combination of variables with the highest dispersion, the second component is the second largest variance, and so on. For each of the following components, the variance decreases, and the last component has the smallest variance. Dispersions corresponding to components are called eigenvalues. One or more of the last eigenvalues of the matrix are sufficiently small. Therefore, rejecting such main components, we get the opportunity to reduce the dimension of the problem, reduce the number of factors in the model. Comparison of the quality of the initial model and regression estimates for the main components was performed using standard Fisher and Student tests, using the standard model error and the Akayke and Schwartz information criteria. The simulation was performed using the Gretl software package.

3. Results and discussion
Analysis of the linear coefficients of pair correlation of regressors with a dependent variable (Ryxj) showed that net profit has a close direct relationship with the inventory turnover ratio (Ryx3 = 0.939), a moderate direct correlation with equity (Ryx1 = 0.346), liquid assets Ryx4 = 0.439), a weak direct relationship with supplier debt (Ryx2 = 0.122). Linear coefficients of inter-factor correlation (Rxixj) show the presence of a close relationship (collinearity) between regressors: Rx1x2 = 0.880; Rx1x4 = 0.875; Rx2x4 = 0.865. By the classical least-squares method, we perform multi-factor regression estimation for a complete set of factors (Figure 1):

![Figure 1](image-url)
To identify multicollinearity we use the criterion of the regression inflation [1]:

\[ VIF_j = \frac{1}{1 - R^2_j}, \]

where \( R^2_j \) is the coefficient of determination in the partial regression equation for the j-th factor.

### Variance Inflation Factors

Minimum possible value = 1.0
Values > 10.0 may indicate a collinearity problem

| Variable | VIF |
|----------|-----|
| X1       | 6.191 |
| X2       | 8.321 |
| X3       | 2.181 |
| X4       | 8.020 |

\[ VIF(j) = 1/(1 - R(j)^2), \]
where \( R(j) \) is the multiple correlation coefficient between variable \( j \) and the other independent variables

### Properties of matrix \( XX' \):

- 1-norm = 6.7758643e+009
- Determinant = 7.0466635e+021
- Reciprocal condition number = 1.8963134e-011

**Figure 2.** Results of testing model 1 for multicollinearity using the method of inflation factors

As can be seen from Figure 2, the values of VIF (j) that are close to the boundary criterion are for regressors X2 - indebtedness to suppliers; X4 - liquid assets. It seems possible to eliminate correlative regressors in order to eliminate duplication of information. Let’s perform the procedure of successively excluding redundant variables (X1, X2, X4) using a two-way p-value of 0.05.

**Model 2: OLS, using observations 1-21**

| Coefficient | Std. Error | t-ratio | p-value |
|-------------|------------|---------|---------|
| const       | -607.088   | 156.903 | -3.8692 | 0.00103 *** |
| X3          | 1040.56    | 87.4941 | 11.8929 | <0.00001 *** |

| Mean dependent var | 1240.619 | S.D. dependent var | 284.6810 |
| Sum squared resid  | 191948.7 | S.E. of regression | 100.5115 |
| R-squared          | 0.881576 | Adjusted R-squared | 0.875344 |
| F(1, 19)           | 141.4409 | P-value(F)         | 3.01e-10 |
| Log-likelihood     | -125.5626 | Akaike criterion  | 255.1251 |
| Schwarz criterion  | 257.2141 | Hannan-Quinn      | 255.5785 |

**Figure 3.** OLS-estimations of multifactor regression of net profit after the elimination of unnecessary variables.

However, to test the hypothesis of research and forecast the net profit of the trading company in the model, it is advisable to keep the factors X1, X3, X4, (X2 not included as weakly informative). To obtain better prognostic characteristics, to maintain reliability and informative modeling, we will perform a regression on the main components for modeling net profit. We perform z-standardization...
of variables and estimate the main components (Figure 4).

Principal Components Analysis
Eigenanalysis of the Correlation Matrix

Component          Eigenvalue  Proportion   Cumulative
1         2.2386       0.7462       0.7462
2         0.6456       0.2152       0.9614
3         0.1158       0.0386       1.0000

Eigenvectors (component loadings)

|       | PC1      | PC2      | PC3      |
|-------|----------|----------|----------|
| X1    | 0.610    | 0.424    | 0.670    |
| X3    | 0.476    | -0.871   | 0.117    |
| X4    | 0.633    | 0.248    | -0.733   |

Figure 4. Estimations of the main components.

Then we will regress the net profit to the first main component (Figure 5):

Model 3: OLS, using observations 1-21
Dependent variable: Y

|       | Coefficient | Std. Error | t-ratio | p-value |
|-------|-------------|------------|---------|---------|
| const | 1240.62     | 22.7772    | 54.4676 | <0.00001 *** |
| PC1   | 119.132     | 15.5995    | 7.6369  | <0.00001 *** |
| PC2   | -248.08     | 29.0476    | -8.5405 | <0.00001 *** |
| PC3   | 49.072      | 68.5755    | 0.7156  | 0.48396 |

Mean dependent var 1240.619 S.D. dependent var 284.6810
Sum squared resid 185211.7 S.E. of regression 104.3782
R-squared 0.885733 Adjusted R-squared 0.865568
F(3, 17) 43.92470 P-value(F) 3.20e-08
Log-likelihood -125.1874 Akaike criterion 258.3748
Schwarz criterion 262.5529 Hannan-Quinn 259.2816

Figure 5. OLS-estimations on first main component.

However, it is difficult to make a meaningful interpretation of the model with respect to the main components: $Y = 1240.62 + 119.132 (0.610Z₁ + 0.476Z₂ + 0.633Z₃) + e$.

Therefore, it is advisable to move to a multi-factor linear regression model of net profit, containing the initial factors, which is easily amenable to economic interpretation. To determine its coefficients, we apply the transformation:
After the transformation, we obtain a linear model of multifactor regression of net profit, which we use for a point forecast of the profit of the trading company:

\[
Y = 416,873 + 0.021X_1 + 220,757X_3 + 0.787X_4 + e
\]

First, let’s perform a point forecast of each of the factors using the trend equations (Table 1).

### Table 1. Forecast of regressors of the net profit of the trading company

| Indicators      | 01.04.2017            | 01.07.2017            | 01.10.2017            | 01.01.2018            |
|-----------------|-----------------------|-----------------------|-----------------------|-----------------------|
| Own capital (X1)| 6040.6+501.28 *22 = 17068.8 | 6040.6+501.28*2 = 17570 | 6040.6+501.28*4 = 18071.3 | 6040.6+501.28*25 = 18572.6 |
| Turnover (X3)   | 1.0607+0.1391*2 2-0.0052*22^2 = 1.6041 | 1.0607+0.1391*2 3-0.0052*23^2 = 1.5092 | 1.0607+0.1391*2 4-0.0052*24^2 = 1.4039 | 1.0607+0.1391*2 25-0.0052*25^2 = 1.2882 |
| Liquid assets (X4)| 73.319+14,612*2 2=394,783 | 73.319+14,612*3 =409,395 | 73.319+14,612*4 =424,007 | 73.319+14,612*25 =438,619 |

We obtain point forecasts of net profit on the basis of the regression model estimated on the main components:

\[
Y_{22}=416,873+0.021X_1 + 220,757X_3 + 0.787X_4 + e
\]

To expand the information needed to make managerial decisions, we will calculate the forecast interval estimates. Interval forecast is the minimum and maximum values of the result, between which the actual value of the result falls with a predetermined fraction of the probability at the given forecast values of the factors. The interval forecast for a linear function is calculated by the formula:

\[
Y_{np} \pm t_{n-m} \cdot se(Y_{np})
\]

where \( t_{n-m} \) is the table value of Student's t-test for \( df = n-m-1 \) degrees of freedom; \( se(Y_{np}) \) - the average error of the forecasted result value, calculated by the formula

\[
se(Y_{np}) = \sqrt{\frac{\sum e^2}{n-m-1}}(1+X_{np}^T(X^TX)^{-1}X_{np})
\]

where \( X \) is the matrix of the initial values of the factors; \( X_{np} \) is a column vector of predicted values of factors of the form
We will calculate the interval estimates of the forecast of net profit. The vector columns of the predicted values of the factors (according to the data in Table 1) have the form:

\[ \mathbf{X}_{22} = \begin{pmatrix} 1 \\ 17068.76 \\ 1.6041 \\ 394.783 \end{pmatrix}, \quad \mathbf{X}_{23} = \begin{pmatrix} 1 \\ 17570.04 \\ 1.5092 \\ 409.395 \end{pmatrix}, \quad \mathbf{X}_{24} = \begin{pmatrix} 1 \\ 18071.32 \\ 1.4039 \\ 424.007 \end{pmatrix}, \quad \mathbf{X}_{25} = \begin{pmatrix} 1 \\ 18572.6 \\ 1.2882 \\ 438.619 \end{pmatrix} \]

Their transposed recordings are as follows:

\[ \mathbf{X}_{T22} = (1;17068.76;1.6041;394.783) \]
\[ \mathbf{X}_{T23} = (1;17570.04;1.5092;409.395) \]
\[ \mathbf{X}_{T24} = (1;18071.32;1.4039;424.007) \]
\[ \mathbf{X}_{T25} = (1;18572.6;1.2882;438.619) \]

The matrix of the initial values of the factors has the following form:

\[
\mathbf{X} = \begin{pmatrix}
1 & 6730 & 1.352 & 100 \\
1 & 6890 & 1.353 & 110 \\
1 & 6990 & 1.366 & 130 \\
1 & 7010 & 1.398 & 125 \\
1 & 10580 & 1.503 & 150 \\
1 & 10550 & 1.723 & 154 \\
1 & 10830 & 1.729 & 170 \\
1 & 10810 & 1.823 & 200 \\
1 & 10980 & 1.924 & 167 \\
1 & 10980 & 1.956 & 154 \\
1 & 11056 & 2.041 & 289 \\
1 & 11456 & 2.093 & 260 \\
1 & 9595.5 & 2.148 & 258 \\
1 & 10909.5 & 1.894 & 312 \\
1 & 11472.5 & 1.984 & 246 \\
1 & 13014 & 1.923 & 274 \\
1 & 14474.3 & 1.978 & 368 \\
1 & 15893 & 1.954 & 331 \\
1 & 16855.8 & 1.627 & 396 \\
1 & 17785.3 & 1.635 & 375 \\
1 & 17786 & 1.885 & 346
\end{pmatrix}
\]
The inverse matrix to the product of the transposed matrix of the initial values of the factors on the proper matrix of initial values has the form:

\[
(X^TX)^{-1} = \begin{bmatrix}
3.0732 & -0.0001 & -1.5874 & 0.0040 \\
-0.0001 & 1.87E-08 & 1.35E-05 & -6.01E-07 \\
-1.5874 & 1.35E-05 & 1.0578 & -0.0019 \\
0.0041 & -6.01E-07 & -0.0019 & 2.67E-05
\end{bmatrix}
\]

As a result, the product of \((X^TX)^{-1}X_y\) is:

\[
(X^TX)^{-1}X_{22} = \begin{bmatrix}
0.4213 \\
4.68E-06 \\
-0.4140 \\
0.0013
\end{bmatrix}
\]

\[
(X^TX)^{-1}X_{23} = \begin{bmatrix}
0.5811 \\
4.03E-06 \\
-0.5356 \\
0.0016
\end{bmatrix}
\]

\[
(X^TX)^{-1}X_{24} = \begin{bmatrix}
0.7575 \\
3.24E-06 \\
-0.6681 \\
0.0019
\end{bmatrix}
\]

\[
(X^TX)^{-1}X_{25} = \begin{bmatrix}
0.9503 \\
2.32E-06 \\
-0.8116 \\
0.0022
\end{bmatrix}
\]

Product of \(X_{26}(X^TX)^{-1}X_{26}\) equals to:

\[
X_{22}^T(X^TX)^{-1}X_{22} = 0.3556;
\]

\[
X_{23}^T(X^TX)^{-1}X_{23} = 0.4925;
\]

\[
X_{24}^T(X^TX)^{-1}X_{24} = 0.6734;
\]

\[
X_{25}^T(X^TX)^{-1}X_{25} = 0.9067.
\]

The calculation of the residual sum of deviation squares for the linear model of multifactor regression of net profit on the main components is presented in Table 2.

| Date       | Net profit - Y | Theoretical values -Yx | e^2     |
|------------|----------------|------------------------|---------|
| 01.01.2012 | 898            | 935.4553               | 1402.901|
| 01.04.2012 | 795            | 946.7628               | 2303.96 |
| 01.07.2012 | 747            | 967.6177               | 48672.19|
| 01.10.2012 | 739            | 971.0566               | 53850.26|
| 01.01.2013 | 1163           | 1088.901               | 5490.696|
| 01.04.2013 | 1198           | 1139.985               | 3365.704|
| 01.07.2013 | 1245           | 1159.782               | 7262.133|
| 01.10.2013 | 1276           | 1203.723               | 5223.963|
| 01.01.2014 | 1367           | 1203.618               | 26693.52|
| 01.04.2014 | 1325           | 1200.452               | 15512.28|
| 01.07.2014 | 1467           | 1327.057               | 19584.03|
| 01.10.2014 | 1548           | 1324.113               | 50125.21|
| 01.01.2015 | 1595           | 1295.611               | 89634.05|
| 01.04.2015 | 1481           | 1309.63                | 29367.59|
| 01.07.2015 | 1434           | 1289.379               | 20915.12|
The residual variance of the linear model of multifactor regression of net profit on the main components is:

\[ \sigma_{\text{RSS}}^2 = \frac{\sum e_i^2}{n-m-1} = \frac{982636.3}{21-3-1} = 57802.134 \]

The forecast error is:

- 01.04.2017:
  \[ se(Y_{21}) = \sqrt{\frac{\sum e_i^2}{n-m-1}} (1 + X_{21}^T (X^T X)^{-1} X_{21}) = 279.925 \] th. rub.

- 01.07.2017:
  \[ se(Y_{23}) = \sqrt{\frac{\sum e_i^2}{n-m-1}} (1 + X_{23}^T (X^T X)^{-1} X_{23}) = 293.712 \] th. rub.

- 01.10.2017:
  \[ se(Y_{24}) = \sqrt{\frac{\sum e_i^2}{n-m-1}} (1 + X_{24}^T (X^T X)^{-1} X_{24}) = 311.008 \] th. rub.

- 01.01.2018:
  \[ se(Y_{25}) = \sqrt{\frac{\sum e_i^2}{n-m-1}} (1 + X_{25}^T (X^T X)^{-1} X_{25}) = 331.984 \] th. rub.

The table value of Student's t-test with the number of degrees of freedom \( df = 21-3-1 = 17 \) and significance level \( \alpha = 0.05 \) is 2.1098. Consequently, the boundaries of the forecast of net profit as of 01.04.2017 are as follows:

Lower: \( 1440,127 - 279,925 \times 2.1098 = 849,538 \) thousand rubles.
Upper: \( 1440,127 + 279,925 \times 2.1098 = 2,030,717 \) thousand rubles.

The limits of the forecast of net profit in 2017 are indicated in Table 3.

| Forecast boundaries | 01.04.2017 | 01.07.2017 | 01.10.2017 | 01.01.2018 |
|---------------------|-------------|-------------|-------------|-------------|
| Lower               | 849,538     | 821,525     | 783,815     | 736,0455    |
| Upper               | 2030,717    | 2060,883    | 2096,155    | 2136,894    |
| Actual profit       | 856,437     | 834,356     | 865,436     | 912,562     |

Summary.
In the initial model (Figure 1), only the free coefficient and the coefficient of regression at the factor X3 are significant - the turnover of commodity-material values. Regression has a coefficient of determination - R-square, close to 1, regression is significant for the Fisher test (P-value <0.01), and in the Student's test, regression coefficients for regressors X1, X2, X4 - are not significant, i.e. they do not confirm the influence of equity, debt to suppliers, liquid assets on net profit, which in part does not correspond to the results of pair correlations. This situation arose because of the multicollinearity of the regressors. Negative consequences of multicollinearity are inaccurate linear coefficients of
correlation of regressors with a dependent variable - net profit, a decrease in the accuracy of estimates of regression coefficients, an incorrect work of the Student's test when checking the significance of a coefficient with a regressor.

After elimination of collinear regressors (Figure 3) the following model is obtained:

\[ Y_t = -607,093 + 1040,56X_{3,t} + \varepsilon_t \]

Regression has a coefficient of determination - R-square, close to 1, regression is significant in the whole for the Fisher test (P-value (F) <0.01), the coefficient of regression at the factor X3 is significant in the Student's test. Testing the regression residuals for heteroscedasticity in model 2 (White's test) with probabilities of 90%, 95%, 99% confirms the homoscedasticity of the regression residues and compliance with the second prerequisite of MNCs. The information criteria of Akaike, Schwartz and Hennan-Quinn, reflecting the quality of the model under other conditions, are lower in model 2 (Figure 3) than in model 1 (Figure 1), which allows model 2 to be preferred.

The calculation of the main components (Figure 4) showed that the first and second principal components have eigenvalues greater than one and account for 74.6% and 21.5% of the variance of the dependent variable, respectively. Factor loads on components are the coefficients of pair correlation, for the first component it is less than 0.7 for all variables. Hence, it is advisable to build a regression on the first major component. Therefore, in subsequent procedures we use the first component and write for it the regression equation with z-standardized variables:

\[ PC_1 = 0,610Z_1 + 0,476Z_3 + 0,633Z_4. \]

In addition, the correlation analysis of the main components obtained with the dependent variable 'net profit' showed that the main components are not correlated, there is a close inverse relationship with the second main component, a moderate straight line with the first main component. Therefore, we will regress the net profit to the first main component: \[ Y = 1240,62 + 119,132PC_1 + \varepsilon. \]

The linear model of multifactorial regression of net profit on main components, obtained after the transformation of z-standardized variables, is used for a point forecast of the profit of the trading company: \[ Y = 416,873 + 0,021X_1 + 220,757X_3 + 0,787X_4 + \varepsilon. \]

A comparison of the actual net profit received by the company, with point and interval forecast estimates, showed that the actual net profit of the company is covered by an interval estimate (Table 3).

Conclusion.

Thus, the repeated use of financial reporting information to obtain various coefficients of the financial condition of the company - regressors of net profit, inevitably leads to their collinearity. Therefore, when predicting a company's net profit based on multifactor regression on the financial state coefficients, it is necessary to eliminate the consequences of collinearity of the regressors, in particular, using regression on the main components. In future studies, it seems possible to apply the proposed methodological approach to obtain predictive estimates of profit based on regression with non-financial indicators of the company and environmental factors, taking into account the qualitative factors and territorial features of the business.

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