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MONETARY POLICY INDICATORS ANALYSIS BASED ON REGRESSION FUNCTION

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Abstract. This article highlights the effective possibilities for the use of linear regression model to analyze the values of interest rates of standing facilities. In this context, I consider these indicators as dependent variables whose variation is significantly determined by the evolution of the monetary policy interest rate representing the interest rates used for the principal money market operations of the BNR. To emphasize the practical aspects related to the use of linear regression in analyzing the instruments of monetary policy, we have developed a practical study in which we defined the interest rate of the monetary policy in the period 2010-2014 as independent variable. The objectives of this analysis is to determine the function that best describes the relationship of the three indicators, observing the relationship that is established between them and estimating a valid and statistically significant econometric model.

1. Introduction

The linear regression model involves the identification of variables for defining the model and the specification of the residual variable. The purpose of using the regression model is to obtain the parameters corresponding to the set of variables formulated by analyzing the dependence between variables, where data series are recorded at the level of population statistics for a period or a moment, and to highlight the dependence between variables in a given time horizon.

In theoretical analysis, the dependence between variables is stochastic. In such a model, the consideration of the residual variable is required. The other factors that influence the outcome variable are grouped in the residual variable.

The linear regression model is based on data series for the two characteristics. These are represented by vectors x (variable factor) and y (variable outcome).

This requires to define the methods used to estimate the two parameters; to specify the methods used for testing the properties of the regression model estimators and to establish how to use the regression model in making predictions [1, 3].

In defining the linear regression function, four hypotheses are most commonly considered, namely:

– data series are not affected by registration errors.
– for each fixed value of the factor characteristic, the average residual variable is zero, namely:

$$E\left(\varepsilon_i \left| X = x_i \right.\right) = 0, \text{ for any } i. \tag{1}$$

– the lack of correlation between residues indicates that there is no phenomenon of covariance between the residuals, which implies.

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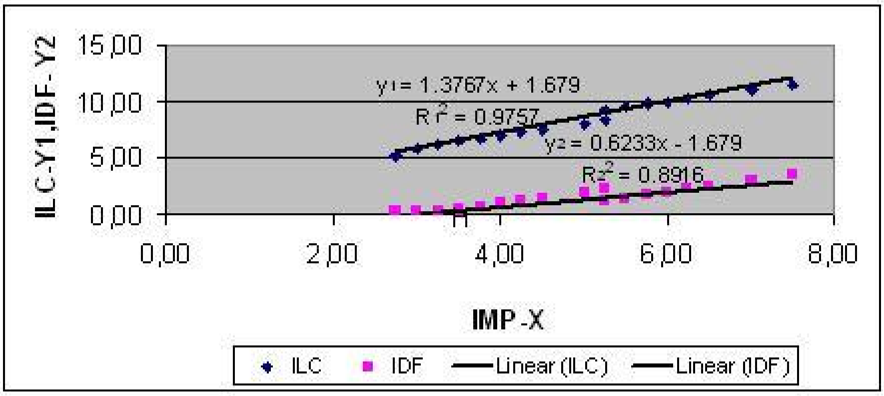


Sursa: BNR, `http://www.bnr.ro/Indicatori-de-politica-monetara-1744.aspx`

FIGURE 1. Correlation between (X, Y_1) and (X, Y_2)

– there is no correlation between the residual and the independent variable, which implies that $cov(X, \varepsilon_j) = 0$, for any j, showing a growth of factor variable values do not automatically lead to an increase of the residual variable values.

Based on the four hypothesis we define linear regression model by function [2]:

$$y_i = ax_i + b + \varepsilon_i, \ i = \overline{1, n}. \tag{2}$$

The purpose of the simple regression is to highlight the relationship between a dependent variable explained (endogenous, outcome) and an independent variable (explanatory factor, exogenous, predictors).

2. Case Study: Monetary Policy Indicators

In order to be able to build a linear regression model, the interest rate of the monetary policy was defined as independent variable, while the standing facilities interest values were considered as the dependent variable.

To determine the parameters of the linear regression model a range of data concerning the evolution of the three indicators of monetary policy was considered.

This study uses three series of data relating to the indicators of monetary policy, namely the monetary policy (IMP), the lending facility (ILC) and the deposit facility (IDF) [4, 5].

To identify the types regression function we performed the plotting of pairs of items that include, on the one hand, the values of monetary policy and the lending facility (X) and, on the other hand, the values of the monetary policy interest (Y_1) and the deposit facility (Y_2).

It can be appreciated that between the monetary policy interest (X), the credit facilities interest (Y_1) and the deposit interest (Y_2), there is a direct and linear connection, respectively

$$Y = a + bX + \varepsilon. \tag{3}$$

Y – Is the dependent variable (explained, endogenous, result)
a – Intercept (constant term)
b – The slope of the regression line
X – Independent variable vector (explanatory exogenous)
ε – A variable interpreted as error.

Based on the graph it is reasonable to assume that the average variable Y depends on X through a linear relationship. From the calculations performed using the linear regression model function we obtain the parameters $a_1 = 1.679$ and $b_1 = 1.3767$, pair for (X, Y_1), and the function of the regression becomes $Y_1 = 1.3767X+1.679$, $a_2 = -1.679$ and $b_2 = 0.6233$ for the pair (X, Y_2), and the function of the regression becomes $Y_2 = 0.6233X - 1.679$.

Using the Excel program/Data Analysis, the following results were obtained [5]:

2.1. **Estimation of Regression Model in Excel.** According to the data resulted after applying the Regression procedure we may say the followings [7]:

Multiple R is the multiple correlation coefficient, in this case, the simple correlation between x and y. Between the X and the Y_1 recorded in the years 2010-2014, there is a direct and very strong connection formulated on the basis of the value of Multiple R (0.99), and between X and Y_2 there is also a direct and very strong Multiple $R = 0.94$.

R Square (is equal to the square of the coefficient of multiple correlation, R^2) is the coefficient of determination, which shows the validity of the model chosen, for an explanation of the variation in Y. It can be expressed as a percentage, as a proportion of the variation in the dependent variable explained by the variation in the independent variable: $97,6\%$ of the variation of Y_1 is explained by the X variable.

Adjusted R Square is a coefficient of determination corrected with degrees of freedom and has the same meaning as R^2.

Standard Error is the standard error which shows the average deviation of the observed values from the theoretical values located on the right side of the regression, (in this case with 0.2586311). The high value to the second power represents the dispersion of the residues.

Observations is n, the number of observations, here $n = 60$.

The ANOVA table represents the analysis of the variance associated with regression estimates. The source of variation shows the decomposition of the total variation in the explained regression change and the residual one (unexplained). For the variant due to the factor x, Regression, the variant residual due to other factors, unregistered, Residual, and the total variance due to all the factors, total, we specify:

- *df* (degrees freedom), degrees of freedom: k - number of explanatory variables x (the simple regression $k = 1$), $n - k - 1$ for residue ($60 - 1 - 1 = 58$ degrees of freedom) and $n - 1$ for total version ($60 - 1 = 59$); Sum *df* for Regression and Residual is equal to the Total *df*: $k + (n - k - 1) = n - 1$.
- SS (short for Square Sum) - the sum of squared deviations, called variances: The total sum of squares = Sum of regression squares + sum of Residual squares.
- MS – average of square sums SS divided to the number of degrees of freedom. The value on the second line (Residual) is the estimate variance for the errors allocation and represents the square of the standard estimation error.

Interpretation of F is required to validate the regression model, [6]; there are 2 assumptions:

H_0: $\alpha_1 = \alpha_2 = \alpha_3 = 0$

H_1: there is at least one nonzero coefficient α_i.

This test refers to all independent variables (H_0 does not refer to the term free), considering that the whole significance of this test verifies regressions.

Significance F - sided probability is critical and the resulting value is lower than the materiality threshold set, then the null hypothesis in favor of the alternative hypothesis; Statistics F test is obtained as a ratio of the average of squared deviations from the average of squared deviations from regression and residue, calculated with the appropriate degrees of freedom.

REGRESSION

SUMMARY OUTPUT			(IMP, ILC)-	(X, Y_1)		
Regression Statistics						
Multiple R	0,987767807					
R Square	0,97568524					
Adjusted R Sq	0,97526602					
Standard Error	0,258631099					
Observations	60					
ANOVA						
	df	*SS*	*MS*	*F*	*Significance F*	
Regression	1	155,6787107	155,67871	2327,382	1,63587E-48	
Residual	58	3,879622643	0,06689			
Total	59	159,5583333				
	Coefficients	*Standard Error*	*t Stat*	*P-value*	*Lower 95%*	*Upper 95%*
Intercept	1,679024362	0,152683958	10,996731	8,16E-16	1,373394217	1,984655
X	1,376723187	0,028537292	48,242951	1,64E-48	1,319599591	1,433847

SUMMARY OUTPUT			(IMP, IDF)-	(X, Y_2)		
Regression Statistics						
Multiple R	0,944241919					
R Square	0,891592801					
Adjusted R Sq	0,889723711					
Standard Error	0,258631099					
Observations	60					
ANOVA						
	df	*SS*	*MS*	*F*	*Significance F*	
Regression	1	31,90787736	31,907877	477,0198	1,14573E-29	
Residual	58	3,879622643	0,06689			
Total	59	35,7875				
	Coefficients	*Standard Error*	*t Stat*	*P-value*	*Lower 95%*	*Upper 95%*
Intercept	-1,679024362	0,152683958	-10,99673	8,16E-16	-1,98465451	-1,373394
X	0,623276813	0,028537292	21,840783	1,15E-29	0,566153217	0,6804

FIGURE 2. Regression model estimation results in Excel

If the test F has a high value and the value corresponding Significance F statistics is low (less than 0.05), the independent variables explain the variation in the dependent variable and vice versa. In this case the value of F is 2327.382 for (X, Y_1) and 477.0198 for (X, Y_2) (are large), and the Significance F is less than 0.05 materiality. It follows that the null hypothesis in favor of the alternative hypothesis H_1, the model is valid.

(IMP, ILC) – (X, Y_1)

Intercept is the name for the free (constant) term of the model, so the coefficient $a_1 = 1.6790244$. The free term is the point where the explanatory variable is 0.

Since statistical $t = 10.996731$, and P - value $8.16E - 16 < 0.05$, it means that this coefficient is significant. The free term of the equation of regression is found with a probability of 95% in the interval: $[1.373394217; 1.984655]$.

The coefficient corresponding to the independent variable, b_1 has a value of 1.3767232 which means that for an increase of X with one unit, Y_1 will increase by 1.3767232. Because the threshold of significance P - value $= 1.64E - 48 < 0.05$ it means that this coefficient is significantly different from zero. The confidence interval for the parameter X is $[1.319599591; 1.433847]$.

From the analysis of the coefficients, we infer that the regression model for (X, Y_1) is:

$$Y_1 = 1.3767X + 1.679 \tag{4}$$

The link between the two variables is straightforward. As we have shown earlier, if X (IMP) increases with one unit, variable Y_1 (ILC) increases by $1,3767$.

(IMP, IDF) – (X, Y_2)

In the case of the (X, Y_2), the free time limit of the model is the coefficient $a_2 = -1.6790244$.

Since the statistical $t = -10.99673$, and P-value $8.16E - 16 < 0.05$, it means that this coefficient is significant. The free term of the equation of regression is to be found with a 95% probability in the interval: $[-1.98465451; -1.373394]$.

The coefficient corresponding to the independent variable, b_2 has the value 0.6232768, which means that at an increase of X with a unit, Y_2 will increase by 0.6232768. Because the threshold of significance P-value $= 1.64E - 48 < 0.05$, it means that this coefficient is significantly different from zero. The confidence interval for the parameter X is $[0.566153217; 0.6804)$.

From the analysis of the coefficients, we infer that the regression model for (X, Y_2) is:

$$Y_2 = 0.6233X - 1.679 \tag{5}$$

The link between the two variables is straightforward. As we have shown earlier, at an increase of X (IMP) with one unit, variable Y_2 (IDF) increases by 0.6233.

Coefficients - contains the estimated values of the coefficients a and b. From the values shown above result the models estimated in the example:

$$Y_1 = 1.3767X + 1.679 \text{ (IMP, ILC)}$$

$$Y_2 = 0.6233X - 1.679 \text{ (IMP, IDF)}$$

The validity of the regression model is confirmed by the values of the F - statistic test (2327.382 and 477.0198 - values much higher than the table level considered to be a landmark in the validity analyses of econometric models) and by the probability of unilateral critical Significance F (1.63587 and 1.14573) higher than $\alpha = 0.05$.

Lower 95%, Upper 95% - the upper and lower limits of the confidence interval for that parameter. The limits to the threshold 0.05 are calculated automatically regardless of the initialization of the regression procedure. It may be interpreted as the parameters of the linear model are included in the following intervals:

$$\begin{aligned}
&1.373394217 < a_1 < 1.984655\\
&1.319599591 < b_1 < 1.433847, \text{ for } (X, Y_1)\\
&-1.98465451 < a_2 < -1.373394\\
&0.566153217 < b_2 < 0.6804, \text{ for } (X, Y_2)
\end{aligned}$$

The study of the residues can be made on the basis of data reported in the tables allocated to residues, with the following structure:

Predicted y - the predicted y value for the respective observation is obtained by substituting the values X of the observation at $Y_1 = 1.3767X + 1.679$ and $Y_2 = 0.6233X - 1.679$, the estimated models. It follows that the sum of the adjusted values is equal to the sum of the values of the empirical Y, which allows us to say that the estimate of the parameters of the regression equations is correct.

Residuals - the value of the prediction error (difference between the observed and predicted value).

Standard Reziduals - standardized error value (obtained by dividing the residue to standard deviation of residues).

2.2. **The Analysis of the Model Quality.** If in the area of the *Output* options for *Residuals* are marked as shown in Figure 3, we obtain theoretical values by the estimated linear model, as well as residuals, as the differences between the observed values of y and these theoretical, estimated values.

The options *Residual Plots* and *Line Fit Plots* lead to the two graphs shown in Figure 3. Based on the shape of the cloud of points, the first leads to the conclusion that there is no correlation between the variable x and residues, which means that the model is well chosen, and the second graph shows the observed and the estimated values (on the regression line) of the dependent variable y.

The points in the figure can be considered in a region of horizontal strip type, which does not contradict the assumptions of normality of errors. The form of uniform strip reflects the constant scattering limits for the entire range of the independent variable X.

To analyze the correlation between the evolution of the monetary policy interest rate and the interest rates of lending and deposit facilities we analyzed data series comprising the interest values of the years 2010 - 2014, processed using Data Analysis Tools in Excel [6].

3. Conclusions

The monetary policy interest rate (IMP) constitutes an extremely important factor for the evolution of the the interest rates of lending (ILC) and deposit facilities (IDF). An increase of the IMP by a monetary unit will lead to an increase of ILC by 1.3767 monetary units and to an increase of IDF with 0.6233.

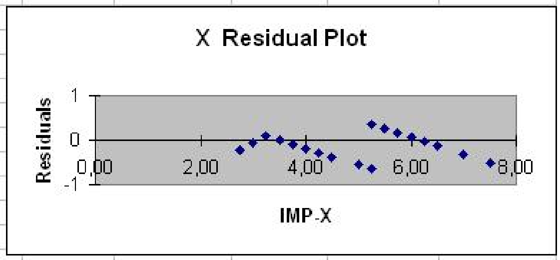
It is noted that the value of the free term is extremely small, which allows us to say that factors that were not considered in the construction of the model show a relatively small influence on the evolution of ILC and IDF.

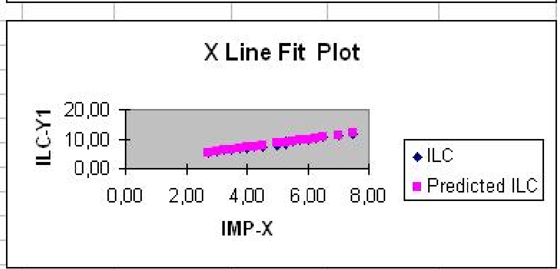
Also, it is noted that the free term a, which can take both positive and negative values, represents the ordinate or is the value of y when x is equal to zero.

The coefficient b - called the regression coefficient - shows the extent to which the dependent characteristic varies if the independent characteristic changes by one unit.

RESIDUAL OUTPUT

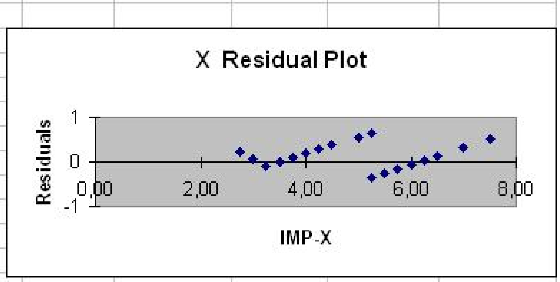
Observation	Predicted ILC	Residuals
1	5,465013126	-0,215013126
2	5,465013126	-0,215013126
3	5,809193923	-0,059193923
4	6,153374719	0,096625281
5	6,153374719	0,096625281
6	6,497555516	0,002444484
7	6,497555516	0,002444484
8	6,497555516	0,002444484
9	6,497555516	0,002444484
10	6,497555516	0,002444484
11	6,497555516	0,002444484
12	6,841736313	-0,091736313
13	7,185917109	-0,185917109
14	7,185917109	-0,185917109
15	7,530097906	-0,280097906
16	7,874278703	-0,374278703
17	7,874278703	-0,374278703
18	8,562640296	-0,562640296
19	8,906821093	-0,656821093
20	8,906821093	-0,656821093
21	8,906821093	0,343178907
22	8,906821093	0,343178907
23	8,906821093	0,343178907





RESIDUAL OUTPUT

Observation	Predicted IDF	Residuals
1	0,034986874	0,215013126
2	0,034986874	0,215013126
3	0,190806077	0,059193923
4	0,346625281	-0,096625281
5	0,346625281	-0,096625281
6	0,502444484	-0,002444484
7	0,502444484	-0,002444484
8	0,502444484	-0,002444484
9	0,502444484	-0,002444484
10	0,502444484	-0,002444484
11	0,502444484	-0,002444484
12	0,658263687	0,091736313
13	0,814082891	0,185917109
14	0,814082891	0,185917109
15	0,969902094	0,280097906
16	1,125721297	0,374278703
17	1,125721297	0,374278703
18	1,437359704	0,562640296
19	1,593178907	0,656821093
20	1,593178907	0,656821093
21	1,593178907	-0,343178907
22	1,593178907	-0,343178907



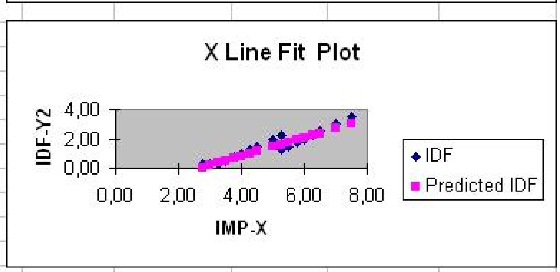


Figure 3. Tables allocated to residues

Depending on the sign of the coefficient of regression, we can appreciate the type of connection: in case of direct correlation, the coefficient has a positive value; in case of inverse correlation, its value is negative; where $b = 0$, it is considered that the variables (x and y) are independent.

In the correlation chart, coefficient b indicates the slope of the straight line.

In this paper we have established a strong link between the interest of monetary policy and two dependent variables – the lending and deposit facilities interest – establishing a model for the evolution of the dependent variables in accordance with the independent variables.

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