The Impact of Financial and Economic Crises on the Performance Indicators of Copper Mining Enterprises

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***Abstract*— The article establishes and characterizes the direction and power of the influence of the cyclical nature of the economy and economic shocks on the performance of activities (characterized by the amount of revenue of companies) of the copper industry. To achieve this purpose the authors solved the following tasks: revealed the cyclical nature of the development of the Russian economy - periods of recessions (financial and economic crises) and booms using the Hodrick-Prescott filter (HP-filter); analyzed the cyclical nature of the corporate economy of the copper industry enterprises using HP-filter and quarterly data of financial statements of PJSC MMC Norilsk Nickel and Uralelectromed JSC from the 1st quarter of 2008 to the 3rd quarter of 2017; determined the power and direction of the influence of indicators of the development of the Russian economy on the performance indicators of the copper industry enterprises, using the results of econometric analysis; interpreted the results of the economic-statistical model.When writing the work the authors used methods of comparative analysis and synthesis of information obtained from various sources. A content analysis of analytical materials from the recent leading domestic and foreign publications has been conducted. The cyclical development of the economy (identification of the financial and economic crisis) was evaluated using the Hodrick-Prescott-method. Statistical data was analyzed (panel data of the enterprises of PJSC MMC Norilsk Nickel and JSC Uralelectromed from Q1 2008 to Q3 2017), and based on the analysis a regression model estimated using the least squares method was compiled. The study concluded that, despite the export orientation of copper industry products — copper cathodes, copper powder, etc. — external state economic shocks directly affect the business performance of copper companies. The findings of the presented work can be applied by the management of metallurgical holdings and individual enterprises of the copper industry for the purpose of theoretical substantiation of corporate development programs, as well as regional executive authorities to identify ways to increase the investment attractiveness of the region.**

Keywords— economic shocks; business performance; copper industry; Least Squares Method; regression analysis; economic-statistical modeling; Hodrick-Prescott filter.

I. INTRODUCTION

The current state of the Russian economy is determined by the negative dynamics or stagnation of a number of macroeconomic indicators: GDP, investment in fixed assets (including foreign direct investment), foreign trade, production and consumption, real wages, etc. Moreover, in the current conditions of low global investment attractiveness, enterprises that provide a significant amount of foreign exchange earnings in the Russian Federation and form a significant amount of the revenue part of the consolidated budget of Russia, are particularly severely affected. These certainly include metallurgical holdings (in particular, enterprises of the copper industry).

Furthermore, the economic downturn of the Russian Federation, along with objective reasons such as the depreciation of the ruble against leading foreign currencies and sanctions pressure, can also be determined by the cyclical nature of the global economy [1].

So, the main goal of this study is to identify the direction and power of the impact of financial and economic crises on the performance indicators of copper industry enterprises, as well as to determine the causes of the identified effect.

The objectives of the research are:

1) to identify the cyclical development of the Russian economy - periods of recessions (financial and economic crises) and booms using the Hodrick-Prescott method (HP-filter);

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2) to analyze the cyclical nature of the corporate economy of the copper industry enterprises using HP-filter and quarterly data of financial statements of PJSC MMC Norilsk Nickel and Uralelectromed JSC from the 1st quarter of 2008 to the 3rd quarter of 2017;

3) to determine the power and direction of the influence of indicators of economic development in the Russian Federation on the performance indicators of copper industry enterprises, using the results of econometric analysis.

4) to interpret the results of economic statistical models.

The authors analyzed the impact of the state of the Russian economy, namely the cycles of economic shocks, on the copper industry. To determine the periods of recessions and progress in the Russian economy, we used the Hodrick-Prescott method (HP filter) [2], which allowed us to identify cyclical components for the variable under study (in other words, cycles).

The authors proposed to express the variable under investigation as the sum of the growth component and the cyclic component:

$$y_t = g_t + c_t, \text{ where } t = 1, 2, \ldots, T \quad (1)$$

where y_t –variable under study for a certain period;

g_t – growth component;

c_t – cyclic component.

Then this method is reflected in the following formula:

$$\min_{g_t}\left\{\sum_{t=1}^{T}(c_t)^2 + \lambda\sum_{t=2}^{T}[(g_t - g_{t-1}) - (g_{t-1} - g_{t-2})]^2\right\} \quad (2)$$

Thus, the variables under study are: GDP (GDP) [3], consumption level (C) [4], government spending (G) [5], investment volume (I) [6]. The data is presented by the Federal Reserve Bank of St. Louis from Q1 2003 to Q4 2016 in rubles. All indicators are seasonally adjusted, that is, the seasonal component is excluded.

II. The Research Method

We applied an HP filter for selected variables using the MATLAB software package. Since in the course of the study, we used quarterly data, the value of the smoothing factor equals λ = 1600. Thus, we obtained cyclic components, which are represented in the graph (Fig. 1).

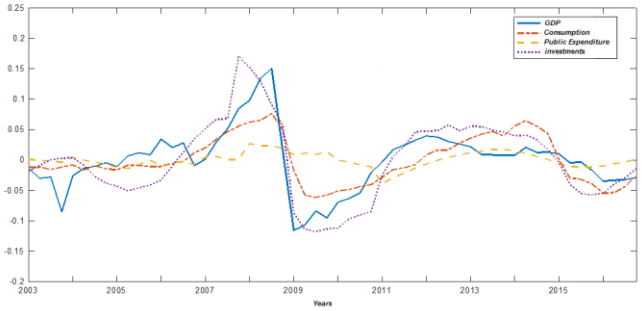

Fig.1. Changes in the cyclical components of GDP, consumption, government spending, and investments in the period from Q1 2003 to Q4 2016.

Based on the presented graph, we see that the most volatile indicator is investment. From 2003 to 2004, an increase was observed, then it fell to almost 5% in 2005. Further, the volume of investments increases sharply and reaches 17% at the end of 2007, and then drops sharply in 2009, which corresponds to the period of the global financial crisis [7]. Since 2010, there has been a gradual recovery to the values of the growth rates of 2014. After that, investments are reduced. A similar indicator is demonstrated in the GDP indicator since the end of 2006. Before 2007, investment and GDP indicators are negatively correlated. Consumption is less responsive to economic shocks, but the dynamics are the same as those of investment and GDP. Since 2009, consumption volumes have been constantly increasing until 2014, after which they have decreased and since the beginning of 2016 they show a positive trend. The decline in consumption in 2014, along with the volume of investment and GDP, is explained by the economic crisis in Russia caused by a sharp drop in oil prices, a fall in the ruble exchange rate and economic sanctions [8]. The least volatile are government spending, whose percentage change is close to zero.

TABLE I. The Matrix of Pairwise Correlations for Cyclical Components of GDP, Consumption, Government Spending and Investment

	GPD	C	G	I
GPD	1.0000	0.7528	0.2042	0.8205
C	0.7528	1.0000	0.5619	0.8789
G	0.2042	0.5619	1.0000	0.3942
I	0.8205	0.8789	0.3942	1.0000

According to Table 1, it can be concluded that the greatest correlation is between GDP and investment indicators, as well as consumption and investment. The least correlated

with each other are GDP and government spending, investment and government spending.

Next, we apply an HP filter to analyze the performance of copper companies. The main financial indicator of the company's performance in this case is revenue. For the analysis, quarterly data were obtained from Q1 2008 to Q3 2017 from the SPARK system for two companies: PJSC MMC Norilsk Nickel and JSC Uralelectromed [9]. For the rest of the industry, quarterly data was not available. Figure 2 shows the revenue dynamics for the two companies and the seasonal adjustment that we applied using the MATLAB program and the stable seasonal filter [10].

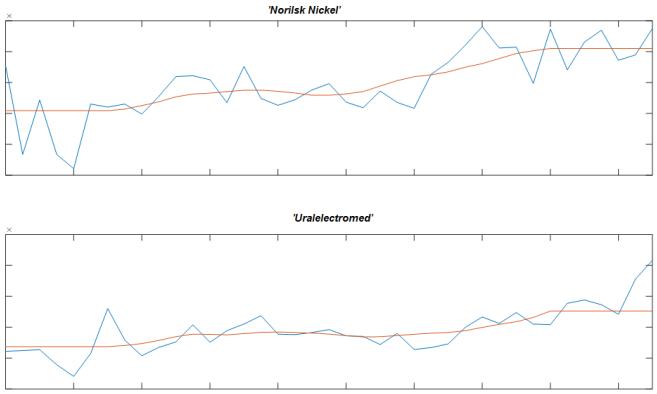

Fig.2. Seasonal adjustment of the revenue of PJSC MMC Norilsk Nickel and Uralelectromed JSC

After applying the HP-filter for the revenue of companies, we obtained the cyclic components presented in Figure 3.

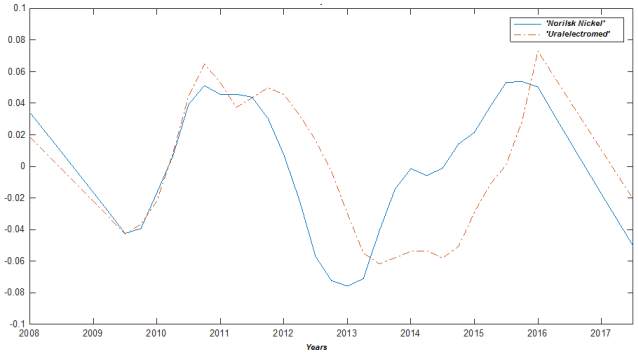

Fig.3. Changes in the cyclical components of the revenue of the companies of PJSC MMC Norilsk Nickel and JSC Uralelectromed in the period from Q1 2008 to Q3 2017.

The graph clearly shows the cyclical nature of the revenue figures of the represented companies. In addition, revenue figures of Norilsk Nickel and Uralelectromed correlate positively; the correlation coefficient is 0.598, which can be explained by a similar reaction to economic shocks. There is almost a 5% decline from the beginning of 2008 to the third quarter of 2009 for both companies. Starting from the third quarter of 2009 to the fourth quarter of 2010, the growth in revenues of Norilsk Nickel is observed to 5%, Uralelectromed - to 6%. Further, starting from the third quarter of 2011, Norilsk Nickel revenue drops by almost 8% in the first quarter of 2013. Since the beginning of 2012, Uralelectromed's revenue has fallen by 6% in the third quarter of 2013. After that, the revenue figures of both companies begin to grow to 5% in the third quarter of 2015 and then, starting in 2016, the values of the indicators drop sharply.

III. Results

The autocorrelation coefficients of the revenue figures, which are presented in table 2, are quite high and indicate that the revenue figures for the previous period strongly influence the current revenue figures.

TABLE II. Autocorrelation Indicators for Cyclical Componenents of revenue Indicators for PJSC MMC Norilsk Nickel and Uralelectromed JSC

Lag	Norilsk Nickel	Uralelectromed
0	1.0000	1.0000
1	0.8695	0.8982
2	0.6117	0.6813
3	0.2899	0.4235

At the next stage of the study, using the methods of econometric analysis, we identified the direction and power of the influence of indicators of the Russian economy on the revenue indicators (Sales) of PJSC MMC Norilsk Nickel and JSC Uralelectromed. For this, we used the following variables: GDP (GDP), US dollar rate at the reporting date (Rate) [11], dummy variable, which corresponds to the periods in which economic shocks were observed (Crisis). We have included an additional variable - investment in fixed assets (Inv), calculated as an increase in the value of fixed assets according to financial statements, as well as the residual value of fixed assets (Assets). Data were also obtained from the SPARK system [9]. Evaluation of regression models was made using the STATA program.

Table 3 presents the matrix of pairwise correlation for indicators of revenue, GDP, investment in fixed assets, dummy variable, fixed assets and the US dollar rate.

TABLE III. The Matrix of Pairwise Correlation for Indicators of Revenue, GDP, Investment in Fixed Assets, Dummy Variable and the US Dollar Exchange Rate

	Sales	GDP	Inv	Crisis	Assets	Rate
Sales	1.0000	0.1967	0.2674	0.0319	0.8871	0.1912
GDP	0.1967	1.0000	0.1906	0.4180	0.3227	0.7533
Inv	0.2674	0.1906	1.0000	0.1281	0.6005	0.2093
Crisis	0.0319	0.4180	0.1281	1.0000	0.1503	0.4908
Assets	0.8871	0.3227	0.6005	0.1503	1.0000	0.2909
Rate	0.1912	0.7533	0.2093	0.4908	0.2909	1.0000

From table 3 it can be seen that the revenue indicator correlates to a greater extent with fixed assets, then with investments. With other indicators, the correlation coefficients are low. This may indicate a nonlinear dependence, so there is a need to bring these indicators to a logarithmic form, the matrix of pairwise correlation of which is presented in Table 4.

TABLE IV. THE MATRIX OF PAIRWISE CORRELATION FOR THE NATURAL LOGARITHM OF REVENUE INDICATORS, GDP, INVESTMENT, DUMMY VARIABLE, FIXED ASSETS AND THE US DOLLAR EXCHANGE RATE

	ln(Sales)	**ln(GDP)**	**ln(Inv)**	**ln(Crisis)**	**ln(Assets)**	**ln(Rate)**
ln(Sales)	1.0000	0.0364	0.7072	0.0142	0.7792	0.0575
ln(GDP)	0.0364	1.0000	-0.0238	0.2490	-0.0063	0.7600
ln(Inv)	0.7072	-0.0238	1.0000	-0.0643	0.9054	0.0106
ln(Crisis)	0.0142	0.2490	-0.0643	1.0000	-0.0400	0.7142
ln(Assets)	0.7792	-0.0063	0.9054	-0.0400	1.0000	0.0120
ln(Rate)	0.0575	0.7600	0.0106	0.7142	0.0120	1.0000

The table shows that the correlation coefficient between revenues and investments has greatly increased compared with the data in table 3. The remaining coefficients are also low. Based on this, for further evaluation, we use the least squares method for panel data and fixed effects, which allow us to take into account the immeasurable individual differences of the companies under study. [12]. In addition, the model is tested for endogeneity, which consists in correlating the errors of the regression model with independent variables ($\mathrm{Corr}(u_{i,t};Xb)$), which indicates the presence of effects unexplained by independent variables. To avoid this problem, instrumental variables are used [12].

The values for revenue indicator with lags in 1, 2 and 3 quarters are as follows: 0.9095; 0.8640; 0.8205. The autocorrelation values are high, which indicates the influence of the previous values of the revenue indicator on the current ones.

Thus, based on the pair correlation matrices, we estimate the following specifications of the regression models: model 1 is represented by equation 3, model 2 by equation 4, model 4 is an estimate of model 1 using the instrumental variable: the logarithm of GDP for the previous period, since this indicator has a high the value of autocorrelation, which can lead to estimations shifts [12]. In addition, we divided the revenue, GDP, investment in fixed assets and fixed assets by the corresponding US dollar rate in order to obtain these figures in dollars. We used models 1-3 with indicators in US dollars, removing the variable 'rate'. These models (4-6) are represented by equations 5-6, respectively. Model 5 is a model 4 using the instrumental variable (which the logarithm of GDP for the previous period). In model 5, we also used this instrumental variable. The results of evaluating the regression model data are presented in Table 5.

$$\ln(Sales)_{i,t} = \beta_0 + \beta_1 \ln(GDP)_t + \beta_2 \ln(Inv)_{i,t} + \beta_3 Rate_t + \beta_4 Crisis_t + u_{i,t} \quad (3)$$

$$\ln(Sales)_{i,t} = \beta_0 + \beta_1 \ln(GDP)_t + \beta_2 \ln(Assets)_{i,t} + \beta_3 Rate_t + \beta_4 Crisis_t + u_{i,t} \quad (4)$$

$$\ln(Sales\,[USD])_{i,t} = \beta_0 + \beta_1 \ln(GDP\,[USD])_t + \beta_2 \ln(Inv[USD])_{i,t} + \beta_3 Crisis_t + u_{i,t} \quad (5)$$

$$\ln(Sales\,[USD])_{i,t} = \beta_0 + \beta_1 \ln(GDP\,[USD])_t + \beta_2 \ln(Assets[USD])_{i,t} + \beta_3 Crisis_t + u_{i,t} \quad (6)$$

where $\ln(Sales)_{i,t}$ – dependent variable, meaning the natural logarithm of the revenue of company i in thousand rubles for the period t, and independent variables:

$\ln(GDP)_t$ – natural logarithm of Russia's GDP (in billions of rubles);

$\ln(Inv)_{i,t}$ – natural logarithm of investment in fixed assets (in thousand rubles);

$Rate_t$ – US dollar exchange rate at the reporting date (in rubles);

$Crisis_t$ – dummy variable denoting a crisis in Russia, where the value 1 corresponds to the crisis period.

β_0 – constant coefficient;

$\beta_1 \dots \beta_4$ – coefficients for independent variables;

$u_{i,t}$ – linear regression errors.

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β_0 – constant coefficient;

$\beta_1 \dots \beta_4$ – coefficients for independent variables;

$u_{i,t}$ – linear regression errors.

TABLE V. RESULTS OF THE EVALUATION OF REGRESSION MODELS 1-6

Variables	Models					
	(1)	*(2)*	*(3)*	*(4)*	*(5)*	*(6)*
GDP logarithm	0.582***	0.852***	0.521***			
	(0.129)	(0.212)	(0.131)			
Investment logarithm	-0.00621		-0.00518			
	(0.00385)		(0.00386)			
US dollar rate	0.00694***	0.00699***	0.00779***			
	(0.00247)	(0.00247)	(0.00246)			
Dummy variable crisis	-0.173***	-0.192***	-0.162***	-0.203***	-0.199***	-0.204***
	(0.0565)	(0.0562)	(0.0562)	(0.0525)	(0.0526)	(0.0517)
Logarithm of fixed assets		-0.204*				
		(0.118)				
Logarithm of GDP in US dollars				0.666***	0.575***	0.715***
				(0.112)	(0.120)	(0.169)
Logarithm of investment in US dollars				-0.00880*	-0.00726	
				(0.00501)	(0.00501)	
Logarithm of fixed assets in US dollars						-0.144
						(0.109)
Constant	11.08***	11.96***	11.61***	9.355***	9.890***	10.97***
	(1.184)	(1.249)	(1.208)	(0.690)	(0.741)	(1.030)
$\mathrm{Corr}(u_{i,t};Xb)$	0.0095	-0.7735	0.0083	-0.0022	-0.0019	-0.6494
The number of observations	72	72	70	72	70	70
R^2	0.521	0.524	0.540	0.536	0.528	0.545

[a.] Standard errors are shown in parentheses

*** – significance at 1% level, ** - significance at 5% level, * - significance at 10% level.

When interpreting the coefficients for the purposes of this study, the fundamental is not its value itself, but only its significance and sign (negative or positive influence). The interpretation of model specifications is presented in table 6.

TABLE VI. INTERPRETATION OF THE COEFFICIENTS OF THE REGRESSION MODEL

Specification		Change	
Dependent variable	***Independent variable***	***in the independent variable***	***in the dependent variable***
Simple	Simple	1 unit	β units
Simple	Logarithmic	1%	β /100 units
Logarithmic	Simple	1 unit	β *100%
Logarithmic	Logarithmic	1%	β %

In model 1, all indicators are significant, except for investments. Moreover, this coefficient is negative. The coefficient for the dummy variable is also negative, which indicates the negative impact of economic shocks on revenue indicators for PJSC MMC Norilsk Nickel and JSC Uralelectromed. The coefficient for the US dollar is positive. This effect may be due to the fact that revenue increased due to the resulting currency difference on contracts. The coefficient for GDP is also positive as the relationship between revenue dynamics and GDP is directly proportional. For model 2, the evaluation results are similar. The coefficient for fixed assets is significant at the 10% level and negative, but because of endogeneity (the correlation between errors and independent variables is -0.77), estimates are shifted, and their interpretation may be erroneous. The inclusion of the instrumental variable in model 3 also gives similar evaluation results. The coefficients in model 4 are significant. Negative coefficient at variable investment (significance at 10% level, independent variables are exogenous) can be explained by the fact that fixed assets also reflect construction in progress, which can adversely affect the revenue figure. In addition, the inclusion of an instrumental variable (model 5) makes this coefficient insignificant. In model 6, the coefficient for fixed assets is insignificant, and independent variables are endogenous.

Next, we conducted a similar econometric analysis using the annual data of the companies in the copper industry from 2007 to 2016. For these purposes, indicators of the financial statements of 87 companies from the SPARK system [9] were used. A matrix of paired coefficients was compiled for the same indicators as in the previous models both for the logarithm and without the logarithm. The data of the matrix is presented in tables 7 and 8.

Values for revenue indicator with lags in 1, 2 and 3 year are as follows: 0.9478; 0.8913; 0.8168. The autocorrelation values are high, which in this case also indicates the influence of the previous values of the revenue indicator on the current ones.

TABLE VII. INTERPRETATION OF THE COEFFICIENTS OF THE REGRESSION MODEL

	Sales	**GDP**	**Inv**	**Crisis**	**Assets**	**Rate**
Sales	1.0000	0.0155	-0.0284	-0.0099	0.8972	0.0038
GDP	0.0155	1.0000	0.0659	0.0365	0.0139	0.7671
Inv	-0.0284	0.0659	1.0000	-0.0298	0.1371	0.0953
Crisis	-0.0099	0.0365	-0.0298	1.0000	-0.0277	0.5440
Assets	0.8972	0.0139	0.1371	-0.0277	1.0000	-0.0010
Rate	0.0038	0.7671	0.0953	0.5440	-0.0010	1.0000

TABLE VIII. THE MATRIX OF PAIR CORRELATION FOR THE NATURAL LOGARITHM OF REVENUE INDICATORS, GDP, INVESTMENT IN FIXED ASSETS, DUMMY CRISIS, FIXED ASSETS AND THE US DOLLAR EXCHANGE RATE

	ln(Sales)	**ln(GDP)**	**ln(Inv)**	**ln(Crisis)**	**ln(Assets)**	**ln(Rate)**
ln(Sales)	1.0000	0.0364	0.7072	0.0142	0.7792	0.0575
ln(GDP)	0.0364	1.0000	-0.0238	0.2490	-0.0063	0.7600
ln(Inv)	0.7072	-0.0238	1.0000	-0.0643	0.9054	0.0106
ln(Crisis)	0.0142	0.2490	-0.0643	1.0000	-0.0400	0.7142
ln(Assets)	0.7792	-0.0063	0.9054	-0.0400	1.0000	0.0120
ln(Rate)	0.0575	0.7600	0.0106	0.7142	0.0120	1.0000

Next, we evaluated models 7-9 using the Least Squares Method. Models are represented by equations 7-9. In model 9, we use the instrumental variable - the logarithm of investment due to the existing endogeneity. Without an instrumental variable, the correlation between remaiders and independent variables is 0.5675. The results of the evaluation of the regression models are presented in Table 9.

$$\ln(Sales)_{i,t} = \beta_0 + \beta_1 \ln(GDP)_t + \beta_2 \ln(Inv)_{i,t} + \beta_3 \ln(Rate)_t + \beta_4 Crisis_t + u_{i,t} \quad (7)$$

$$\ln(Sales)_{i,t} = \beta_0 + \beta_1 \ln(GDP)_t + \beta_2 \ln(Inv)_{i,t} + \beta_3 Crisis_t + u_{i,t} \quad (8)$$

$$\ln(Sales)_{i,t} = \beta_0 + \beta_1 \ln(GDP)_t + \beta_2 \ln(Assets)_{i,t} + \beta_3 Crisis_t + u_{i,t} \quad (9)$$

For all models, the coefficient of GDP is significant, and it is positive, which confirms previous results. For model 7, the remaining coefficients are insignificant. In model 8, we excluded the logarithm of the US dollar due to its insignificance. The coefficient for a dummy variable, meaning a crisis, is significant at the 1% level and is negative, which confirms the negative impact of economic shocks on the revenues of companies in the copper industry. The coefficient for investment is insignificant. For model 9, the results are similar to the results for model 8, the coefficient for fixed assets is not significant.

TABLE IX. THE RESULTS OT THE EVALUATION OF REGRESSION MODELS 7-9

Variables	Model		
	(7)	(8)	(9)
GDP logarithm	2.687***	2.583***	2.465***
	(0.758)	(0.387)	(0.426)
Dummy variable crisis	-0.455	-0.500***	-0.501***
	(0.326)	(0.166)	(0.163)
Logarithm of the US dollar exchange rate	-0.111		
	(0.691)		
Investment logarithm	0.0364	0.0339	
	(0.0574)	(0.0549)	
Logarithm of fixed assets			0.0808
			(0.129)
Constant	-11.50*	-10.68**	-10.37**
	(6.722)	(4.386)	(4.237)
$Corr(u_{i,t}; Xb)$	-0.0171	-0.0240	0.1879
The number of observations	151	151	151
R^2	0.324	0.324	0.345

[b.] Standard errors are shown in parentheses

[c.] *** – significance at 1% level, ** - significance at 5% level, * - significance at 10% level.

IV. DISCUSSION AND CONCLUSIONS

Thus, this paper examined the impact of financial and economic crises on the performance indicators (represented by the company revenue) of the copper industry enterprises.

During the preparation of the article the following results were obtained:

1) using the Hodrick-Prescott-method for the purpose of studying indicators of GDP, consumption level, government spending and investment, cyclical nature of the development of the Russian economy (periods of downturns (financial and economic crises) and booms) was identified. At the same time, it is determined that the most volatile is the investment indicator, the least volatile is public spending, whose percentage change in the study period is close to zero. In addition, it was possible to identify the greatest correlation between GDP and investment, as well as the level of consumption and investment. The least correlated are GDP and government spending, investment and government spending, which is primarily associated with the implementation of long-term government programs;

2) the cyclical nature of the corporate economy of copper industry enterprises using HP-filter and quarterly data of financial statements of PJSC MMC Norilsk Nickel and JSC Uralelektromed from the 1st quarter of 2008 to the 3rd quarter of 2017 was analyzed. In the course of the study, it was possible to identify the cyclical nature of the revenue indicators of the presented companies. In addition, the revenue of Norilsk Nickel and Uralelectromed positively correlated, the correlation coefficient was-0.598, which can be explained by a similar reaction to economic shocks;

3) using the results of the econometric analysis, the authors determined the strength and direction of influence of indicators of development of economy of the Russian Federation on indicators of activity of the enterprises of the copper industry. For this purpose, the following variables were used in the econometric modeling: GDP, the US dollar exchange rate at the reporting date, a fictitious variable corresponding to the periods in which economic shocks were observed, investments in fixed assets, as well as the residual value of fixed assets;

4) the results of evaluation of economic and statistical models are interpreted. At the same time, when interpreting the coefficients for the purposes of this study, its value itself was not fundamental, but only its significance and the sign in front of it, characterizing a negative or positive influence. Thus, it was found that even despite the export orientation of the sales policy of the copper industry and the determination of the value of commodity copper on the London commodity exchange, the performance indicators (revenue) of the copper industry directly depend on the stages of development of the state economy. A similar conclusion was obtained in the analysis using the annual data of 87 companies of the copper industry for the period from 2007 to 2016.

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