

**EXTERNAL FACTORS IMPACT ON THE UKRAINIAN METALLURGICAL ENTERPRISES FINANCIAL EQUILIBRIUM****Tetiana Gudz****ВИПЛИВ ЗОВНІШНІХ ФАКТОРІВ НА ФІНАНСОВУ РІВНОВАГУ МЕТАЛУРГІЙНИХ ПІДПРИЄМСТВ УКРАЇНИ****Тетяна Гудзь**

*Summary.* This paper objective is to construct the economic-mathematical model of external factors impact on the Ukrainian metallurgical enterprise financial equilibrium. The following general scientific and special research methods have been used to achieve the objectives: dialectical approach, induction, deduction, coefficient analysis, taxonomy method, mathematical gnostics, trend analysis. The index of financial equilibrium of metallurgical enterprises of Ukraine is substantiated. It includes the indicators characterizing liquidity of assets, financial stability, profitability of the metallurgical enterprise. The proposed index allows comprehensively assessing Ukrainian metallurgical enterprises financial equilibrium state. The obtained financial equilibrium index is economic-mathematical modeling object. The methodical tool for modeling the impact of monetary and economic factors on the metallurgical enterprises financial equilibrium is created. The developed economic-mathematical model of metallurgical enterprises financial equilibrium index forecasting can be applied with similar studies countries economics in the world. The results of the study have some practical value for metallurgical enterprises financial management improving.

**Keywords:** financial equilibrium, financial health, mathematical gnostics, external factors impact.

**Анотація.** Метою статті є побудова економіко-математичної моделі впливу зовнішніх факторів на фінансову рівновагу підприємства. Досягнення поставленої мети здійснено за допомогою таких загальнонаукових і спеціальних методів дослідження: діалектичного підходу, індукції, дедукції, аналізу коефіцієнтів, методу таксономії, математичного гностичного аналізу, трендового аналізу. Обґрунтований індекс фінансової рівноваги металургійних підприємств України. До складу індексу входять показники, що характеризують ліквідність активів, фінансову стійкість, прибутковість підприємств металургії. Виведений індекс дозволяє комплексно оцінити стан фінансової рівноваги металургійних підприємств України. Отриманий індекс фінансової рівноваги є об'єктом економіко-математичного моделювання. Створений методичний інструмент для моделювання впливу монетарних та економічних факторів ринкового середовища на фінансову рівновагу металургійних підприємств. Розроблена економіко-математична модель прогнозування індексу фінансової рівноваги металургійних підприємств може бути застосована при аналогічних дослідженнях економік держав світу. Результати дослідження мають практичну цінність для удосконалення фінансового менеджменту металургійних підприємств.

**Ключові слова:** фінансова рівновага, фінансове здоров'я, математичний гностичний аналіз, вплив зовнішніх факторів.

**Introduction.** Financial equilibrium reflects enterprise financial health. Financial equilibrium is an object in enterprise financial management functioning mechanism. It's necessary to take into account external factors influence while managing the enterprise financial equilibrium.

Financial equilibrium management at different enterprises issues were studied by some Ukrainian and foreign scientists: I.A. Blank [1], T.E. Unkovskaya [2], N. Abdusalomova [3], A. Bisin, P. Gottardi & G. Ruta [4], S.L. Foo & P. Shaakalya [5], J. Hajek & D. Camska [6].

However, modeling of the enterprise financial equilibrium dependence on external factors has not been properly studied yet. Therefore, our study purpose in this article is to construct economic-mathematical model of relationship between enterprise financial equilibrium and external factors.

**The main chapter.** At fifteen largest Ukrainian metallurgical enterprises the research was conducted. Among them, the most famous are PJSC "ArcelorMittal Kryvyi Rih", PJSC "Nikopol Ferroalloy Plant", PJSC "Dniprovskiy Metallurgical Plant", PJSC "INTERPAIP Nyzhnodniprovskiy Tube Rolling Plant", PJSC "Dniprospsstal", PJSC "EVRAZ Dniprovskiy Metallurgical Plant" and others. Their share in ukrainian manufacturing of metals and metal products had been diminishing during 2004-2016, but it remained significant: 2004 – 40 %, 2015 – 51 %, 2016 – 27 % [7].

Enterprise financial equilibrium is assessed by some indicators. Though, the economic-mathematical model can have only one resulting indicator. There is some need to develop any unified comprehensive indicator for assessing of the enterprise financial equilibrium. We call it an enterprise financial equilibrium index. For its development, we apply taxonomy method.

We have already identified six major indicators of metallurgical enterprise financial equilibrium in a body of this index: the first ( $X_1$ ) and the second ( $X_2$ ) indicators of financial equilibrium, financial leverage in assets ( $X_3$ ) and capital ( $X_4$ ), autonomy factor ( $X_5$ ) and net profit margin ( $X_6$ ) (Table 1).

**Tab. 1: Major indicators for calculating the metallurgical enterprises financial equilibrium index in Ukraine, 2004-2016.**

Symbol	2004	2005	2006	2007	2008	2009	2010	2011	2012	2013	2014	2015	2016
$X_1$	0.92	1.00	0.98	1.00	0.68	0.68	0.58	0.58	0.45	0.42	0.41	0.40	0.64
$X_2$	0.95	1.00	0.99	1.00	0.72	0.70	0.54	0.48	0.50	0.43	0.33	0.15	0.76
$X_3$	0.59	0.56	0.64	0.66	0.59	0.62	0.64	0.72	0.40	0.41	0.47	0.57	0.44
$X_4$	0.67	0.56	0.66	0.67	1.22	1.31	2.02	2.59	1.82	2.27	3.42	9.40	0.91
$X_5$	1.49	1.78	1.52	1.50	0.82	0.76	0.50	0.39	0.55	0.44	0.29	0.11	1.10
$X_6$	7.68	8.71	10.35	12.80	3.00	-7.54	-3.55	-3.54	-9.87	-6.65	-22.04	-16.63	0.54

Source: calculated by the author on the basis of (smida.gov.ua) [8].

The major indicators allow some comprehensive assessment of financial management quality from the perspective of enterprise financial health preservation. Standardized major indicators are displayed in Table 2. The standardization was carried out by ratio between actual and average values of the major indicators.

**Tab. 2: Standardized major indicators for calculating the metallurgical enterprises financial equilibrium index in Ukraine, 2004-2016.**

Symbol	2004	2005	2006	2007	2008	2009	2010	2011	2012	2013	2014	2015	2016
$X_1$	1.37	1.49	1.46	1.49	1.01	1.01	0.87	0.86	0.66	0.62	0.62	0.60	0.95
$X_2$	1.44	1.52	1.51	1.52	1.09	1.07	0.83	0.73	0.76	0.65	0.51	0.23	1.15
$X_3$	1.04	1.00	1.14	1.18	1.05	1.10	1.13	1.27	0.72	0.72	0.84	1.01	0.78
$X_4$	0.32	0.27	0.31	0.31	0.58	0.62	0.95	1.23	0.86	1.07	1.62	4.44	0.43
$X_5$	1.72	2.06	1.76	1.74	0.95	0.89	0.57	0.45	0.64	0.51	0.34	0.12	1.27
$X_6$	1.07	1.21	1.44	1.78	0.42	-1.05	-0.49	-0.49	-1.37	-0.93	-3.07	-2.32	0.08

Source: calculated by the author on the basis of (Table 1).

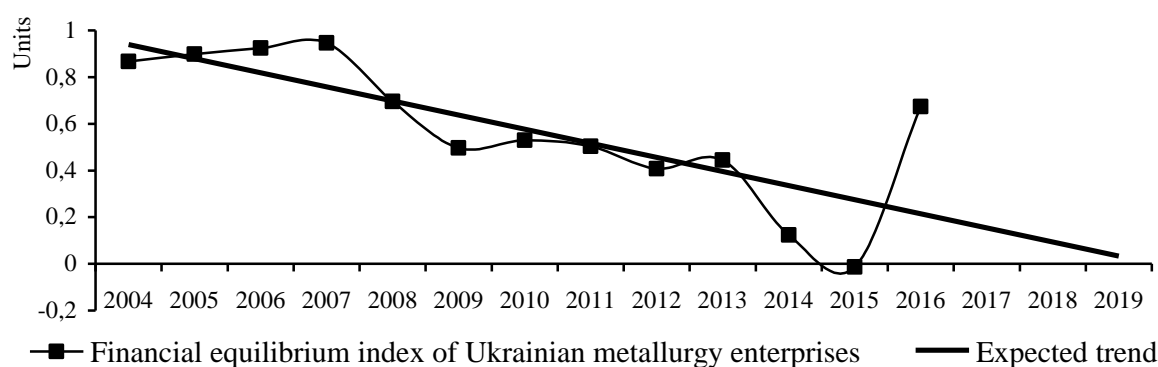
The stages of taxonomy method are successively presented in our article [9, Kartseva, Gudz, 2017, p. 86-87]. Their application on the basis of standardized major indicators allowed to obtain the Ukrainian metallurgical enterprises financial equilibrium index (Table 3).

**Tab. 3: Financial equilibrium index of Ukrainian metallurgy enterprises, 2004-2016.**

Symbol	2004	2005	2006	2007	2008	2009	2010	2011	2012	2013	2014	2015	2016
$I_{FE}$	0.87	0.90	0.92	0.95	0.7	0.5	0.53	0.5	0.41	0.44	0.12	-0.01	0.67

Source: calculated by the author on the basis of (Table 2).

The calculated value of the Ukrainian metallurgical enterprises financial equilibrium index had been fluctuating and displaying general downward trend for the whole study period (Figure 1).



**Fig. 1: Dynamics of the Ukrainian metallurgical enterprises financial equilibrium index within 2008-2016 and its expected trend for 2017-2019.**

Source: made by the author on the basis of (Table 3).

Increase of the Ukrainian metallurgical enterprises financial equilibrium index in 2016 is caused by rising equity, decreasing liabilities and repairing profitability. At the same time, liquidity of Ukrainian metallurgical enterprises is still insignificant. This conclusion is confirmed by stable excess of financial equilibrium second indicator above its first ( $I_{FE1} < I_{FE2}$ ). Besides, the structure of sources of financial resources and their forms of placement at metallurgical enterprises of Ukraine is unbalanced. Besides, Ukrainian metallurgical enterprises capital structure is unbalanced in terms of financial stability loss risk.

We have some excess of the financial leverage in capital over the financial leverage in assets ( $FL > AL$ ). The divergence between two financial leverages is evidence of liquidity and profitability imbalance at metallurgical enterprises in Ukraine. Therefore, it is important for each enterprise to monitor some factors of its financial health.

The researching of external factors impact is the most difficult task in any economic phenomenon study. Enterprise's financial equilibrium isn't an exception.

It is interesting to research the Ukrainian metallurgical enterprises financial equilibrium formation in the short and long term under the influence of following external factors: producer price index by commodity for metals and metal products, inflation, metallurgy export-to-import ratio, average annual discount rate, devaluation (-) or revaluation (+) (Table 4).

**Tab. 4: External factors of the metallurgical enterprises financial equilibrium in Ukraine, 2004-2016.**

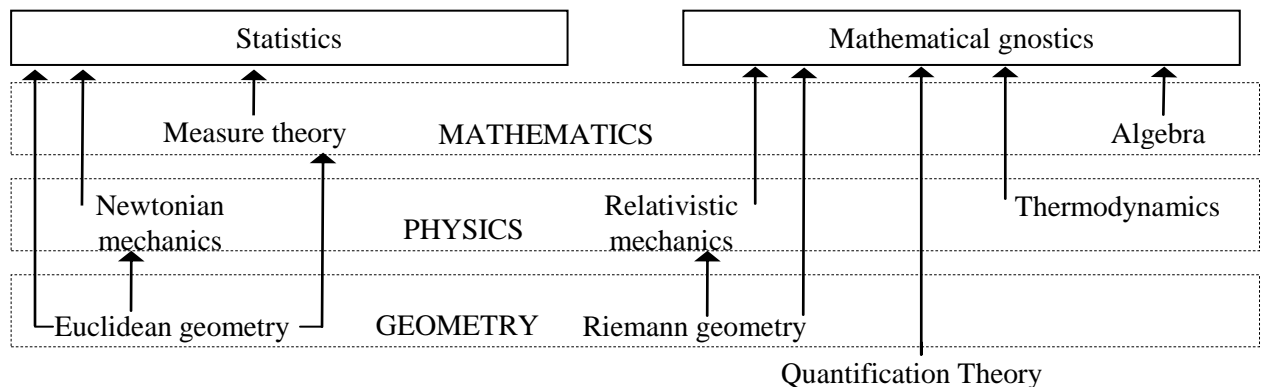
External factor	2004	2005	2006	2007	2008	2009	2010	2011	2012	2013	2014	2015	2016
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Producer price index by commodity for metals and metal products, %	112	98.5	108.9	106.1	86	72.9	113.8	109.9	95.9	94.4	85.3	83	106.3
Inflation, %	112.3	110.3	111.6	116.6	122.3	112.3	109.1	104.6	99.8	100.5	124.9	143.3	112.4
Metallurgy export-to-import ratio, units	7.45	5.69	4.93	4.38	4.32	4.79	4.22	3.94	3.63	3.54	4.58	4.73	3.62
Average annual discount rate, %	7.5	9.2	8.9	8.2	10.7	11.2	8.7	7.75	7.5	7	10.19	25.54	17.77
Devaluation (-) or revaluation (+), %	0.49	4.81	0	0	-52.5	-3.7	-1.81	-0.4	-0.29	-0.03	-32.76	-45.5	-14.63

Source: calculated by the author on the basis of (ukrstat.gov.ua) [7].

The modeling of Ukrainian metallurgical enterprises financial equilibrium taking into account some influence of market economic and monetary factors is carried out on the basis of mathematical gnostics. It has been quite actively used as the unit-factor method in European countries so far. At the same time mathematical gnostics using has been just begun lately for Ukrainian economy research. Mathematical gnostics is an alternative method for processing and evaluating small samples of informative data with some uncertainty based on the use of gnostics theory.

Gnostics theory is the mathematical non-statistical theory of data obtained on the basis of quantification taking into account the uncertainty factor. The economic direction of gnostics theory has got its development through Paul Kovanic's professional activities and his scientific developments (Czech Republic, Prague) [10, Kovanic, 2011]. Figure 2 displays the methodology of mathematical gnostics.



**Fig. 2. Methodology of mathematical gnostics [10, Kovanic, 2011, p. 7-36].**

The mathematical gnostics practical application is realized in the program R shell. The R Project allows for statistical computing using mathematical analysis. R Project is widely used in European and American practice for mathematical modeling of economic processes at micro and macro levels.

The database on metallurgical enterprises in Ukraine (Table 3 & 4) was processed in the R Project to realize our research aim. The following commands were used:

$$R1 < -\text{PredMD}(t(\text{DATES}), \text{Dep} = 6, \text{ww} = 6, \quad (1)$$

$$R2 < -\text{PredMD}(t(\text{DATES}), \text{Dep} = 6, \text{ww} = 8, \quad (2)$$

$$R3 < -\text{PredMD}(t(\text{DATES}), \text{Dep} = 6, \text{ww} = 9, \quad (3)$$

$$R4 < -\text{PredMD}(t(\text{DATES}), \text{Dep} = 6, \text{ww} = 10, \quad (4)$$

$$R5 < -\text{PredMD}(t(\text{DATES}), \text{Dep} = 6, \text{ww} = 11, \quad (5)$$

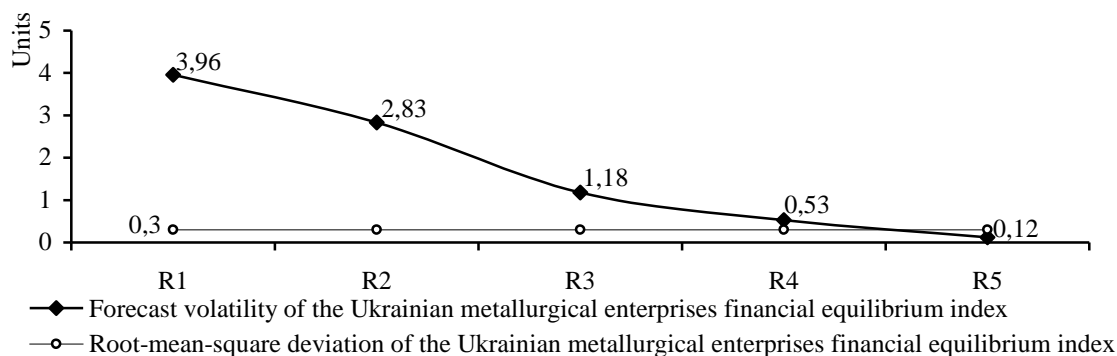
where R1, R2, ... R5 is the modeling option of external factors and the financial equilibrium index depending on the forecasting period from six to two years;

DATES are the names of database (Table 3 & 4);

Dep is the symbol of Ukrainian metallurgical enterprises financial equilibrium index of which is resulting indicator of modeling;

ww is the time period (in years) taken into account for forecasting.

The standard error of each model for the modeling of the financial equilibrium index of metallurgical enterprises of Ukraine under the influence of external factors is shown in Figure 3.



**Fig. 3: Ukrainian metallurgical enterprises financial equilibrium index modeling option statistical characteristic.**

Source: made by the author.

Long-term forecasts are shown by options R1 (for six years), R2 (for five years), R3 (for four years), medium-term forecast – option R4 (for three years), short-term forecast – option R5 (for two years). Figure 3 displays that the longer forecast’s interval, the higher its error. The validity of R1 forecasting model might be in doubt. All the rest modeling options have some permissible error of forecast.

Table 5 displays estimation parameters of external factors impact on the Ukrainian metallurgical enterprises financial equilibrium index in the long and short terms.

**Tab. 5: External factors impact on the forecast of the Ukrainian metallurgical enterprises financial equilibrium index, 2011-2016.**

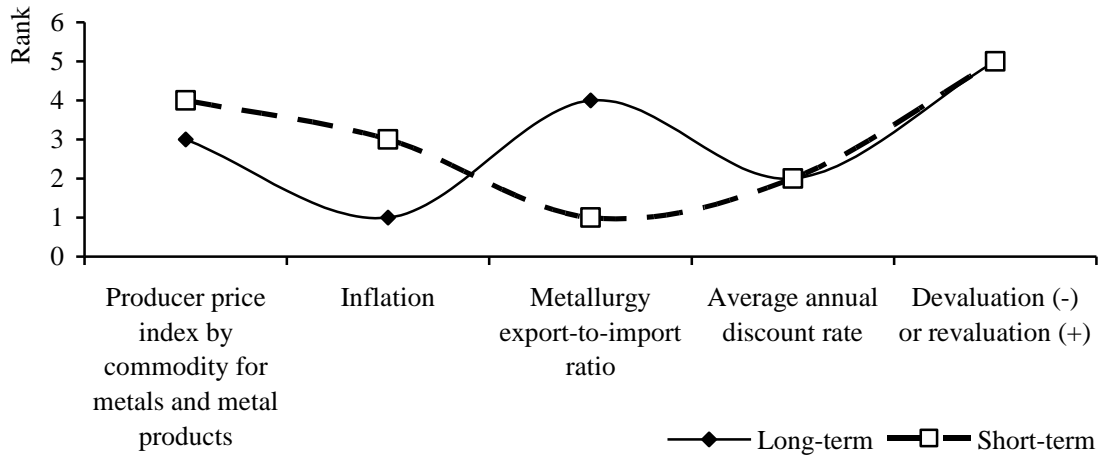
Modeling option	Year	External factors participation in index of financial equilibrium forecast					Forecast of financial equilibrium index
		Producer price index by commodity for metals and metal products	Inflation	Metallurgy export-to-import ratio	Average annual discount rate	Devaluation (-) or revaluation (+)	
R2	2012	-0,9394	3,1884	-0,0332	-1,5561	-0,0006	0,6590
R3	2013	0,3607	-0,5474	0,4283	0,1427	0,0002	0,3844
R4	2014	0,1561	-0,0574	0,4874	-0,1033	0,1522	0,6350
R5	2015	0,1746	-0,3995	0,5273	0,4247	-0,5478	0,1792
R5	2016	0,2457	-0,6667	1,1204	-0,7907	0,1010	0,0098

Source: calculated by the author.

The dates in Table 5 show time change of external factors impact on the forecast of Ukrainian metallurgical enterprises financial equilibrium index. In the long term, the most significant impact is exercised inflation. However, it is true due to moderate and galloping inflation. These types of inflation were alternating each other in the Ukrainian economy during 2004-2016. When the forecast period declines, the primacy in impact on the metallurgical enterprises financial equilibrium will be had the metallurgy export-to-import ratio. Among the external factors of financial equilibrium’s formation the second place was stably fixed for the average annual discount rate. It directly affects enterprise’s liabilities. In the short-term, inflation is inferior to the first-rate and falls to the third place. The producer price index by commodity for metals and metal products ranks the third in the formation of metallurgical enterprise long-term financial equilibrium. In the short-term, it belongs to the fourth place. This fact is due to the long cyclical fluctuations of the producer price index by commodity for metals and metal products

while it is maintaining relative stability in the short term. The impact of Ukrainian currency devaluation on national metallurgical enterprises financial equilibrium is most significant in the biennial forecast. The reason for it is the coherence of the short-term financial cycle, generated by devaluation surges, and the long-term business cycle of metallurgical industry production.

Figure 4 displays external factors ranking by importance of the impact on Ukrainian metallurgical enterprises financial equilibrium index in the long and short terms.



**Fig. 4: External factors ranking by importance of the impact on the Ukrainian metallurgical enterprises financial equilibrium index in the long and short terms.**

Source: made by the author.

Among five forecast variants the most statistically substantiated is the fifth option R5. This model allows you to predict Ukrainian metallurgical enterprises financial equilibrium index for up to two years. The forecast of the option R5 has the least volatility. Its error is substantially less than the error of the resulting factor. Therefore, let us consider the fifth variant of the mathematical modeling in more detail.

The main result of mathematical gnostics is the economic-mathematical model for short-term forecasting of the Ukrainian metallurgical enterprises financial equilibrium index under the impact of economic and monetary factors (Table 6).

**Tab. 6: Statistical characteristic of the economic-mathematical model for short-term forecasting of the Ukrainian metallurgical enterprises financial equilibrium index.**

External factor	Coefficient	Standard deviation of the coefficient	Level of significance of the variable	Mean impact of variable on the resulting factor	Probability value
Producer price index by commodity for metals and metal products, ( $X_1$ )	0,0023	0,0018	95,88	13,05	0,2296
Inflation, ( $X_2$ )	-0,0059	0,0032	114,12	12,54	0,0902
Metallurgy export-to-import ratio, ( $X_3$ )	0,3095	0,0386	4,43	0,62	0,00001
Average annual discount rate, ( $X_4$ )	-0,0445	0,0068	10,44	5,18	0,0001
Devaluation (or revaluation), ( $X_5$ )	-0,0069	0,0016	-12,02	20,86	0,0017

Source: calculated by the author.

On the basis of data in Table 6, we can write the economic-mathematical model (6):

$$Y = 0.0023 \cdot X_1 - 0.0059 \cdot X_2 + 0.3095 \cdot X_3 - 0.0445 \cdot X_4 - 0.0069 \cdot X_5, \quad (6)$$

where Y – financial equilibrium index of Ukrainian metallurgy enterprises.

The model (6) allows you to predict Ukrainian metallurgical enterprises short-term financial equilibrium dependent on changing external factors. The financial equilibrium index of Ukrainian metallurgy enterprises is increasing, while producer price index by commodity for metals and metal products is growing. It is due to the replenishment of equity capital by the net profit. The higher the sales revenue, the greater the net profit. In turn, metallurgical enterprises sales revenue depends on the price index for their product. If the producer price index by commodity for metals and metal products increases by one, the financial equilibrium index of Ukrainian metallurgy enterprises will be grown on 0.0023.

An inflation worsens enterprise financial equilibrium. If the inflation increases by one percent, the financial equilibrium index of Ukrainian metallurgy enterprises will be dropped by 0.0059. The inflation aggravates the disparity of producers and consumers prices of metal products in Ukraine and lowers the price competitiveness of Ukrainian metal producers on the world market.

An excess of Ukrainian metals export above metal products import strengthens our producers' financial equilibrium. If the metallurgy export-to-import ratio grows to one, the financial equilibrium index of Ukrainian metallurgy enterprises will be raised on 0.3095.

The growth of metal producers' liabilities, caused by interest rate's increase, leads to some deterioration of their financial equilibrium. In case when average annual discount rate increases by one, the financial equilibrium index of Ukrainian metallurgy enterprises will be decreased by 0.0445.

The currency instability in Ukraine has some negative impact on metallurgy enterprise financial equilibrium. Ukrainian currency devaluation by one percent causes the decrease of metallurgy enterprises financial equilibrium index by 0.0069.

Let us consider other components of table 6.

Standard deviation of the coefficients shows that the variation of factor  $X_3$  is more than the variation of other factors. It is caused by high volatility of metallurgy export and import in ukrainian real economic instability conditions. Standard deviations of other factors are within the limits of confidence interval. Hence their variations are insignificant, and their significance levels are sufficient.

Mean impact of variable factors on the resulting factor demonstrates three factors having the biggest impact on metallurgy enterprises financial equilibrium. There are devaluation or revaluation ( $X_5$ ), producer price index by commodity for metals and metal products ( $X_1$ ) and inflation ( $X_2$ ).

Column "Probability value" of Table 6 shows probability's evaluation of null hypothesis and indicates its insignificance. So hypothesis expressed by the regression model (6) is a fair.

**Conclusions.** The monetary factors impact on both long-term and short-term financial equilibrium of metallurgy enterprises is stronger in comparison with the economic factors impact.

However, forces correlation in the short term is somewhat shifts to economic factors side. Simultaneously, regardless of business cycle duration, monetary factors may soon cause fluctuations to the detriment of the enterprise financial equilibrium. It testifies that fast-moving monetary factors may unbalance the metallurgical enterprise financial equilibrium faster than economic factors fluctuations. Cyclic financial crises in the state economy are more painful for the financial health of Ukrainian metallurgical enterprises than cyclical economic downturns. That it is true for the modern Ukrainian economy. During 2004-2016 our national economy had been survived three short-term financial crises (2004, 2008, 2014-2015). However, their negative effects have long-term character.

The proposed economic-mathematical model (6) allows you to predict the Ukrainian metallurgical enterprises short-term financial health depending on changes in external factors. It has the following benefits. Firstly, there is some scientific novelty. The new tool for studying the complex interconnections of micro and macroeconomic environment was created. Secondly, the realistic forecast based on model (6) is high. Thirdly, information to calculate factors of this

model is available. Fourth, it is possible to use it to simulate enterprise's financial equilibrium in the short-term perspective by substituting probable values of external factors. Fifthly, the transparency of model (6) opens up some possibility of its application for other countries metallurgical enterprises financial health study. Sixth, the model is easy to use as managers and owners of the enterprise and scientists from different countries.

The limited use of model (6) is due to its narrow specialization. It is designed only for metallurgical enterprises. However, the algorithm for developing model (6) can be implemented for any kind of economic activity enterprises.

The following scientific researches in the field of these problems are related to the development of mathematical gnostics application. In particular, it is interesting to disseminate similar research into the activities of other domestic enterprises. Such scientific research will contribute to improve the information provision quality to enterprise's financial management. It is especially true in preventing the development of the financial crisis at any enterprise.

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