The Impact of Financial Crises on the Development of the Passenger Air Transportation Industry Zok Taking into Account Cyclicity and Forecasting

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Abstract: The scientific article is devoted to the factors of influence of financial crises on development of the passenger air transportation industry based on application of methodological content of cyclical analysis and forecasting. The problem of forecasting financial crises is connected with many factors and reasons influencing occurrence of financial crises. The research is aimed at systematization of the main theoretical provisions of concepts of financial crises within the framework of cyclical analysis and forecasting, including: the main methods allowing to make effective forecasting of crises based on leading indicators are defined; regression modeling of signs of cyclical nature of financial crises is disclosed, which is aimed at determining indicators of early diagnostics and prevention of financial crises. The research used general scientific methods of cognition, economic and statistical methods of information processing, methods of system, comparative, functional and factor analysis with construction of analytical models based on synthesis of modern scientific methods of cognition of economic processes. Representativeness of the information base allows to characterize it as a reliable basis for an integrated approach to development of the system of early forecasting of financial crises.

1 INTRODUCTION

Assumptions about the cyclical development of life processes have an evolutionary content of development. Many scientists have attempted to identify patterns and calculate the periods of recurrence of certain events.

Thus, in the 18th century, the French scientist Francois Quesnay developed a methodology for repeating production processes. But at that time, a crisis was considered a sign of a socio-economic shock, and not as part of the cyclical development of the economy. From the point of view of the cyclicality of economic crises, the first to determine the length of economic cycles was the French scientist and physicist Juglar in the mid- 19th century. He determined that the average duration of an economic cycle is 9 years.

the 1920s, Russian economist Nikolai Dmitrievich Kondratiev defined the so-called “long cycles” – large economic cycles lasting 48-55 years, which are explained by the fact that, on average, revolutionary discoveries occur with such frequency, which lead to serious economic upheavals. For his calculations, Kondratiev studied huge arrays of statistical data on economic indicators of different countries. The wave consists of two phases: upward and downward. The upward phase is characterized by active growth and development of the economy with short-term minor declines. During the downward phase, there is an economic downturn, a deep crisis, and wars. Kondratiev believed that the basis of such cyclical fluctuations is the organization of the

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capitalist system, which gives rise to uneven distribution of capital (Kunaeva, 2023).

In modern economic theory, the following types of economic cycles are distinguished (Fig. 1), which can be classified by duration into: short (Kitchin cycles); medium (Juglar cycles and Kuznets cycles); long (Kondratiev cycles).

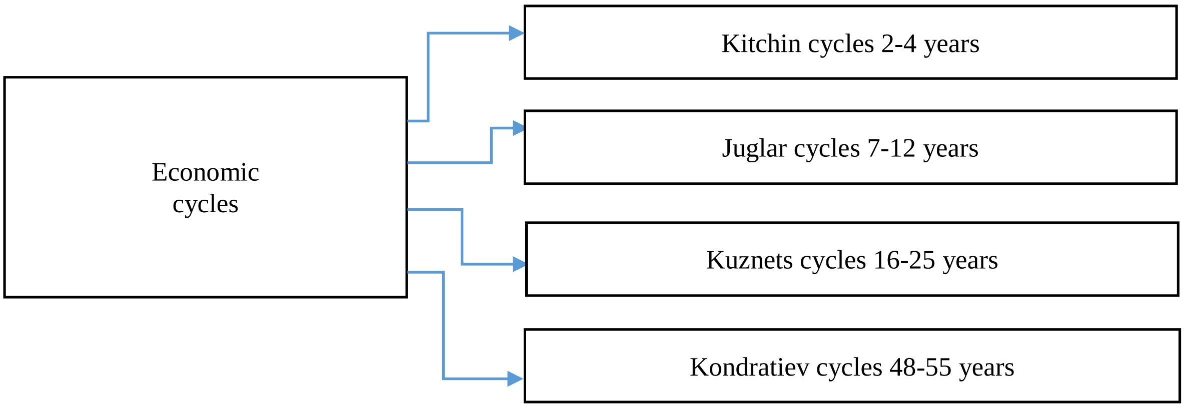

Figure 1: Main types of economic cycles (Isakova, 2015; Lukasevich, Fedorova, 2022).

2 RESULTS AND DISCUSSUON

For the purposes of detailed analysis, the authors of the study presented analytical data on the fall of the Dow Jones index and the RTS index by year, which were summarized in Table 1 to analyze the dependence of the decline in indices on the time intervals between crises, demonstrating the evolutionary content of volatility.

Table 1: The magnitude of the fall of the Dow Jones index and the RTS index.

Year	Dow Jones Index Falls	RTS index falls	Time interval between crises, years
1926	-16%		
1932	-89%		6
1942	-52%		10
1949	-22%		7
1953	-13%		4
1958	-20%		5
1962	-28%		4
1966	-26%		4
1970	-37%		4
1974	-46%		4
1978	-27%		4
1982	-24%		4
1987	-41%		5
1990	-22%		3
1994	-12%		4
1998	-21%	-93%	4
2002	-39%	-34%	4
2008	-54%	-80%	6
2015	-16%	-73%	7
2020	-38%	-51%	5
2022	-22%	-68%	2
Average value	-32%	-66%	4.8

The average time interval between crises for the period from 1926 to 2022 was 4.8 years. Economic cycles with a drop in the Dow Jones index by more than 40% were 10, 34, 13 and 21 years. It can also be noted that the fall in the RTS index is on average more than 2 times higher than the fall in the Dow Jones index during crises (Fig. 2). At the same time, before the crisis of 2022, there was a correlation between the indices. It can also be noted that a strong economic downturn is preceded by a rapid growth of the indices, and a dependence can be derived: the stronger the growth, the stronger the fall.

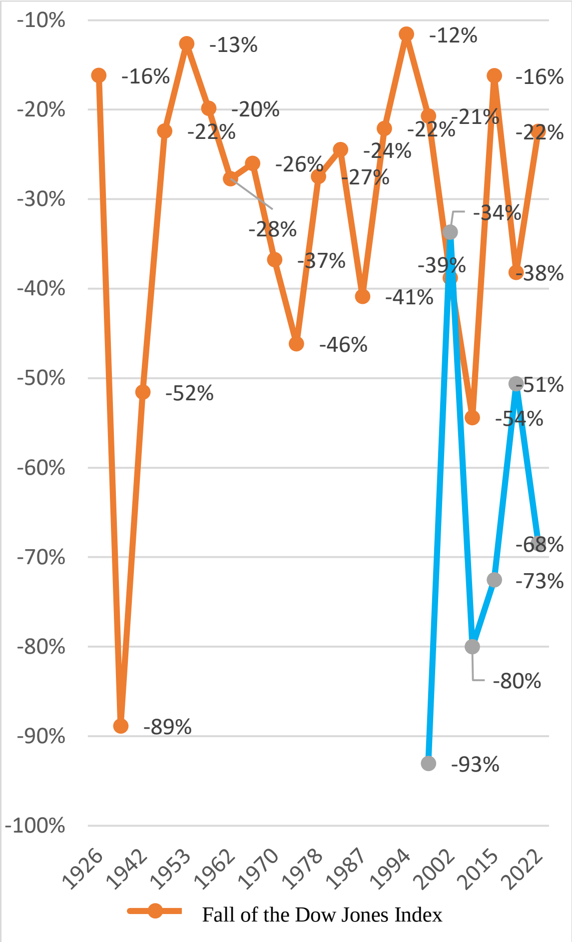

Figure 2: Fall of the Dow Jones Index and the RTS Index.

Based on the conducted research, it can be concluded that with the help of short economic cycles it is possible to forecast future crises quite accurately with a minimum error. Geopolitical factors and wars often interfere with forecasting with the help of longer economic cycles. They introduce a fairly large error, interrupting a long economic cycle and creating a strong financial crisis.

The main problem with global financial crises is that they have a significant impact on many sectors of the economy. One of them is the passenger air transportation industry. For comparative analysis, data on changes in the number of transported passengers (passenger flow) and passenger turnover by year with changes in the Moscow Exchange index were studied (Table 2).

Table 2: Passenger air transportation and the Moscow Exchange index .

Year	Passenger transportation by air, million people	Passenger turnover by air transport, billion passenger-kilometers	Moscow Exchange Index
2002	28	64.7	319
2003	31	71.1	515
2004	35	83	552
2005	37	85.8	1011
2006	40	93.9	1693
2007	47	111	1889
2008	51	122.6	620
2009	47	112.5	1370
2010	59	147.1	1688
2011	66	166.8	1402
2012	76	195.8	1475
2013	86	225.2	1504
2014	95	241.4	1395
2015	94	226.8	1761
2016	91	215.6	2232
2017	108	259.4	2153
2018	118	286.9	2371
2019	131	323	3059
2020	71	153.5	3306
2021	112	243.3	3825
2022	95	228	2157
2023	105	264.7	3100

The graph shows that, in general, the Russian passenger air transportation industry correlates with the Moscow Exchange index in terms of direction, but at the same time does not repeat it in terms of the level of decline during crisis periods, and there are also temporary shifts in the peaks of decline (Fig. 3).

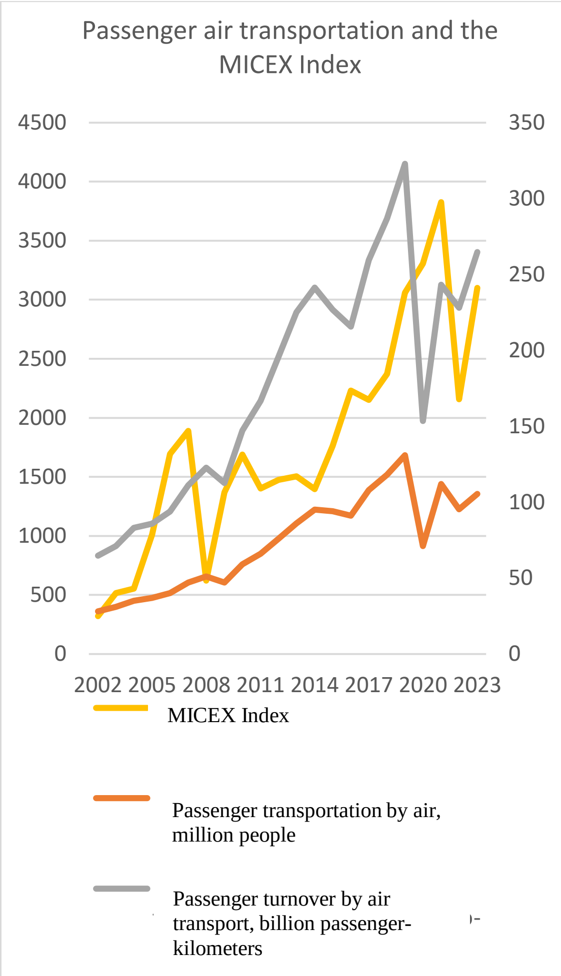

Figure 3: Passenger transportation and the Moscow Exchange Index.

The largest decline in the passenger air transportation industry occurred in 2020 by 45.8% - during the crisis caused by COVID -19 (Table 3). At the same time, the Moscow Exchange index did not show a decline at the end of the year, unlike other financial crises - 2008-2009, 2014-2015 and 2022, when there was a high correlation between the index and the industry, and the index fell more than the passenger air transportation industry.

Table 3: Changes in passenger air transportation and the Moscow Exchange index.

Year	Change in the number of passengers carried by air transport, %	Change in passenger turnover by air transport, %	Change in the Moscow Exchange Index, %
2003	10.7%	9.9%	61.4%
2004	12.9%	16.7%	7.3%
2005	5.7%	3.4%	83.1%
2006	8.1%	9.4%	67.5%
2007	17.5%	18.2%	11.5%
2008	8.5%	10.5%	-67.2%
2009	-7.8%	-8.2%	121.1%
2010	25.5%	30.8%	23.2%
2011	11.9%	13.4%	-16.9%
2012	15.2%	17.4%	5.2%
2013	13.2%	15.0%	2.0%
2014	10.5%	7.2%	-7.3%
2015	-1.1%	-6.0%	26.3%
2016	-3.2%	-4.9%	26.7%
2017	18.7%	20.3%	-3.5%
2018	9.3%	10.6%	10.1%
2019	11.0%	12.6%	29.0%
2020	-45.8%	-52.5%	8.1%
2021	57.7%	58.5%	15.7%
2022	-15.0%	-6.3%	-43.6%
2023	10.7%	16.1%	43.7%

During the 2020 crisis, having suffered huge losses, airlines were forced to restructure their business models taking into account the specifics associated with the regional heterogeneity of the aviation infrastructure, external restrictions on mobility and sanitary and epidemiological safety. A transition was made to a multi-level route network, the development of regional hubs accelerated, and the range of services was expanded to attract new consumer groups (Fokeev, 2022).

On the one hand, the restrictions imposed by the state have significantly reduced passenger traffic in the passenger air transportation industry. At the same time, based on applications received by Rosaviatsia from most airlines, a positive decision was made to provide subsidies to cover the costs of commercial transportation performed from February to June 2020.

The Federal Air Transport Agency was allocated 23.4 billion rubles from the reserve fund of the Russian Federation to provide subsidies to Russian airlines for partial compensation of expenses. In 2021, a measure to stimulate domestic tourism and passenger demand was in effect. According to the Decree of the Government of the Russian Federation of July 14, 2021 No. 1176, a subsidy was introduced to compensate for losses in income arising from the establishment of benefits on fares for family travel by air passengers.

As a result of the measures taken, as well as the partial lifting of sanitary and epidemiological restrictions in 2021 and deferred demand in 2021, the passenger air transportation industry showed a 57.7% increase in passenger traffic and approached the pre-crisis 2018 level in terms of indicators. However, in 2022, the Russian passenger air transportation industry again faced a crisis phenomenon after the start of the COVID-19 pandemic, failing to achieve the expected recovery of pre-pandemic passenger traffic levels. In March 2022, the European Aviation Safety Agency (EASA) issued a notice in which 2 packages of restrictive measures related to the Russian aviation industry were applied. A list of suspended EASA certificates and approvals was also issued in relation to Russian airlines. The main restrictions in the aviation industry are presented in Figure 4.

The Russian government took countermeasures and issued Resolutions No. 411 and No. 412 of March 19, 2022, which established that domestic airlines will be able to register ownership of foreign aircraft in operation within five days and enter them into the state register. Insurance, reinsurance and technical maintenance of aircraft will be carried out on the territory of Russia.

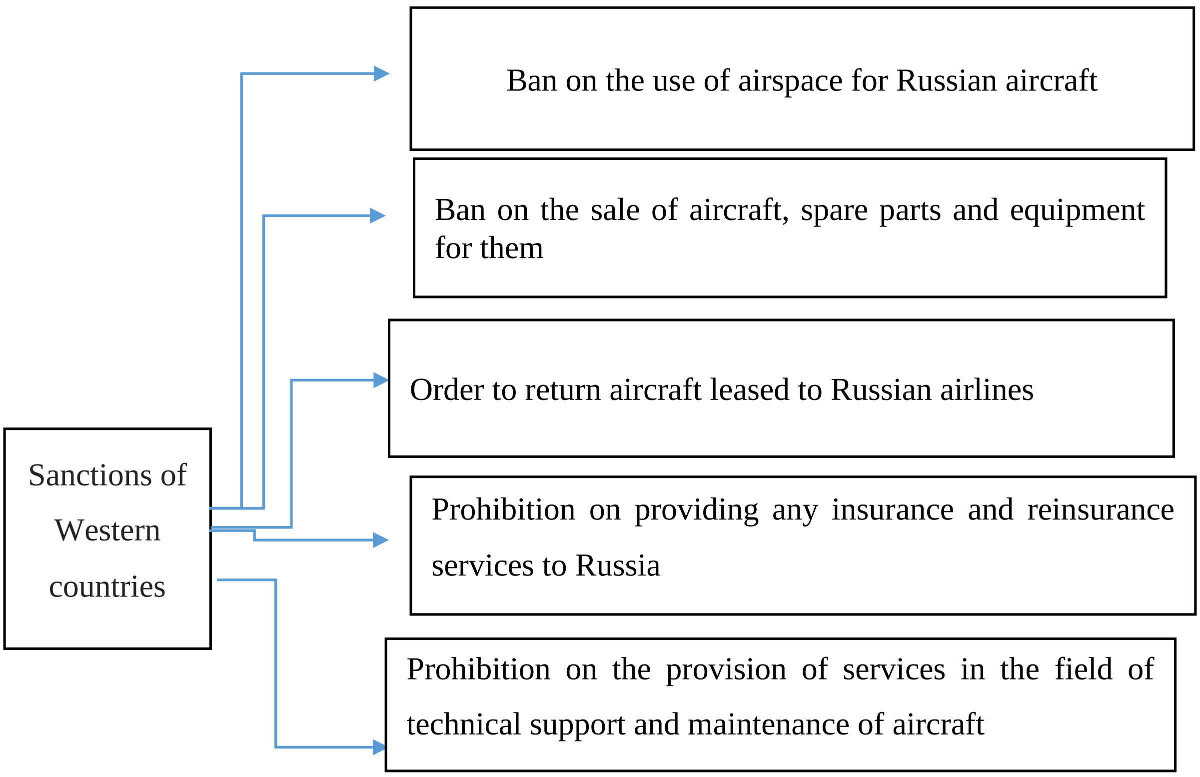

Figure 4: Western sanctions on the aviation industry.

Presidential Decree No. 100 "On the application of special economic measures in the sphere of foreign economic activity to ensure the security of the Russian Federation" prohibited the export of aircraft from the country if there was a requirement for the early return of a foreign aircraft to the lessor or landlord. The Russian Government also continued the practice of providing subsidies to Russian airlines to compensate for losses in the context of external sanctions pressure. All these measures allowed the industry to recover and show slight growth in 2023.

Most processes in the economy are interconnected and the study of these connections is of great importance for a more detailed understanding of the mechanism of cause-and-effect relationships between these processes.

The conducted analysis of the dynamics of changes in passenger traffic in the aviation industry and the Moscow Exchange Index for the period 2002-2023 allows us to assume the existence of a functional dependence of changes in the state of the passenger air transportation industry on the state of the country's economy as a whole and crisis phenomena in it. Let's plot a correlation field graph using passenger traffic data depending on the year and add a trend line to assess the deviation of values (Fig. 5).

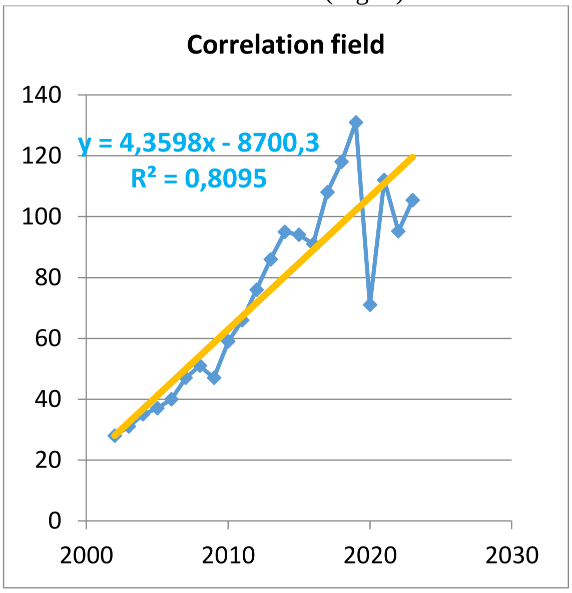

Figure 5: Functional dependence of the change in the state of the passenger air transportation industry on the state of the economy.

To assess the dependence of passenger traffic on the Moscow Exchange Index, you can use a statistical research method and conduct a linear regression analysis. We will calculate the linear regression in Microsoft Excel . To do this, we will use the Data Analysis → Regression function.

The input interval on the Y axis will be data on passenger traffic in the aviation industry in millions of people for 2002-2023. The input interval on the X axis will be data on the Moscow Exchange index for 2002-2023 and the data will be output. The results of the regression statistics calculation are displayed in Table 4.

Table 4: Regression statistics.

Regression statistics	
Multiple R	0.756
R-squared	0.571
Normalized R-squared	0,550
Standard error	21,108
Observations	22

Regression statistics parameters:

- Multiple R is the coefficient of *multiple* correlation R.

$$R = \sqrt{R^2}$$

Higher values indicate higher predictability of the level of passenger traffic in air transportation depending on the Moscow Exchange index.

A value of 1 means that the prediction is absolutely correct.

A value of 0 means that no linear combination of independent variables is a good enough predictor.

- R-square (R ^{2}) is the determination coefficient. This indicator characterizes the quality of the regression equation. The closer R -square to 1, the better the regression approximates the passenger flow data and the Moscow Exchange Index.

- Normalized R is the normalized (adjusted) value of the correlation coefficient taking into account the predictors in the model.

the coefficient of determination R2 is that it increases with the number of new variables. However, this does not always mean an improvement in the quality of the regression model. Therefore, it is preferable to use the normalized R-square , which can decrease when introducing new explanatory variables into the model that do not have a significant impact on the dependent variable.

- Standard error is the standard deviation of the residuals.

This is the average distance that the observed values deviate from the regression line. The smaller the residual standard error, the better the regression model fits the data set.

- Observations – the number of original observations. In our case, this is the number of periods in the study.

The results of the variance analysis calculation, which are used to test the significance of the determination coefficient R2 , are presented in Table 5.

Table 5: Calculation of variance analysis.

Analysis of variance					
Indicator	df	SS	M.S.	F	Significance of F
Regression	1	11882,7	11882,7	26.67	0,00005
Remainder	20	8910,82	445,541		
Total	21	20793,52			

Parameters of the analysis of variance:

- Column df is the number of degrees of freedom.

For the Regression row, the number of degrees of freedom df_p is determined:

$$df_p = KKR - 1,$$

where KKR is the number of regression coefficients (number of predictors).

For the Residual row, the number of degrees of freedom df_o is determined:

$$df_o = KH - m - 1,$$

where KH is the number of observations (the number of periods in the study).

For the Total row, the number of degrees of freedom n is determined:

$$df_{and} = KH - 1$$

- Column SS is the sum of squared deviations.

In the *Regression row,* the SS value is defined as the sum of the squared difference between the predicted value and the mean of all data points:

$$SS_1^2 = \sum_{i=1}^{n} (\hat{y}_i - \bar{y})^2$$

This is the total change in the dependent variable that is explained by the regression model.

In the Residual (residual SS) row, SS is defined as the sum of the squares of the difference between the actual and predicted values of all data points :

$$SS_2^2 = \sum_{i=1}^{n} (y_i - \hat{y}_i)^2$$

This total variation in the dependent variable that remains unexplained by the regression model is also called the sum of squared errors. The smaller the error, the better the regression model explains the variation in the data set.

In the *Total line* SS is defined as the sum of the squares of the deviations of the estimated data from the mean or the sum of the regression SS and the residual SS :

$$SS_3^2 = \sum_{i=1}^{n} (y_i - \bar{y})^2 \text{or} SS_3^2 = SS_1^2 + SS_2^2$$

The ratio $SS_1^2$to SS_3^2means how well the regression model explains the change in passenger traffic in the aviation industry based on the Moscow Exchange index data.

- The MS column contains the dispersion values, which are calculated using the formula:

$$MS = \frac{SS}{df}$$

For the *Regression row*, this is the factor variance:

$$\sigma_{\text{ф}}^2 = \frac{\sum_{i=1}^{n} (\hat{y}_i - \bar{y})^2}{\text{dfp}}$$

For the *Residual row*, this is the residual variance:

$$\sigma_{\text{ост}}^2 = \frac{\sum_{i=1}^{n} (y_i - \hat{y}_i)^2}{\text{dfp} - (\text{dfo} + 1)}$$

- Column F contains the calculated value of Fisher's F-criterion Fp, calculated using the formula:

$$F_p = \frac{MS(\text{Регрессия})}{MS(\text{Остатки})}$$

F - is used to test the hypothesis that the slope of the independent variable is zero.

- *F Significance* column contains the significance level value corresponding to the calculated Fp value.

This means that the coefficient of the independent variable is zero.

A small value of Fp indicates that there is a significant relationship between the dependent and independent variables.

Regression analysis data (Table 6) :

- Coefficients – the value of the coefficients b_i .

The Y-intercept line is the regression coefficient b_0.

Line Moscow Exchange Index - free coefficient b_1.

Moving on to the analysis of the obtained calculated data, it will be possible to construct a regression equation with the calculated coefficients, which will express the dependence of passenger traffic on the Moscow Exchange Index. The linear regression equation looks like this:

$$\hat{y} = b_0 + b_1 x,$$

where b_0 is the regression coefficient,
b_1 – free coefficient.

$$b_1 = \frac{cov(x,y)}{S_x^2}$$

where cov (x , y) is the sample covariance,

S_x^2– sample variance of variable X.

$$cov(x,y) = \overline{xy} - (\bar{x})(\bar{y})$$

$$S_x^2 = \frac{1}{n}\sum_{i=1}^{n} x_i^2 - (\bar{x})^2$$

$$b_0 = \bar{y} - b_1\bar{x}$$

- Standard error – standard errors of the coefficients b $_i$

This is the estimated standard deviation of the distribution of coefficients.

The amount by which a coefficient varies. A coefficient that is much larger than its standard error implies the probability that the coefficient is not 0.

- t-statistics - calculated values of the t-criterion, calculated using the formula:

$$t - \text{статистика} = \frac{\text{коэффициенты}}{\text{стандартная ошибка}}$$

For the t-statistic, the null hypothesis is tested that it is equal to zero. If the t-statistic =is 0, then b $_{is\ 1}$ =0, which will indicate the absence of a linear relationship between passenger flow and the Moscow Exchange Index.

- P-value is the significance level values corresponding to the calculated t $_{p\ values}$.

The t-statistic is compared to the t-distribution to determine the p-value.

A p-value below 0.05 indicates 95% confidence that the slope of the regression line is not zero and therefore there is a significant linear relationship between passenger traffic and the MICEX Index.

- Lower 95% and Upper 95% are the lower and upper boundaries of the confidence intervals for the regression coefficients b $_i$

Table 6: Regression analysis data.

Indicator	Coefficients	Standard error	t-stat.	P-Value	Lower 95%	Top 95%
Y-intersection	28,489	9,861	2,889	0,00907	7,920	49,058
Moscow Exchange Index	0.025	0.005	5,164	0,0005	0,015	0.036

After receiving and analyzing the data, we will calculate the passenger flow using the regression equation and plot a graph of the actual passenger flow and the calculated one (Fig. 6):

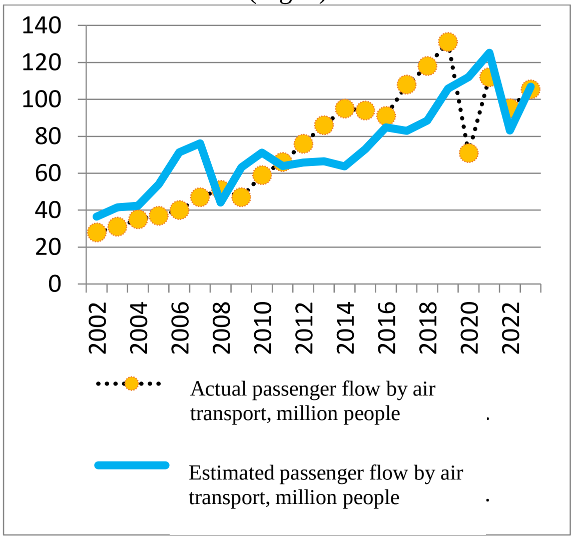

Figure 6: Estimated and actual passenger traffic.

As a rule, the linear regression method has disadvantages in the form of:

- Linear regression assumes a linear relationship between the dependent variable and the independent variables, which may not be appropriate for all data sets;
- Linear regression assumes that the errors are normally distributed, which may not be the case for all data sets;
- Linear regression assumes that the errors are independent, which may not be the case for all data sets;
- Linear regression may not be appropriate for modeling nonlinear relationships between the dependent variable and independent variables.

Unlike linear regression, L ASSO regression methods regularize parameters and overcome some of the shortcomings of the linear method. It is used to combat data overload, when independent variables are correlated with each other (multicollinearity). The L ASSO method often allows for a reduction in variance. As a result, the accuracy of the forecast increases due to the introduction of an additional coefficient λ. The larger the coefficient λ , the more the model is penalized. With a lambda coefficient equal to 0, we obtain regression using the least squares method. As a result of applying λ, the coefficients for some predictors of the linear model approach zero (or become zero). Thus, the norm of the estimate vector decreases with an increase in λ. LASSO selects a subset of variables, i.e.

3 CONCLUSION

In conclusion of the study, it should be noted that the main theoretical provisions of the study of financial crises within the framework of cyclical analysis and forecasting have been systematized, including: the main methods allowing for effective forecasting of crises based on leading indicators have been defined; regression modeling of signs of cyclicality of financial crises has been disclosed, which is aimed at determining indicators of early diagnostics and prevention of financial crises; recommendations have been formulated for actions that reduce financial risks at the early stages of crisis development. This study will serve as a scientific basis for developing a system for early forecasting of financial crises based on leading indicators that ensure a reduction in potential financial losses associated with the crisis, and modeling of predictor indicators that determine probable financial destabilization has also been carried out.

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