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Methods for prediction of economic crises in the global economy and financial centers

Abstract

The paper studies the issues pertaining to the timely identification of economic crises under conditions of globalization. It offers an integral indicator of the economy’s development level (global economy and financial centers), carries out the filtering of the trend and systemic components of this indicator’s time series, which makes it possible to determine the cyclicity of crises and to predict the min short-term and long-term perspective. It introduces the indicator to formalize and quantify the crises on the global scale and in the three major financial centers (the United States, Europe and Asia). It also examines the adequacy of the proposed approach based on the dynamics of the global crises over the past 50 years.

Keywords: crisis indicator, integral indicator, level of economic development, forecasting, decomposition analysis, regression analysis.

JEL Classification: G10

Introduction

With the transformation of the global financial architecture the strengthening of integration processes within the national and international financial markets is occurring. Along with the free movement of the capital, goods and services the crisis phenomena and their destructive impact on the economy are increasing. Therefore, the need for preliminary identification, monitoring and development of measures to mitigate the negative effects of the market, interest rate, currency, political and other risks determines the necessity of forming the instruments of economic and mathematical modeling and forecasting of crises.

1. The main results of the research

In the recent decades the economic development has been accompanied by the search for instruments of an early warning and detection of imbalances in the national economies. Integration processes, which have covered the whole range of social activities, led to the rapid expansion of destructive factors both within and outside individual countries. Crisis phenomena on certain markets destabilize the effective functioning of the whole financial system of a country. The high level of interconnection and interpenetration of domestic and international financial markets leads to the negative synergistic effect and the loss of equilibrium by the entire global economy.

The identification of sources of financial instability at the level of individual countries and financial centers is the basis for the prevention of possible shocks to the global economy. The forecasting of crisis at the local level makes it possible to reduce financial losses and, considering the characteristic features and economic potential of the regions, improve the effectiveness of preventive measures. The forecasting of the cyclicity of the world economy also serves as an essential element of effective crisis assessment and prevention systems. This is connected to the ability to form a coherent strategy for an early detection of crises and to create conditions for overcoming their consequences.

Therefore, the formation of scientific and methodical approach for the formalization of the process of prediction of global economic crises under conditions of integration is becoming increasingly relevant.

Based on the importance of this problem we propose a methodology for the forecasting of crises in the global economy. We will consider the stages of this methodology.

Stage 1. Formation of the knowledge base of research – relevant indicators of the level of development of the world economy and its three financial centers (the United States, Europe and Asia [2]). Selection of data about the financial centers and a further study of peculiarities of crisis forecasting within national economies caused by the different mentality of the population and the structure of financial systems. As a knowledge base of the proposed approach we consider the data describing the development of the world economy during the period 1960-2012 and serving directly or indirectly as indicators of crises. The source of the input information base for our research is the website of the World Bank [9]. Similar tables have been drawn up for the financial centers.

Stage 2. Bringing the indicators of Table 1 to comparable form. As input indicators have different effects on the resultant indicator and have different measurement units, it is proposed to normalize the input data base through the use of the following mathematical correlations:
for destimulating indicators – savage normalization:

\[ NC_{a} = \frac{C_{a} - \min\{C_{a}\}}{\max\{C_{a}\} - \min\{C_{a}\}}, \]  

(1)

where \( C_{a} \) is a relevant indicator of the global economy's (financial centers') development level characteristics during the t-year; \( NC_{a} \) – normalized value of the indicator during the t-year;

for stimulating indicators – natural normalization:

\[ NC_{s} = \frac{\max_{t}\{C_{a}\} - C_{a}}{\max_{t}\{C_{a}\} - \min_{t}\{C_{a}\}}, \]  

(2)

The results of realization of this stage for the world economy are presented in Table 2 (See Appendix).

Stage 3. Calculation of the integral indicator for the development level of the global economy and world financial centers, which is based on the convolution of the normalized indicators presented in Table 2. It is assumed that the weight of the input information base indicators will be the same. Thus, at this stage the calculations will be conducted by using the following formula:

\[ IIC(t) = \sum_{t=1}^{n} NC_{a}, \]  

(3)

where \( IIC(t) \) is an integral indicator of the level of economic development (world economy or a certain financial center) in the period \( t \).

Practical results of implementation of the above-mentioned approach, namely, the calculated values of the integral indicator of the economy’s development level for each year in the period of 1960-2012 are presented in graphical form (Figure 1 in Appendix).

On the basis of the graphical analysis we made the following conclusions:

- There is a growing oscillating trend in the IIC indicator. This shows the progressive development of the economy and realization of the existing potential despite certain periods of financial instability.
- One can observe a cyclical change of the IIC indicator making it possible to identify the periods of economic booms and recessions.
- There are periodic changes in the leading position among the American and the European financial centers; countries, which form the Asian financial center, demonstrate the record growth of economic development.

Stage 4. Research and periodization of global crises from 1960 to 2012 as a basis for examining the adequacy of economic and mathematical model (Table 3 in Appendix). Based on systematization of the existing approaches to defining crises, their factors, negative consequences and duration [2, 3, 5, 9, 10, 12] in the period 1960-2012, we will consider the international financial crises, the characteristics of which are presented in Table 3.

Thus, over the past 50 years there have been 4 global economic crises, the biggest of which was the crisis of 2008-2010.

Stage 5. Selection and justification of the crisis indicator as an indicator, which makes it possible to predict with the highest degree of accuracy the occurrence of a crisis and to make appropriate managerial decisions to counteract it [12]. As the IIC indicator shows the average trend, it is proposed to analyze its derivatives in order to interpret the crises [6].

We consider different approaches to determining the crisis indicator. On the basis of identification of their main advantages and drawbacks we will formulate the basic requirements for the application of these methods. For example, as a crisis indicator we consider the value of the chain growth rate time series for the integral indicator of the economic development (Figure 2 in Appendix).

The analysis of data (Figure 2) reveals all crisis periods (shown in Table 3) in which the smallest values of this indicator are observed. The only exception is the economic bubble of 2001-2003, in which the crisis indicator does not adopt the smallest values, but there is a much longer period of oscillation of this indicator at a zero level compared to other intervals.

The crisis indicator may be the testing of the anomalous levels of the global economy’s integral indicator [8] according to the Irwin method (Figure 3).

\[ \lambda(t) = \frac{|IIC_{t}^{W} - IIC_{t-1}^{W}|}{\sigma_{IIC_{t}^{W}}}, \]  

(4)

where \( \lambda(t) \) is the characteristics of the anomalous values of the ICC indicator in time \( t \) - the crisis indicator when estimated values exceed critical table values \( \chi^2 \); \( \sigma_{IIC_{t}^{W}} \) is a standard deviation for the values of the IIC indicator.

On the basis of the graphical analysis we discover that the anomalous levels of the ICC indicator are the values of the crisis periods, which are characterized by a significant deviation from its average value. Considering the fact that the database (Figure 3) can help reveal all crisis periods from 1960 to 2012, it would be right to regard it as a crisis indicator.
Thus, one could argue that the most informative indicator in terms of identifying crisis phenomena seems to be the anomalous levels of time series.

**Stage 6. Identification of crisis phenomena on the basis of the indicator of anomalous levels of time series for the IIC indicator and the testing of the developed model’s adequacy.** The realization of this stage involves the definition and graphical representation of crisis indicators (Figure 4 in Appendix).

Based on the comparison of the data (Figure 4) and major financial shocks (Table 3), it can be argued that the obtained results with their marginal deviations and with the time lag between the initial impact of the factor and its subsequent effects correspond to the actual statistical data, confirming the expediency of using the developed crisis indicator in crisis forecasting.

**Stage 7. Decomposition of time series for the values of the IIC indicator [1, 11].** The realization of this stage gives an opportunity to determine the trend in the changes of the indicator, the cyclicity of crises and to get a mathematical provision in the form of regression equations for predicting the anomalous levels and making decisions regarding the preventive measures. Thus, it is proposed to detect the presence of systematic components of the tested time series based on the correlogram for first differences (Figure 5 in Appendix).

The dependence of autocorrelation coefficients on the value of the time lag shows the following:

- Autocorrelation coefficient for the time lag of one year is statistically significant, which (though not showing the cyclicity of crises) confirms the lag of information flow.
- Autocorrelation coefficient for the time lag of 4 years is statistically significant, i.e. the cyclicity of crises and anomalous values of the crisis indicator are characterized by the time interval of 4 years.

In its turn, the correlogram of zero differences for the IIC indicator’s successive values demonstrates the specification of unsystematic component (trend) of this time series in the form of second-degree polynomial. Statistical estimations of the parameters of nonlinear regression for the trend component, the corresponding standard errors, the confirmation of the statistical significance of coefficients and their intervals are presented in Table 5 (See Appendix).

Thus, on the basis of the data in the column “Coefficients” of Table 5 and the results of filtration of the cyclical component of time series for the values of the IIC indicator with the help of seasonality index, it is proposed to build the following trend-cyclical additive model:

\[
IIC^w(t) = 0.0016 \cdot I_1^2 + 0.0294 \cdot I_1 + 4.8026 - 0.0166 \cdot I_1 - 0.0274 \cdot I_2 - 0.0988 \cdot I_3 + 0.1092 \cdot I_4,
\]

where \(IIC^w(t)\) is an integral indicator of the level of the global economic development in the period \(t\); \(I_1, I_2, I_3, I_4\) is an indicator of each of the first (second, third, fourth) year since 1960 at intervals of 4 years, which adopts a unit value in the described case and a zero value in the opposite case.

The characteristic of the cyclic component (equation (5)) makes it possible to conclude that fluctuations happen every fourth year since 1960. The first three years are characterized by a significant downward trend while the last fourth year is characterized by a slight growth as the coefficient of the dummy variable \(I_1\) takes on positive values showing the growth of the world economy’s integral indicator by 10.92%. At the same time, it should be noted that this paper describes only the behavior of cycles. In the future, it is necessary to carry out adjustments regarding the dynamic component, which will indicate the presence of crisis phenomena.

**Stage 8. The building of autoregressive linear equations for the dependence of the integral indicator of financial centers’ development level on the values of the same time series shifted by several years [4, 7].**

At this stage calculations form the equation systems (autoregressive linearmultifactor equation for the dependence of the integral indicator of financial centers’ development level on the values of the time series with lags from 1 to 5 years; equation of dependence of the examined result characteristics with a 5 year lag, which allows to make predictions for 5 years into the future; multifactorial line ar regression equation for the dependence of the integral indicator of financial centers’ development level on the relevant characteristics of the objects of study in terms of describing the crisis phenomena) and are conducted both in the context of the global economy: 49
\[ IIC^W(t) = 0.1590 + 0.6601 \cdot IIC(t-1) + 0.2391 \cdot IIC(t-2) - \\
-0.0589 \cdot IIC(t-3) - 0.1925 \cdot IIC(t-4) + 0.3630 \cdot IIC(t-5) \]
\[ IIC^W(t) = 0.6218 + 0.9948 \cdot IIC(t-5) \]
\[ IIC^W(t) = 52.9059 - 1.8217 \cdot C_1(t) - 0.1342 \cdot C_2(t) - 0.1564 \cdot C_3(t) - \\
-0.1341 \cdot C_4(t) + 0.0424 \cdot C_5(t) - 0.5752 \cdot C_6(t) - 0.1637 \cdot C_7(t) - \\
-0.0453 \cdot C_8(t) - 0.0619 \cdot C_9(t) - 0.0077 \cdot C_{10}(t) - 0.0237 \cdot C_{11}(t) + \\
+ 0.3679 \cdot C_{12}(t) + 0.7847 \cdot C_{13}(t) + 0.0091 \cdot C_{14}(t) - 0.0178 \cdot C_{15}(t) \]

and within individual financial centers:

American:
\[ IIC^{AM}(t) = 0.0021 \cdot t^2 - 0.0752 \cdot t + 6.9187 + \\
+ 0.0413 \cdot I_1 + 0.0172 \cdot I_2 + 0.0015 \cdot I_3 - 0.0391 \cdot I_4 \]
\[ IIC^{AM}(t) = -0.3239 + 0.7716 \cdot IIC(t-1) + 0.4142 \cdot IIC(t-2) - \\
-0.3781 \cdot IIC(t-3) + 0.0045 \cdot IIC(t-4) + 0.2460 \cdot IIC(t-5) \]
\[ IIC^{AM}(t) = 0.0535 + 1.0011 \cdot IIC(t-5) \]

European:
\[ IIC^{EU}(t) = 0.0009 \cdot t^2 - 0.0068 \cdot t + 6.3807 - \\
-0.0177 \cdot I_1 - 0.0012 \cdot I_2 + 0.0173 \cdot I_3 - 0.0803 \cdot I_4 \]
\[ IIC^{EU}(t) = 0.4284 + 0.8421 \cdot IIC(t-1) - 0.0573 \cdot IIC(t-2) + \\
+ 0.0299 \cdot IIC(t-3) - 0.0711 \cdot IIC(t-4) + 0.2014 \cdot IIC(t-5) \]
\[ IIC^{EU}(t) = 2.7920 + 0.6128 \cdot IIC(t-5) \]

Asian:
\[ IIC^{AS}(t) = -0.0009 \cdot t^2 + 0.1207 \cdot t + 4.8572 + \\
+ 0.0575 \cdot I_1 - 0.0106 \cdot I_2 - 0.0100 \cdot I_3 + 0.1303 \cdot I_4 \]
\[ IIC^{AS}(t) = 1.0126 + 0.3380 \cdot IIC(t-1) + 0.3786 \cdot IIC(t-2) - \\
-0.2741 \cdot IIC(t-3) + 0.1602 \cdot IIC(t-4) + 0.2865 \cdot IIC(t-5) \]
\[ IIC^{AS}(t) = 2.0259 + 0.7711 \cdot IIC(t-5) \]

Stage 9. Prediction of values of integrated indicators for the global economy’s and financial centers’ development level in the period from 2013 to 2020 and determination of anomalous values for these time series as indicators of crisis phenomena in accordance with the Irwin method [13]. It is proposed to systematize the results of the calculations and present them in a tabular form in the context of the two research methods: decomposition analysis (Table 6) and autoregressive analysis (Table 7 in Appendix).

The analysis of the data in Table 6 reveals the following:

- two phases of the crisis the first, the end of 2014 and 2015, the second, in 2018 given the lag of 1 year between the anomalous level of the observed time series values and the cyclicity of depressions after 4 years;
- crisis phenomena expand, first of all, to the American center, for which the parameter of anomalous levels of time series for the crisis integral indicator does not have a lag as evidenced by statistically insignificant values of autocorrelation coefficients of the corresponding correlogram;
- after the American financial center the crisis with a one year lag extends to the European center where the first phase of the crisis will begin in 2015-2016, and the second phase with a lag of 4 years in 2019;
- although the Asian financial center is characterized by the late manifestation of crisis phenomena (2016-2017 and 2020, respectively), its
peculiar feature is the ability of an early prediction of possible negative consequences of the crisis – the availability of the time series anomalous values for the IIC indicator ahead of other financial centers.

The results of the integral indicator autoregressive analysis show with a slight deviation a similar trend regarding the periodization, duration and cyclicity of crises that have been identified through the method of decomposition analysis (Table 7).

Stage 10. Development of a system of preventive-measures to counteract the destructive factors of crises. The proposed instruments for crisis forecasting make it possible to develop an effective set of measures against destructive influences. The availability of information about the periods of a crisis, its duration and expansion characteristics, creates an opportunity for supranational regulation of the process of counteraction to financial instability and, as a result, reduction of economic losses for individual states from crises.

Conclusions

The paper proposes: a crisis indicator on the basis of the Irwin test to examine the anomalous levels of time series; an integral indicator for the development level of the global economy and three major financial centers (American, European and Asian) on the basis of decomposition and autoregressive analysis making it possible to conduct an adequate prediction of crises under international integration. The proposed methods are the basis for effective decision-making regarding the development of measures to prevent crises and minimize their impact on the macro level.

References

1. Anderson T.W., Hsiao C. (1981). Estimation of dynamic models with error components, *Journal of the American Statistical Association*, 76, pp. 598-606.
2. Bagmet K.V. *Transformatsiia modeley bankiv’skogo strakhuvannia v umovakh integratsii svitovoi finansovoi systemy* [Transformation of banking insurance models in terms of integration of world financial system]. Development of economy of Ukraine in terms of globalization: Proceedings of all Ukrainian research and practice conference with the participation of young scholars and students, 5 (102) (March 18, 2011). Kharkiv National University of Economics, 2011, pp. 48-50.
3. Banking crisis and world financial architecture. See at http://www.polit.nnov.ru/2008/03/26/crisbankglob/.
4. Box G.E.P. and Pierce D.A. (1970). Distribution of residual autocorrelations in autoregressive-integrated moving average time series models, *Journal of the American Statistical Association*, 65, pp. 1509-1526.
5. Delovie tsykly, tsykly “puzyrey”, Kondrat’evskie tsykly i Pervaia global’naia Velikaia depressiia [Business cycles, cycles of “bubbles”, Kondrat’ev cycles and the First Global Great Depression]. Available at http://www.polit.nnov.ru/2008/04/07/bubblecycles/.
6. Filler W.A. (1976). *Introduction to Statistical Time Series*, Wiley, New York, pp. 366-382.
7. Granger C.W.J. (1969). Investigating casual relations by econometric methods and cross-spectral methods, *Econometrica*, 37, pp. 424-438.
8. Keuzenkamp H.A. and Magnus J.R. (1995). On tests and significance in econometrics, *Journal of Econometrics*, 67, pp. 5-24.
9. Krizis mirovoy (dollarovoy) valiutno-finansovoy systemy, multivaliutniy mir i Pervaia global’naia Velikaia depressiia XXI veka [Crisis of the world (dollars) monetary and financial system, multicurrency world and the First Global Great Depression of 21st century]. Available at http://www.polit.nnov.ru/2008/02/16/dollcrismulti/.
10. Lepeshkina K.N. Krizis na mirovom finansovom rynke [Crisis on the world financial market]. Monograph. Moscow: Infra-M, 2011, 160 p.
11. MacKie-Mason J.K. (1992). Econometric software: A user’s view, *Journal of Economic Perspectives*, 6 (4), pp. 165-187.
12. Mishkin, F.S. (1991). “Anatomy of a Financial Crisis”, NBER Working Paper No. 3834.
13. Pindyck R., Rubinfeld D. (1991). *Econometric models and economic forecasts*, Mc. Grow-Hill, Inc., USA.
14. Official site of World Bank. Access: www.worldbank.org.
15. Risk menegement, upravlenie riskami I risk nastupleniia Pervoy global’noy Velikoy depressii XXI veka [Risk management, risk control and risk of coming of the First Global Great Depression of 21st century]. Available at http://www.polit.nnov.ru/2008/04/27/globrisk/.
Table 1. Information base for the research of the dynamics of the global economic development

| Indicator                                  | Indicator value by year |
|--------------------------------------------|-------------------------|
|                                            | 1960  | 1961  | 1962  | ...   | 2010  | 2011  | 2012  |
| International migrant stock (% of population)* | 2.6   | 2.6   | 2.6   | ...   | 3.1   | 3.1   | 3.2   |
| Gross savings (% of GNI)**                  | 20.1  | 20.1  | 20.2  | ...   | 22.9  | 23.5  | 23.6  |
| GDP growth (annual %)*                      | 4.3   | 4.3   | 5.6   | ...   | 4.0   | 2.8   | 2.2   |
| Inflation, GDP deflator (annual %)*         | 2.5   | 2.5   | 2.6   | ...   | 4.5   | 5.7   | 3.2   |
| Gross capital formation (annual % growth)** | 2.6   | 2.7   | 2.7   | ...   | 9.6   | 4.9   | 4.9   |
| Household final consumption expenditure, etc. (% of GDP)** | 60.1  | 60.1  | 60.1  | ...   | 60.8  | 61.2  | 61.3  |
| General government final consumption expenditure (% of GDP)** | 13.5  | 13.9  | 14.1  | ...   | 16.6  | 18.3  | 18.4  |
| Total tax rate (% of commercial profits)*   | 70.0  | 69.6  | 69.2  | ...   | 48.0  | 45.1  | 44.7  |
| Compensation of employees (% of expense)**  | 23.6  | 23.6  | 23.6  | ...   | 22.7  | 21.5  | 21.5  |
| Liquid liabilities (M3) as % of GDP*        | 37.3  | 38.0  | 34.5  | ...   | 46.9  | 48.9  | 50.7  |
| Claims on other sectors of the domestic economy (% of GDP)* | 201.6 | 200.4 | 199.2 | ...   | 150.2 | 145.1 | 147.3 |
| Bank liquid reserves to bank assets ratio (%)** | 6.1   | 6.2   | 6.4   | ...   | 14.6  | 14.6  | 15.2  |
| Bank capital to assets ratio (%)**          | 6.0   | 6.0   | 6.1   | ...   | 9.5   | 9.7   | 9.7   |
| Stocks traded, total value (% of GDP)**     | 15.8  | 16.3  | 16.8  | ...   | 105.1 | 97.0  | 72.7  |
| Market capitalization of listed companies (% of GDP)** | 41.4  | 41.9  | 42.4  | ...   | 87.5  | 67.8  | 77.2  |

Note: * Destimulating indicators (the growth of the indicator means stagnation (the decline means development)). ** Stimulating indicators (the growth of the indicator means development (the decline means stagnation)).

Table 2. Normalized values for the indicators of the world economy development level

| Indicator                                  | Indicator value by year |
|--------------------------------------------|-------------------------|
|                                            | 1960  | 1961  | 1962  | ...   | 2010  | 2011  | 2012  |
| International migrant stock 0.56           | 0.59  | 0.61  | 0.61  | ...   | 0.04  | 0.02  | 0.00  |
| Gross savings 0.00                         | 0.02  | 0.03  | 0.03  | ...   | 0.72  | 0.90  | 0.91  |
| GDP growth 0.26                            | 0.27  | 0.12  | 0.12  | ...   | 0.29  | 0.43  | 0.51  |
| Inflation, GDP deflator 0.99                | 0.99  | 0.98  | 0.98  | ...   | 0.85  | 0.77  | 0.94  |
| Gross capital formation 0.65               | 0.66  | 0.66  | 0.66  | ...   | 0.98  | 0.76  | 0.76  |
| Household final consumption expenditure, etc. 0.44 | 0.45  | 0.46  | 0.46  | ...   | 0.74  | 0.92  | 0.93  |
| General government final consumption expenditure 0.00 | 0.06  | 0.10  | 0.10  | ...   | 0.95  | 0.89  | 0.91  |
| Total tax rate 0.00                         | 0.02  | 0.03  | 0.03  | ...   | 0.87  | 0.99  | 1.00  |
| Compensation of employees 0.73              | 0.73  | 0.73  | 0.73  | ...   | 0.49  | 0.17  | 0.18  |
| Liquid liabilities (M3) 0.95                | 0.93  | 0.99  | 0.99  | ...   | 0.79  | 0.76  | 0.73  |
| Claims on other sectors of the domestic economy 0.00 | 0.02  | 0.04  | 0.04  | ...   | 0.91  | 1.00  | 0.96  |
| Bank liquid reserves to bank assets ratio 0.00 | 0.01  | 0.02  | 0.02  | ...   | 0.93  | 0.93  | 1.00  |
| Bank capital to assets ratio 0.00            | 0.01  | 0.03  | 0.03  | ...   | 0.94  | 0.98  | 1.00  |
| Stocks traded, total value 0.00             | 0.00  | 0.01  | 0.01  | ...   | 0.54  | 0.49  | 0.34  |
| Market capitalization of listed companies 0.00 | 0.01  | 0.01  | 0.01  | ...   | 0.60  | 0.34  | 0.46  |

Table 3. International crises (from 1960 to 2012)

| Name of a crisis and global depression       | Period             | Duration | Causes                                                   |
|---------------------------------------------|--------------------|----------|----------------------------------------------------------|
| Oil crisis                                  | 1973-1975          | 2 years  | 4 times increase in oil prices, inflation.               |
| Crisis of 1987                              | 1987-1991          | 4 years  | The dollar crisis, illiquidity of real estate.            |
| Recession of 1990                           | 2001-2003          | 2 years  | Events of September 11, 2001, accounting scandals.       |
| Economic bubble                             | 2008 – beginning;  | 1.5-3 years | Real estate, bankruptcy of banks.                      | 2009 – peak; 2010 – stabilization |
| International financial crisis of 2008-2010 | 2008 – beginning;  |          |                                                          | 2009 – peak; 2010 – stabilization |
|                                             | 2008 – beginning;  |          |                                                          | 2009 – peak; 2010 – stabilization |
|                                             | 2009 – peak;       |          |                                                          | 2009 – peak; 2010 – stabilization |
|                                             | 2010 – stabilization|          |                                                          | 2010 – stabilization |

Table 4. Periodization of international crises in the period from 1960 to 2012

| Name of a crisis | Period   | Anomalous values of the integral indicator for the financial centers’ development level |
|------------------|----------|----------------------------------------------------------------------------------------|
| Oil crisis       | 1973-1975| World economy 1974, 1976-1977 American center 1971-1973 European center 1974-1976 Asian center 1974-1976 |
| Crisis of 1987   | 1987-1991| World economy 1986, 1995 American center 1984-1985, 1991 European center 1990-1991 Asian center 1990-1991, 1993 |
Table 4 (cont.). Periodization of international crises in the period from 1960 to 2012

| Name of a crisis                              | Period                                      | Anomalous values of the integral indicator for the financial centers' development level |
|----------------------------------------------|---------------------------------------------|----------------------------------------------------------------------------------------|
| Economic bubble                              | 2001-2003                                   | World economy 1999<br>American center 1999-2001<br>European center 1998-1999, 2001-2002<br>Asian center 1999 |
| International financial crisis of 2008-2010  | 2008 – beginning; 2009 – peak; 2010 – stabilization | World economy 2007-2009<br>American center 2005, 2008-2012<br>European center 2007-2009<br>Asian center 2006-2011 |

Table 5. Results of the statistical analysis of the regression model data for the IIC indicator in the period of 1960-2012

|                      | Coefficients | Standard error | t-statistic | p-values | Lower 95% | Upper 95% |
|----------------------|--------------|----------------|-------------|----------|-----------|-----------|
| Y-intercept          | 0.16         | 0.31           | 0.51        | 0.62     | -0.47     | 0.79      |
| Lag1                 | 0.66         | 0.14           | 4.57        | 0.00     | 0.37      | 0.95      |
| Lag2                 | 0.24         | 0.18           | 1.36        | 0.18     | -0.12     | 0.59      |
| Lag3                 | -0.06        | 0.18           | -0.33       | 0.74     | -0.42     | 0.30      |
| Lag4                 | -0.19        | 0.18           | -1.07       | 0.29     | -0.55     | 0.17      |
| Lag5                 | 0.36         | 0.15           | 2.39        | 0.02     | 0.06      | 0.67      |

Table 6. Prediction of crisis phenomena (anomalous levels) based on the results of decomposition analysis of the integral indicator as time series

| Global level (world economy) | American center | European center | Asian center |
|------------------------------|-----------------|-----------------|-------------|
| Year                         | Indicator of anomalous levels of the integral indicator of crisis | Year | Indicator of anomalous levels of the integral indicator of crisis | Year | Indicator of anomalous levels of the integral indicator of crisis | Year | Indicator of anomalous levels of the integral indicator of crisis |
| 2013                         | 0.319216        | 2013            | 0.257367    | 2013 | 0.028873 | 2013 | 0.974363 |
| 2014                         | 0.064941        | 2014            | 0.532011    | 2014 | 0.998362 | 2014 | 0.206863 |
| 2015                         | 0.15813         | 2015            | 0.311824    | 2015 | 0.717366 | 2015 | 0.197466 |
| 2016                         | 0.111453        | 2016            | 0.33975     | 2016 | 0.74162  | 2016 | 0.287118 |
| 2017                         | 0.329063        | 2017            | 0.294225    | 2017 | 0.016756 | 2017 | 0.946426 |
| 2018                         | 0.074786        | 2018            | 0.568669    | 2018 | 1.043991 | 2018 | 0.236799 |
| 2019                         | -               | 2019            | 0.061305    | 2019 | -        | 2019 | 0.021309 |
| 2020                         | -               | 2020            | 0.089089    | 2020 | -        | 2020 | 0.003679 |

Table 7. Prediction of crisis phenomena (anomalous levels) based on the results of autoregressive analysis of the integral indicator as time series

| Global level (world economy) | American center | European center | Asian center |
|------------------------------|-----------------|-----------------|-------------|
| Year                         | Indicator of anomalous levels of the integral indicator of crisis | Year | Indicator of anomalous levels of the integral indicator of crisis | Year | Indicator of anomalous levels of the integral indicator of crisis | Year | Indicator of anomalous levels of the integral indicator of crisis |
| 2013                         | 0.658126        | 2013            | 0.14199     | 2013 | 2.087983 | 2013 | 0.838302 |
| 2014                         | 0.521572        | 2014            | 0.21244     | 2014 | 0.397656 | 2014 | 1.287174 |
| 2015                         | 0.063138        | 2015            | 1.137737    | 2015 | 0.298227 | 2015 | 0.529016 |
| 2016                         | 0.162449        | 2016            | 0.852762    | 2016 | 0.029009 | 2016 | 0.498107 |
| 2017                         | 0.160843        | 2017            | 0.941688    | 2017 | 0.651173 | 2017 | 0.30456  |
| 2018                         | -               | 2018            | -           | 2018 | -        | 2018 | -        |
| 2019                         | -               | 2019            | -           | 2019 | -        | 2019 | -        |
| 2020                         | -               | 2020            | -           | 2020 | -        | 2020 | -        |
Fig. 1. Dynamics of the integral indicator for the development level of the global economy and three major financial centers

Fig. 2. Dynamics of the integral indicator of the global economy’s development level and its growth rates over the period of 1960-2012

Fig. 3. Dynamics of the integral indicator of the global economic development and its anomalous levels over the period of 1960-2012
Fig. 4. Dynamics of anomalous levels of the IIC indicator

| Lag | Corr. S.E. | 0   | p   |
|-----|------------|-----|-----|
| 1   | -0.292 .1348 | 4.70 | 0.0301 |
| 2   | +0.025 .1334 | 4.74 | 0.0935 |
| 3   | -0.036 .1321 | 4.81 | 0.1859 |
| 4   | -0.274 .1307 | 9.19 | 0.0565 |
| 5   | +0.125 .1294 | 10.12 | 0.0719 |
| 6   | -0.163 .1280 | 11.73 | 0.0682 |
| 7   | +0.177 .1266 | 13.69 | 0.0571 |
| 8   | +0.048 .1252 | 13.83 | 0.0863 |
| 9   | -0.160 .1237 | 15.51 | 0.0779 |
| 10  | +0.020 .1223 | 15.54 | 0.1138 |
| 11  | +0.075 .1208 | 15.93 | 0.1440 |
| 12  | +0.156 .1194 | 17.63 | 0.1274 |
| 13  | -0.240 .1179 | 21.80 | 0.0587 |
| 14  | +0.123 .1163 | 22.92 | 0.0617 |
| 15  | -0.112 .1148 | 23.86 | 0.0675 |

Fig. 5. Correlogram of dependence of autocorrelation coefficients on the value of the time lag of first differences for the IIC indicator