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FORECASTING AND ASSESSING THE SUSTAINABILITY OF ECONOMIC DEVELOPMENT DYNAMICS OF UKRAINE

The paper offers a composite leading indicator model based on the statistical analysis of leading relationships and weighting coefficients; the model can be used to perform short-term forecasts of changes in the economic activity of Ukraine, as well as a procedure of assessing the sustainability of economic development of Ukraine.

Keywords: *forecast; dynamics; sustainability; composite leading indicator.*

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ПРОГНОЗУВАННЯ ТА ОЦІНЮВАННЯ СТІЙКОСТІ ДИНАМІКИ РОЗВИТКУ ЕКОНОМІКИ УКРАЇНИ

У статті запропоновано модель інтегрального випереджувального індексу, в основі якої лежить статистичний аналіз випереджувальних зв'язків та вагових коефіцієнтів, що дозволяє здійснювати короткострокове прогнозування зрушень в економічній активності України, а також методику оцінювання стійкості розвитку економічної системи України.

Ключові слова: *прогнозування, динаміка, стійкість, інтегральний випереджувальний показник.*
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ПРОГНОЗИРОВАНИЕ И ОЦЕНИВАНИЕ УСТОЙЧИВОСТИ ДИНАМИКИ РАЗВИТИЯ ЭКОНОМИКИ УКРАИНЫ

В статье предложена модель интегрального опережающего индекса, в основе которой лежит статистический анализ опережающих связей и весовых коэффициентов, что позволяет совершать краткосрочное прогнозирование сдвигов в экономической активности Украины, а также методика оценивания устойчивости развития экономической системы Украины.

Ключевые слова: *прогнозирование, динамика, устойчивость, интегральный опережающий показатель.*

Problem-setting. The internal capabilities of a company and its performance under current economic conditions are largely affected by external macroeconomic factors such as national and world economy development, political situation, business cycle stages, inflation etc. As a result, the company has to function dynamically, adapt itself to various threats, and switch over to the reactive form of management aimed at predicting the future situation at the macroeconomic level. However, due to inactivity and lags in the appropriate assessment of the varying external environment, these actions sometimes lead to bankruptcy [6, *260*].

Analysis of recent research and publications. Of late the non-structural forecast models based on the search for the probabilistic and statistical regularities, causal relationships and correlation between parameters have been used in the forecast performance. Meanwhile, the researchers do not go too much into the theory which gives an explanation for the dependencies found. The development of non-structural macroeconomic models is due to the improvement of statistical methods and PC capabilities [11, *64*].

The international experience shows that countries are characterized by wavelike development, and cyclicity with a clear alternation of expansion and recession periods is inherent in the economic dynamics. Under global transformations, with crisis phenomena synchronized and global economic cycles formed in the world economy, one of the most important tools is cycle diagnosing which involves continuous monitoring of macroeconomic conditions and tracking of the turning points in the business cycles of Ukrainian economy [10, *80*].

One of the tools for forecasting the turning points of a business cycle is the system of economic indicators, i.e. a set of such indicators which have either a specific value or typical dynamics in the pre-crisis period. This approach is based on the use of the so-called leading indicators. The dynamics of such indicators generally changes a few months before the crisis. Leading indicators, or an early warning system, have been developed and improved over the last 50 years and become widespread in the countries of the Organization for Economic Cooperation and Development (OECD). The first leading indicator was developed in 1938 at the US National Bureau of Economic Research (NBER) by Wesley Mitchell and Arthur Burns to predict changes in the US economic activity [1, *377*].

The basic idea underlying the leading indicator approach is simple: to predict when the economy will go over from the growth to recession (or vice versa), an "early warning system" should be constructed. In other words, it is necessary to find such indicators the turning points of which occur earlier than those of the economy as a whole. A peak or trough in the leading indicator would then show the probability of a forthcoming peak or trough in the macroeconomic dynamics [14, *79*].

Pending problems. Similar calculations for Ukraine were only experimental. The main reasons and sufficient justification for this were the long-term decline in production never reaching its lowest point, the transformation of the economic system; the small time interval of just a few years, not decades was too small to actually "distinguish" a long-term trend from short-term fluctuations.

Now the situation has changed. The long-term trends have already appeared. Therefore, the following (previously unsolved) interrelated tasks have become urgent: identifying the phases in the business cycle of Ukraine; dating the turning points of the economic cycle; constructing a leading indicator system; calculating the composite leading indicator.

The objective of the research is to develop the methods of forecasting and assessing the sustainability of the economic development dynamics of Ukraine.

Research findings. Before passing on to the procedure of calculating the composite leading indicator it is necessary to introduce some specific terminology related to the characteristics of the cyclic behavior of macroeconomic indicators. A macroeconomic indicator varying in the same direction as the aggregate economic activity (increases and decreases with expansions and reductions) is called procyclic. An indicator varying oppositely to the aggregate economic activity (decreases with expansions and increases with reductions) is called countercyclic. Indicators having no clear patterns of behavior in relation to the phases of a business cycle are called acyclic. An indicator is called leading if its moving direction changes before that of the aggregate economic activity. A coincident indicator is an indicator, the peaks and troughs of which coincide with the peaks and troughs of the appropriate business cycle. And finally, a lagging indicator is an indicator the peaks and troughs of which occur later than the peaks and troughs of the appropriate business cycle [1, *375*].

The procedure for calculating a composite leading indicator is based on the idea of a reference indicator, which is often an industrial production index in practice. It is for this index that the peaks and troughs are determined and the whole system of leading indicators is constructed.

In the first step of data sampling and assessment a series of economic indicators is selected which could potentially be considered as constituent elements of the composite leading indicator. Both interval and point values of indicators may be used for calculations here. Interval indicators may be taken as point values obtained using the uncertainty center method.

An indicator can be leading if it:

- causes changes in the general economic dynamics through the changes in supply and demand;
- reflects the expectations of economic agents;
- responds to changes in economic activity earlier than an economy as a whole;
- has established itself as such in other countries.

Practically indicators should meet the following obvious requirements:

- there should be no abrupt and inexplicable jumps in their fluctuations;
- series should be sufficiently reliable and comparable throughout the analyzed period;
- the duration of series (a sufficient number of observation points without interruptions);
- information should be promptly updated (i.e. monthly and with minimal delays relative to the calendar month).

The theoretical criteria may include:

- availability of an economic substantiation for the inclusion of one or another indicator in the list;

- sufficient depth in the description of the selected economic process;
- maximum relevance of an indicator for Ukrainian economy.

Once selected, the indicators are conventionally divided into several groups: real economy, financial and external sectors. This classification allows the required breadth of data and assures a balanced representation of different indicators in the overall composite indicator.

Official statistical data for the previous month are traditionally published during the fourth week of the next month, so they can be incorporated into the calculations and used in making economic decisions a month after the expiration of the reporting period.

A completely different situation is observed when using quarterly data. In this case, the first publications of statistical information and, consequently, the calculation of the composite indicator of a business cycle appear with a delay of more than 3 months. This lag is potentially admissible in market economy and absolutely unacceptable for modern conditions where significant deviations and rates of the economic dynamics change are observed (3 months is a long-term period already) [12, *125*].

The second step includes the statistical treatment of the selected indicators. The selected indicators should be subject to standard methods of statistical treatment:

1. All indicators are standardized, i.e. indexed to the initial calculation basis.

2. The linear trend is eliminated from all indicator time series, i.e. a series is adjusted for changeability so that the indicators with more significant fluctuations and more significant month-to-month growth rate have no undue impact on the level of the indicator.

3. Using a moving average or other filters, seasonality should be removed from time series of most indicators.

4. The selected indicators are compared with the reference indicator using a crosscorrelation function with a time lag of ±15 months. Indicators with the highest correlation rates with a shift of +1 or more are checked for the significance of correlation. This is because the correlation coefficient is calculated for a limited number of observations and subject to random fluctuations in both the values, i.e. as any sampling indicator, it contains a random error and not always unambiguously reflects the truly actual relationship between the parameters under consideration.

The significance of the correlation coefficient is based on the comparison of the value *r* with its root-mean-square error [4, *211*]:

$$\frac{r}{\sigma_r} > 3. \qquad (1)$$

If there are enough observations and reasons to believe that the sampling was carried out from a normal population, the coefficient average error is calculated as follows:

$$\sigma_r = \frac{1-r^2}{\sqrt{n}}. \qquad (2)$$

If the value of ratio (1) is higher than 3 the correlation coefficient is considered to be significant and the connection is real. Indicators with the largest and statistically significant level of correlation are selected and formed to build a composite leading indicator model.

In the third step the selected indicators are grouped and their weights are calculated to be included into the composite leading indicator. The weighting coefficients calculation for the indicators is based on a specially developed weighing method which consists of the following steps:

1. Displacing all the selected leading indicators to the indicator with the smallest time lag relative to the reference indicator.

2. Calculating the growth chain indices for all the selected indicators and the reference indicator.

3. Using the mapping operator for countercyclic indicators ($r < 0$):

$$X'_j = (\overline{X_j} - X_j) + \overline{X_j}. \quad (3)$$

where X_j is the leading indicator for the reference indicator E; $\overline{X_j}$ is an average of the leading indicator X_j.

4. Carrying out a comparison of the chain indices of the selected leading indicators and the reference indicator based on the calculation of the square root of the squared difference of the chain index of the reference indicator E_t / E_{t-1} and that of the leading indicator $X_{j\,t} / X_{j\,t-1}$:

$$d_{j_t} = \sqrt{\left(\frac{\mathrm{E}_t}{E_{\mathrm{t-1}}} - \frac{\mathrm{X}_{jt}}{X_{j\,\mathrm{t-1}}}\right)^2}. \quad (4)$$

5. The weighting coefficients w_j are calculated based on the assumption that the weight of a factor should be greater at lower values of the roots d_{jt} of the squared difference of the chain indices of the leading indicators and the reference indicator, while the sum of the weighted coefficients should be $\sum \mathrm{w}_j = 1$:

$$\mathrm{w_j} = \frac{2\sum_{\mathrm{j=1}}^{\mathrm{p}}\sum_{t=1}^{n} d_{j_t}}{\sum_{t=1}^{n} d_{j_t} \times \sum_{j=1}^{p} \frac{2\sum_{\mathrm{j=1}}^{\mathrm{p}}\sum_{t=1}^{n} d_{j_t}}{\sum_{t=1}^{n} d_{j_t}}}, \quad (5)$$

where n is the number of series in E; p is the number of the selected leading indicators.

Using this technique gives more reasonable weighting coefficients for the model parameters than expert evaluations used to calculate the leading indicator in the US or to weight coefficients on the basis of a correlation matrix proposed in [12] by A. Frenkel, N. Rayskaya, Y. Sergiyenko.

On receiving the weighting coefficients w_j the theoretical variety is calculated on the basis of the linear combination of the selected leading indicators X_j with various time lags:

$$LEI' = w_1 X_1^{L_1} + w_2 X_2^{L_2} + \ldots + w_j X_j^{L_i}, \quad (6)$$

where i is the time lag of X_j of the structural element.

In the final step a regression model of the reference indicator dependence $E = f(LEI`)$ is constructed, the trend obtained in the second step of the method is added.

In the fourth and the final step the obtained theoretical series based on the composite leading indicator model

$$LEI = abw_1 X_1^{L_1} + abw_2 X_2^{L_2} + \ldots + abw_j X_j^{L_j} + bc, \quad (7)$$

with *a, c* denoting the parameters of the regression model and *b* denoting the linear trend parameter; is compared with the industrial production index on the basis of correlation calculation; the obtained correlation coefficients are tested for statistical significance (1).

When using the composite leading indicator for forecasting a recession it is possible to rely on the six-month rule and the C. Romer criterion by which an economic depression occurs after a 40% cumulative decline of real industrial production output over a month. According to the six-month rule, when the industrial production index falls a recession occurs within 6 months [13, *83*]. The empirical study of NBER shows that the decline of the index within 3 months increases the probability of a recession in the next 6 months [14].

In carrying out the first step of the developed procedure for constructing a composite leading indicator, the possible set of indicators consisting of 29 indicators was formed and grouped; the data used were taken from the websites of the State Statistics Commitee Service of Ukraine [5], the National Bank of Ukraine [9], the International Centre for Policy Studies [7], the International Monetary Fund [2]. For the research, the data were collected for most selected indicators from January 2005 to December 2011.

Thereafter, indexation of all the indicators was carried out, with the initial level of each indicator (i.e. January 2005) taken as the indexation base (100%).

Trend equations were calculated for all the indicators with further elimination of trends from the initial series. The resulting series were smoothed by the moving average with a smoothing "interval" equal to 5.

The next step is to check the correlation between the reference index and each indicator with time lags of ±15 months.

The following indicators were taken as leading: number of the unemployed registered; financial result from ordinary activities before taxation; interest rates on loans to the real sector of economy; lending to residents; world price index of metal; cast iron and steel output; total trading volume on the FSTS (the First Stock Trading System) per month; NBU discount rate; consumer sentiment index; consumer expectations index; the FSTS stock index; producer price index. Table 1 groups these indicators and gives the characteristics necessary for the inclusion of the indicators as components into the composite leading indicator model.

As a result of the analysis of all the indicators mentioned in Table 1, the following indicators were selected as leading indicators to be included in the composite leading indicator model: number of the registered unemployed; interest rates on loans to the real sector of economy; world price index of metal; cast iron and steel output; consumer sentiment index; and the FSTS stock index.

To estimate the weighting coefficients chain indices were calculated and compared with those of the reference indicator (due to their acyclicity the indices of the interest rates on loans to the real sector of economy and the number of the registered unemployed were "mapped" using the mapping operator) based on (3). All conducted steps made it possible to calculate the weight indices; the results are given in Table 2.

Table 1. **Indicators leading the industrial production index** *(developed by the authors)*

Indicator	*Sector of the economy*	*Lag, months*	*Correlation coefficient*	*Correlation coefficient significance*	*Procyclic / countercyclic*
Number of the registered unemployed, ths persons	real	2	-0.664	-5.537	countercyclic
Financial result from ordinary activities before taxation, mln UAH	real	2	0.743	6.195	procyclic
Interest rates on loans to the real sector of economy, %	financial	4	-0.726	-5.419	countercyclic
Lending to residents, mln UAH	financial	4	-0.551	-4.110	countercyclic
World price index of metal, USD	external	2	0.683	5.691	procyclic
Cast iron and steel output, ths tons	real	3	0.795	6.622	procyclic
Total trading volume on the FSTS for a period, mln UAH	financial	5	0.846	5.564	procyclic
NBU discount rate, %	financial	8	-0.672	-5.376	countercyclic
Consumer price index, %	real	10	-0.647	-5.092	procyclic
Consumer sentiment index (International Centre for Policy Studies)	real	4	0.735	6.075	procyclic
Consumer expectations index (International Centre for Policy Studies)	real	5	0.666	5.460	procyclic
The FSTS stock index	financial	5	0.846	5.545	procyclic
Producer price index, %	real	10	-0.716	-5.641	countercyclic

Table 2. **Weighting coefficients for the composite leading indicator components** *(obtained by the author)*

Indicator	*Weighting coefficient*
Number of the registered unemployed, ths persons	0.1105
Interest rates on loans to the real sector of economy, %	0.1113
World price index of metal, USD	0.1982
Cast iron and steel output, ths tons	0.2052
Consumer sentiment index (International Centre for Policy Studies)	0.1995
The FSTS stock index	0.1753

The initial model of the composite leading indicator (without the trend) has the form:

$$LEI' = 0.1982 \times I_M^2 + 0.2052 \times V_M^3 + 0.1995 \times I_C^4 + \\ + 0.1753 \times I_S^5 + 0.1113 \times P^4 + 0.1105 \times U^2, \quad (8)$$

where U is the index of the registered unemployed; I_M is the world price index of metal; V_M is the index of cast iron and steel output in Ukraine; I_C is the consumer sentiment index; I_S is the FSTS stock index; P is the index of the average interest rate on loans to the real sector of economy; the superscript denotes the leading time lag for the reference indicator.

The regression analysis of the dependence of the reference indicator on the composite leading indicator $E = f(LEI`)$ led to the equation

$$E = 1.379 \times LEI' - 57.09. \quad (9)$$

The calculated regression equation is statistically significant, $R^2 = 0.819$.

Taking the incline angle of the trend $y = 2.4437 \times t$, which has been eliminated, and equation (9) into account, we obtain the composite leading indicator:

$$LEI^2 = 0.2733 \times I_M^2 + 0.2829 \times V_M^3 + 0.2751 \times I_C^4 + \\ + 0.2417 \times I_S^5 + 0.1534 \times P^4 + 0.1523 \times U^2 + 2.4437 \times t - 57.09, \quad (10)$$

where $t_{01.2005} = 1$ is the time parameter.

Figure 1 shows the charts of the developed composite leading indicator with the anticipated value for two months in advance (*LEI*), the seasonally adjusted industrial production index, and the initial industrial production index.

In the final step the forecasting capabilities of the composite leading indicator were verified; the correlation coefficient between the initial index of industrial production and the developed indicator with a shift for two months in advance is 0.9658, which shows a substantial relation between the indicators; the coefficient of the average error of approximation is 4.33%, which shows a high degree of probability to forecast the business activity in Ukraine. The composite leading indicator makes it possible to forecast the level of the business activity in Ukraine for 2 months in advance with high accuracy, as well as to predict a recession and depression using the criterion of C. Romer and the six-month rule.

Based on the index dynamics study a conclusion is made that there is a trend to the slowdown and decrease in the business activity in Ukraine, which can be confirmed by the reports on the slowdown in the GDP this January and February.

In the future, it is of interest to improve the obtained model through:

- annual adjustments associated with the rapid variability of the macroeconomic situation in Ukrainian economy;
- implementation of additional components;
- employment of new tools to analyze the initial time series;
- enlargement of the information base with a sufficient number of episodes and repeats.

The developed indicator can also be used to diagnose the sustainability of economic development of Ukraine because assuring the sustainable economic development is one of the most important issues [8].

In general understanding the sustainability of the economic system development characterizes its ability to respond to internal and external shocks while retaining its structure and dynamic behavior in the direction of steady growth over a certain period of time.

It is suggested to use the composite leading indicator and the moving coefficient of variation calculated on its basis (with a rolling window of more than 6 months which is C. Romer's condition) to diagnose the economic development sustainability of Ukraine. The use of the variation coefficient in this case helps to determine the development trend sustainability in dynamics. The rolling coefficients of variation are calculated based on the assumption that sustainability implies the stability of the dynamic parameters of system development and functioning over the whole time interval under consideration. If the variation parameters are preserved the development is sustainable.

The sustainability coefficient of the rolling coefficients of variation is calculated as follows:

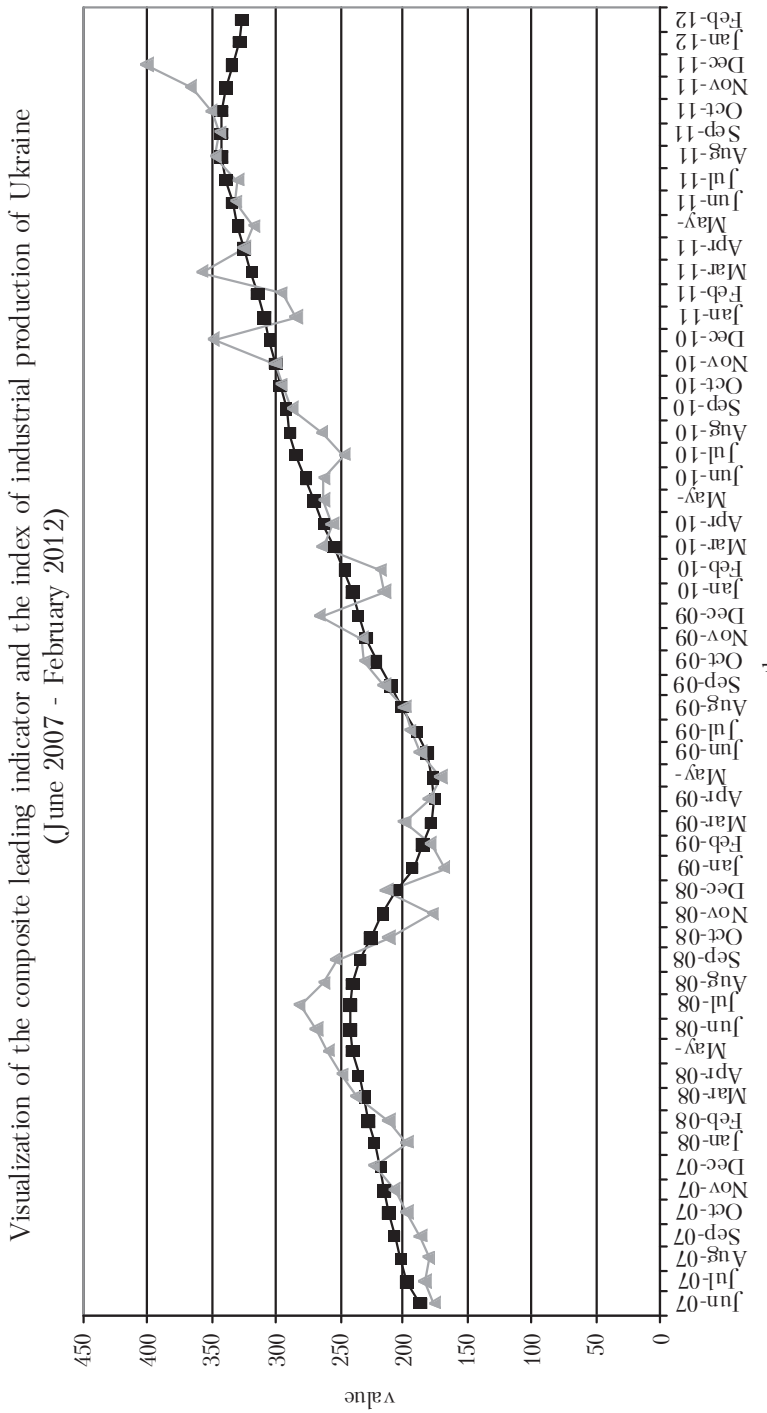

Figure 1. **Visualization of the forecasting capabilities of the composite leading indicator (shift of the composite leading indicator for 2 months in advance)**

$$U = 1 - \sqrt{\frac{\sum_{i=1}^{n}(V_i - \overline{V})^2}{n}} \Big/ \overline{V}, \qquad (11)$$

where V_i is the value of the rolling coefficient of variation of the composite leading indicator in the period i; $\overline{V}$ is the average value of the rolling coefficients of variation of the composite leading indicator.

If $1 < U \le 0.9$ than the process is strongly sustainable; if $0.9 < U \le 0.8$ the process is sustainable; if $0.8 < U \le 0.6$ the process is weakly sustainable, and if $0.6 < U$ the process is unsustainable [3].

At the moment, the value of the sustainability indicator for the economy of Ukraine is $U = 0.663$, which indicates unsustainable development of the dynamics of Ukrainian economy and the crisis phenomena in 2008–2009. Consequently, the theoretical and empirical studies show a close correlation between the sustainability and growth of the economy. The economy cannot grow if macroeconomic environment is unsustainable. It may be concluded that unlike other more developed countries Ukrainian economy was not prepared for the crisis of 2008–2009. This resulted in the changes in the structural and dynamic characteristics of the economic system development. Therefore, in the future there is an objective need to study the shock factors influencing the sustainability of the economic system development of Ukraine and to elaborate recommendations to overcome the detrimental effect of these destabilizing factors.

Conclusions. Analyzing the above mentioned, the following can be concluded:

1. A composite leading indicator model was obtained; it is based on the statistical analysis of leading relationships and weighting coefficients which are criteria of sensitivity to the upcoming business environment changes; in comparison with already known models of leading indicators, it allows short-term forecast performance for the changes in the economic activity of Ukraine.

2. In the future, it is of interest to improve the obtained model through annual adjustments associated with the changes in the macroeconomic situation of Ukraine; implementation of additional model parameters and revision of existing components; employment of new tools for statistical treatment and modeling; enlargement of the information base with a sufficient number of episodes and repeats.

3. A procedure for diagnosing the sustainability of the economic development of Ukraine was obtained; it is based on the composite leading indicator calculation and the hypothesis that sustainability implies the stability of dynamic parameters of economic system development and functioning over the whole time interval considered. Using the procedure it is possible to diagnose and forecast the sustainability of the economic development dynamics of Ukraine.

References:

1. *Абель Э., Бернанке Б.* Макроэкономика / Пер. с англ. – СПб.: Питер, 2010. – 768 с.

2. Агентство з розвитку інфраструктури фондового ринку України // www.smida.gov.ua.

3. *Башина О.Э., Спирин А.А.* Общая теория статистики: статистическая методология в изучении коммерческой деятельности. – М.: Финансы и статистика, 2011. – 440 с.

4. *Громыко Л.Г.* Теория статистики. – М.: ИНФРА-М, 2002. – 414 с.

5. Державна служба статистики України // www.ukrstat.gov.ua.

6. *Лук'янихіна О.А., Панасовський Ю.В. , Мудрик Є.А.* Організація, технології та механізм антикризового управління підприємством // Проблеми і перспективи розвитку банківської системи України: Зб. наук. праць. – №26. – Суми, 2009. – С. 260–266.

7. Міжнародний центр перспективних досліджень // www.icps.com.ua.

8. *Мірошніченко Т.С.* Основні поняття стійкості економічного розвитку // Економічний вісник Донбасу. – Вип. 3. – Луганськ, 2011. – С. 37–41.

9. Національний банк України // www.bank.gov.ua.

10. *Сацик В.* Циклічність економічного розвитку України // Економіст.– 2005.– №5. – С. 80–83.

11. *Столярчук М.* Особливості антикризового управління підприємством з позиції теоретико-методологічного аналізу // Вісник Львів. нац. ун-ту.– Економічна серія.– 2008.– №40. – С. 230–232.

12. *Френкель А.А., Райская Н.Н., Сергиенко Я.В.* Использование интегральных индексов в анализе циклических изменений российской экономики // Материалы междунар. науч. конф. по проблемам развития экономики и общества (Москва, 6–8 апр. 2010 г.). – М., 2010. – С. 125.

13. *Чевычелова Е.С.* Подходы к анализу неопределенности среды функционирования предприятия при осуществлении адаптивного стратегического планирования // Экономика, менеджмент, предпринимательство: Сб. науч. трудов. – №21. – Луганск, 2009. – С. 37–43.

14. *Янч Э.* Прогнозирование научно-технического прогресса: Науч. изд. – М.: Прогресс, 1980. – 568 с.

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