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THE ANALYSIS OF CYCLIC RECURRENCE OF NATIONAL ECONOMY DEVELOPMENT

Abstract. The paper deals with fundamental problem of economic development in terms of its complex and nonlinear character, compound form as a combination of general evolutionary trend and cyclic components. Specific importance of cyclic recurrence as both ordering and fluctuating element of Ukrainian economic dynamics is stressed. Based on harmonic analysis Fourier and formed line spectrums, medium-term industrial cycle is determined among cyclic components of Ukrainian economic dynamics. General cycle's characteristic of amplitude, frequency, phase and time-period are formulated. Math and graphic description of cyclic regularity of developmental macroindicators are given. In context of balanced development, comparing analysis of national and global economies dynamics is made.

Keywords: development, economic dynamics, GDP, cyclic recurrence, harmonic analysis Fourier, line spectrum, cycle's characteristics

Formulas: 3, fig.:10, tabl.: 4, bibl.:38

JEL Classification: E32, E37, O11, O57

Introduction. Economic development is directed temporally continuous process accompanied by undulate motion of economic elements' totality and their structural proportions. Generating the complex structure of waved developmental character, reversible changes stand out against the background of evolutionary transformations. According to long-term dynamics of economic indicators, national economies repeat some stages with renovated characteristics during their evolution. Scientists call such processes as a cyclic recurrence. For the first time being determined in the works of C. Marks, C. Juglar, M. Tugan-Baranovskiy, N. Kondratieff cycle, as a regular repeatability of the XIX century industrial crises, becomes fundamental essential pattern of economic development in XX-XXI centuries.

The research of various economic cycles, their historical chronology, shape, structure and nature of origin has a vital importance for understanding of the modern stage of world and national economic development; for definition deep reasons of originating and unfolding mechanism of global crises in the past; for prediction and prevision potential socio-economic shocks in the future. It means that solving the whole series of problems relies on the analysis of cyclic developmental regularities.

Literature review and the problem statement. The cyclic recurrence of national economic development includes wide spectrum of interconnected problems and serves as a field of attention for numeral economists' generations. The great part of foreign scientific researches is formed by works of J. Goldstein [Goldstein 1988], M. Hirooka [Hirooka 2006], A. Maddisson [Maddisson 2003], G. Mensch [Mensch 1979], G. Modelski [Modelski 2006], W. Rostow [Rostow 1978]. Extending Kondratieff's tradition, Russian school of long-waved periodicity is developing nowadays. As for investigation of periodization and K-cycles forming mechanism, S. Glasiev's [Glasiev 1993] and Yu. Yakovets's [Yakovets 1984] works are to be mentioned. An important contribution in the research of the reasons for long waves and unevenness of development is made by A. Akaev [Akaev 2011], S. Rumyantseva [Rumyantseva 2012]. Speaking about systematization of statistical and mathematical methods of separation cyclic component out of long-termed dynamic, it is possible to highlight A. Fomina's [Fomina 2005], A. Korotaev's, S. Tsirel's [Korotaev, Tsirel 2009] works. Besides, important problems of state regulation are established in studies of K. Zoidov [Zoidov 2012] and others. Wave oscillations' questions are studied by national scientist in terms of technological multiplicity and innovative character of development [Fedulova 2015], [Geets 2006], [Kravchenko, Kvilinskiy 2016], of understanding developmental megatrends of national economy [Basilevich 2012], of variability and sustainability economic-institutional organization [Dement'ev, Dalevska 2011] and others.

Relying on such fundamental methodological base and conceptual apparatus of the cycle and crisis

theory, the long-termed waved dynamic conception, it is necessary to concentrate exactly on an ambivalent character of cyclic recurrence. On the one hand, cycle periodicity, as constant alternation of growth and drop phases, takes the form of ordered and structured element of development. On the other hand, recurrence, as a regular repeatability of developmental collapses, shows itself in imbalance and volatility of development. Such dual view makes topical the research of cyclic component of economic dynamic as a national economy's development phenomenon, definition of its presence, analysis of its shape and structure. These are the main objectives of the paper.

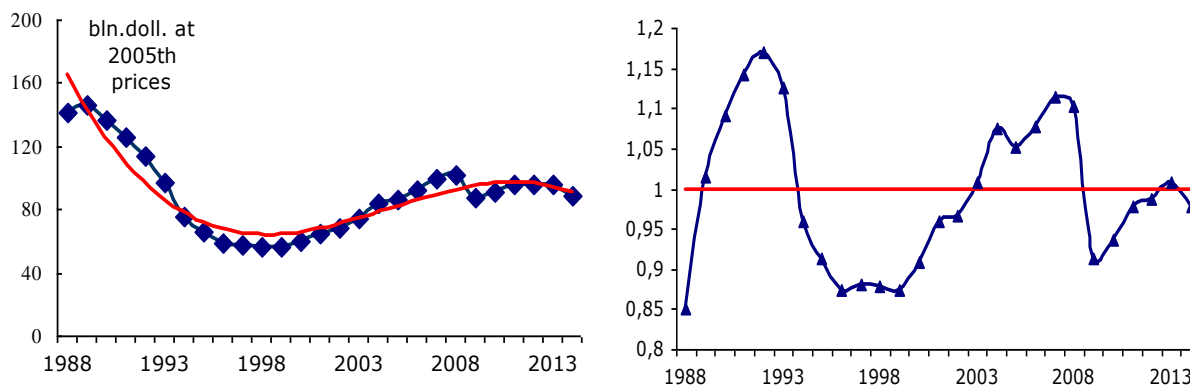


Figure 1 – Wave dynamics of Ukrainian GDP at constant 2005 prices along its polynomial trend (A) and evaluation of its cycle component (B)

Source: own development based on data of World Bank Official Databases, 2016

Research results. Wide-accepted form of modern development of equal global and national economies is undulate. It shows itself in periodic oscillations of macroeconomic indicators around their evolutionary trend; that is represented in fig.1 (A). Cycles of variable duration can be established in dynamics of GDP, technological innovations, indexes of industrial output, inflation rates, etc. Compound shape of development is explained by sum of numerous waves with different amplitudes and frequencies, which are superimposed one on another and define such result that is represented in fig.1 (B).

For Ukrainian economy, which during short – on the scale of a country – time period has passed through formation stage by fundamental economic-organizational changing, subsequent transformational crisis and joining the global social and economic space, dynamic oscillations are characterized by intensity, rapidity and wide amplitude. From this point of view singling the cyclic recurrence, periodicity, regularity out of stochastic 'fluctuating' noise becomes complicated but major objective. In accordance with this, essential developmental patterns could be found, and so relevant measures of stabilizing policy could be used by the government for effective regulation of this complex process. Extracting scientifically proved classical cycles of economic dynamics, description of its modern stage in terms of the cycles' theory gives an opportunity to apply totality of methods being saved by world economics during last two centuries and being historically tested by leading economically developed countries.

Speaking about complexity and large scale of researched question, certain requirements are to be formed for selecting efficient instruments of estimation and description of cyclic recurrence. Among them, there are confined lifetime frames of the analyzed object (only 25 years of existence of Ukrainian economy) and specific character of economic time series as the information carrier of analyzed object (their nonstationary and discrete form, potential changing of dimensions scale, etc). It is necessary to highlight the harmonic analysis amid well-known approaches to modeling and estimating of cyclic regularity of economic processes. This method could be used to deal with short-long time series of actual data, in which cyclic oscillations are noised with mean trend and trend of dispersion. It gives appropriate results for next activities such as prognostication or valuation of process structure. The possibility of forming models of nonstationary processes without previous trend estimation and series filtration is also to be referred to harmonic analysis' advantages. High speed of calculations – both for model itself and for next model estimation – is characterized by such harmonic models. Highlighted opportunities are certainly important for the dynamics series of Ukrainian economy.

According to the wide-world scientific practice, essentiality of the cyclic component is defined with observance requirements of noticeability, comprehensiveness and pithiness [Bessonov 2003]. Basing on the statement that determined cycles have to stand out against background of other components of economic dynamics strongly enough, it is possible to conclude the following. Being formed with harmonics that make the most significant contribution to the total cyclic dynamics, cycles are regarded as meaningful.

Requirement of generality supposes that determined cycles have to become apparent among different parts of national economy and have to be of total character. Taking into account demand of pithiness, defined cyclic recurrence of Ukrainian economy could be compared with well-known short-term 3-4 years lasting G. Kitchin's cycles, medium-term 8-10 years lasting C. Marks' industrial cycles, 10- years lasting economic K. Juglar's cycles, 15-20 years lasting S. Kuznets' cycles.

So, the research of cyclic component of developmental dynamics of Ukrainian economy is realized in the growth cycles' concept with methods of harmonic analysis supplemented with Fourier's line spectrum. For time series analysis a wide applied in national practice functional software AtteStat (version 12.5.0) as a superstructure for the MS Excel has been used. In terms of selected estimated method, objectives of cyclic recurrence analysis are brought to identification of this dynamics component; to its description with frequency response; to definition its shape and duration; to its math modeling with the help of poly-harmonic patterns based on Fourier transform.

For getting the most reliable results of estimation and satisfying requirements mentioned before, time series of macroeconomic indicators from different parts of economy and during the maximum period are established in the table 1. In compliance with world practice, the dynamics of national GDP is poly-harmonic oscillatory process with compound structure of different waves of various lengths, which define general form and intensity of economic development. On the one hand, it characterizes the general phase of economy development and unfolding of long-waved process. At the same time, GDP dynamics combines all totality of casual factors for long cycle which become apparent in shorter duration oscillations of scientific and technical, financial, resourcing and infrastructural sphere [Fomina 2005].

Results of harmonic analysis of annual GDP growth rates of Ukraine during the period from 1988 to 2014 years are represented in the table 2. The sum total of 13 harmonics has been received. Among them, the most essential ones have been selected, basing on indicator of average capacity being calculated according to Parseval's theorem [Jenkins, Watts 1971].

Amplitude and frequency characteristics of analyzed dynamics series are figured in the form of Fourier's line spectrum, which reflects the structure of total dynamics of GDP that is represented in fig.2. So, the overtone, second and seventh harmonics are characterized by the greatest 'power contribution'. It is evidence of the fact that form, intensity and nature oscillations of Ukrainian GDP rates of growth – as general measurement of Ukrainian economic development – are described by waves of cycles with duration of 27, 14, 4 years.

Table 1 – The Dynamics of Macroeconomic Indicators of Ukrainian Economy during 1988-2014

Time series	GDP growth, Annual Rate of Growth - Percentage	Exports of goods and services, Annual Average Rate of Growth - Percentage	Imports of goods and services, Annual Average Rate of Growth - Percentage	Gross fixed capital formation, at current prices - US Dollars	Inflation (GDP deflator), Annual Rate of Growth - Percentage	Industry, value added - constant 2005 US Dollars
1	2	3	4	5	6	7
1988	2,6	n/a	n/a	n/a	1,72	n/a
1989	3,9	n/a	n/a	n/a	3,9	n/a
1990	-6,3	n/a	n/a	22,6	16,3	53,9
1991	-8,4	-17,2	-25,9	18,9	95,6	48,5
1992	-9,7	-47,3	-47,1	22,4	1761	40,2
1993	-14,8	-10,8	-34,7	17,6	3335	31,3
1994	-22,8	10,4	35,9	13,4	953,5	20,4
1995	-12,1	1,1	-4,6	11,8	415,8	17,4
1996	-9,9	16,9	15,8	9,7	66,2	15,7
1997	-3,2	-5,4	-4,6	10,4	18,1	15,1
1998	-1,8	1,2	2	8,6	12	15
1999	-0,2	-2,2	-16,7	6,4	27,4	15,7
2000	5,9	21,5	23,8	6,4	23,1	17,4
2001	9,2	-2,1	2,2	7,8	9,95	19,9
2002	5,3	7,4	3,7	8,5	5,1	21,3
2003	9,5	10,6	3,3	10,7	8,2	22

End of table 1

1	2	3	4	5	6	7
2004	11,8	22,7	15,5	15,1	15,2	24,5
2005	3,1	-12,2	2,1	19,6	24,6	24,5
2006	7,6	-5,8	6,8	27,3	14,9	26,3
2007	8,2	3	19,9	40,4	22,8	29,1
2008	2,2	5,7	17	48,8	28,6	27,4
2009	-15,1	-22	-38,9	22,3	13,1	22,1
2010	0,3	2,3	11,1	25,5	13,8	24,2
2011	5,5	3,1	15,4	31,1	14,2	27,9
2012	0,2	-5,5	3,8	35,5	7,8	27,9
2013	0	-7,4	-3,5	33	4,3	26,9
2014	-6,8	-22,8	-22,1	18,5	14,7	23

Source: [World Bank and International Monetary Fund Official Databases 2016]

As a result of harmonic and spectrum analysis graphic model of cyclic component of economic series of GDP is built. It is formed as a sum of defined before harmonics and determines shape and structure of real national economy dynamic; that is represented in figure 3.

For the opportunity of next prognostication, the graphic model of the dynamic Ukrainian GDP rates of growth (fig. 3, red line) could be described with main formulas of discrete Fourier transform [Jenkins, Watts 1971]. According to results of harmonic analysis, general parameters of each from m -harmonic – amplitude (R_m), frequency (f_m), initial phase (φ_m) and oscillation period (T_m) – have been formed in table 2.

Table 2 – The Fourier Harmonic Analysis Results

Time series		Annual Rate of GDP Growth during 1988-2014						
Number of spots		27						
The method		The Fourier Harmonic Analysis						
Number of spots		13						
COS-Coefficient A_m	SIN-Coefficient B_m	Amplitude R_m	Phase φ_m	m -harmonic	Contribution to the RMS, %	Contribution to RMS, Unit weight	Frequency, cycle per year f_m	Cycle duration years T_m
-1,329	0,000	1,3	0	0 average	1,77	0,59	0,00	
-3,328	-7,741	8,4	-67	1 overtone	142,01	47,7	1/27	27,00
5,320	2,782	6,0	-28	2 harmonic	72,08	24,2	2/27	13,50
0,879	1,587	1,8	-61	3 harmonic	6,58	2,21	1/9	9,00
-1,409	-0,828	1,6	-30	4 harmonic	5,34	1,79	4/27	6,75
-1,940	-1,061	2,2	-29	5 harmonic	9,78	3,28	5/27	5,40
-1,437	1,974	2,4	54	6 harmonic	11,92	4,00	2/9	4,50
-1,167	3,156	3,4	70	7 harmonic	22,64	7,60	7/27	3,86
0,984	-0,211	1,0	12	8 harmonic	2,02	0,68	8/27	3,38
-1,105	-2,139	2,4	-63	9 harmonic	11,60	3,90	1/3	3,00
-0,127	-0,794	0,8	-81	10 harmonic	1,29	0,43	10/27	2,70
-1,455	-0,228	1,5	-9	11 harmonic	4,34	1,46	11/27	2,45
-1,544	0,327	1,6	12	12 harmonic	4,98	1,67	4/9	2,25
0,828	0,030	0,8	-2	13 harmonic	1,37	0,46	13/27	2,08
Total sum					297,73	100		

Source: compiled by the author based on own research

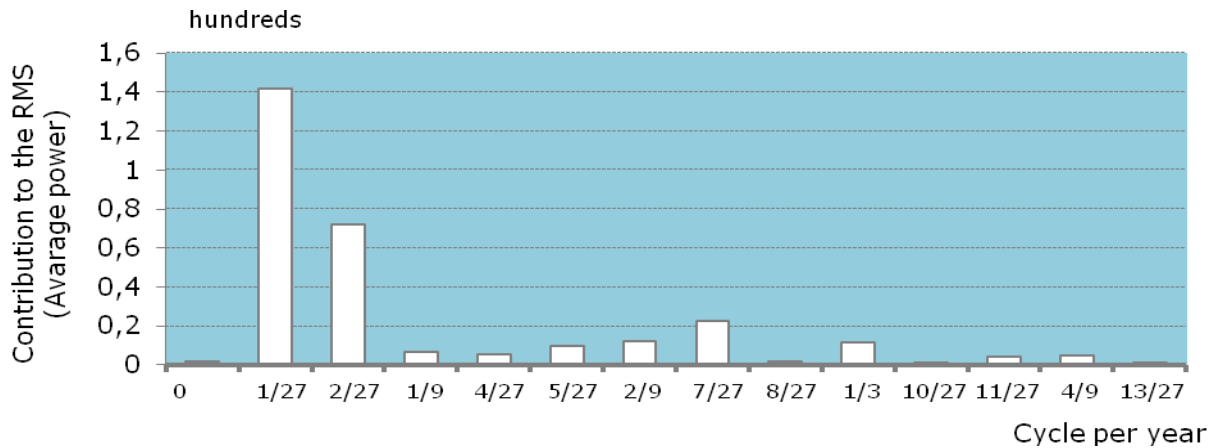


Figure 2 – Fourier’s Line Spectrum of Ukrainian GDP Dynamics during 1998-2014

Source: own development

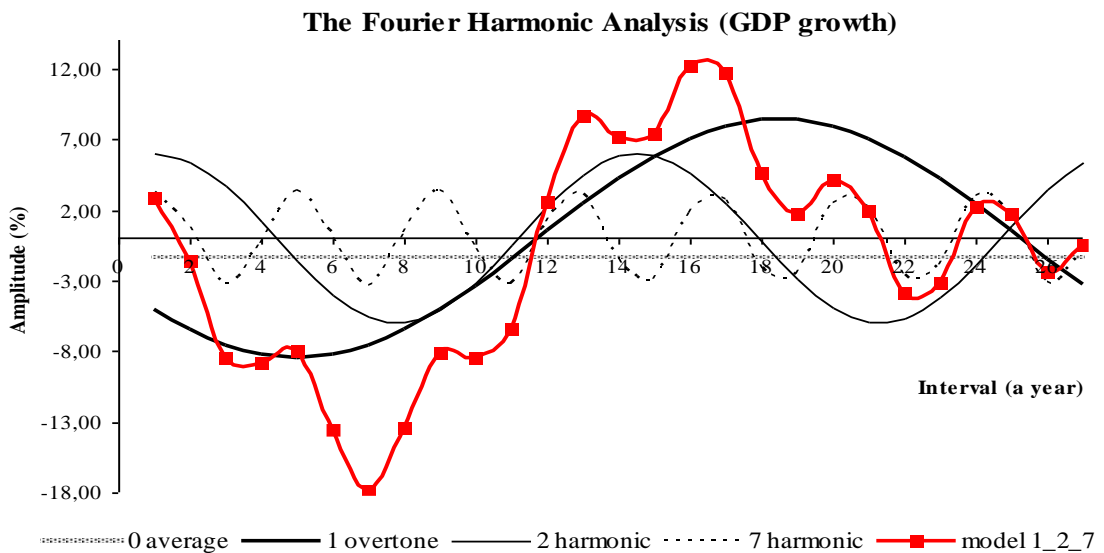


Figure 3 – Modeling of national GDP economic dynamic

Source: own development

In terms of harmonic analysis any real time series of economic dynamics could rate as a signal which is determined in discrete time moments in equal intervals r ($r = -n, \dots, 0, 1, \dots, n-1$) with duration Δ . Total period of signal recording is marked as T . Formed on the ground of Fourier transform (formulas 1-2), discrete function s_r becomes approximation to real series of dynamic in the interval $-T/2 \leq r \leq T/2$.

For the signal with even quantity of values (if $N=2n$):

$$s_r = R_0 + 2 \sum_{m=1}^{n-1} R_m \cos\left(\frac{2\pi m}{N} r + \varphi_m\right) + R_n \cos\left(\frac{2\pi n}{N} r\right), \quad (1)$$

N – quantity of values of determined signal s_r , $N=T/\Delta$

For the signal with odd quantity of values (if $N=2n-1$):

$$s_r = R_0 + 2 \sum_{m=1}^{n-1} R_m \cos\left(\frac{2\pi m}{N} r + \varphi_m\right) \quad (2)$$

So, total time series duration of actual Ukrainian GDP dynamic during 1988-2014 years comes to 27 years. Length of series fragmentation interval $\Delta=1$ year, quantity of values $N=27/1=27$. According to formula 1 and data of table 2, approximated function s_r or dynamic model is formed (formula 3).

$$s_r = 1,329 + 16,8 \cos\left(\frac{2\pi}{27} r - 67^\circ\right) + 12,0 \cos\left(\frac{4\pi}{27} r - 28^\circ\right) + 6,8 \cos\left(\frac{2\pi}{3} r + 70^\circ\right) \quad (3)$$

Taking into account that sum contribution of an average, overtone, second and seventh harmonics into distribution of 'energy' of the function s_r in frequencies comes to 81%, it is possible to conclude that this model is well-approximated and can be used for further prediction. Results of cyclic estimation and graphic modeling of selected in table 1 in order to economic practicability and informative capability macroindicators are given in the table 4 and in figures 4, 5 accordingly.

Table 4 – Amplitude-frequency characteristics of time series

Time series	Amplitude R_m	Phase Φ_m	m-harmonic	Contribution to the RMS, %	Contribution to the RMS, Unit weight	Frequency, cycle per year f_m
Gross fixed capital formation, at current prices - US Dollars, 1990-2014	13,29	51	1 overtone	40	1/25	25,0
	3,90	2	2 harmonic	3	2/25	12,5
	4,41	-54	5 harmonic	4	1/5	5,0
Inflation (GDP deflator), Annual Rate of Growth - Percentage, 1988-2014	1,43	83	1 overtone	17	1/27	27,0
	1,68	3	2 harmonic	24	2/27	13,5
	0,88	-57	3 harmonic	6	1/9	9,0
	0,76	51	4 harmonic	5	4/27	6,8
Industry, value added - constant 2005 US Dollars, 1990-2014	8,31	10	1 overtone	14	1/25	25,0
	7,35	-63	2 harmonic	11	2/25	12,5
	4,54	-89	3 harmonic	4	3/25	8,3
Exports of goods and services, Annual Average Rate of Growth - Percentage, 1991-2014	11,49	3	1 overtone	28	1/24	24,0
	8,69	-53	3 harmonic	16	1/8	8,0
	7,84	-5	7 harmonic	13	7/24	3,4
	6,13	2	11 harmonic	8	11/24	2,2

Source: compiled by the author based on own research

Economic interpretation of received totals could be used as a base for general and individual conclusions. With some science caution and restraint it is possible to affirm the following. The hypothesis about existence both short-term and medium-term cycles of national economy development are being proved by steady spikes at the diagrams of Fourier line spectrum that is given in fig. 5. Industrial dynamics as a main sector of Ukrainian economy gives two medium-terms cycles (8.3 and 12.5 years). Their duration coincides with 8th-12th years C. Marks' cycles, which he connected with renovation of fixed capital. The same cycle could be observed in the dynamics of Gross fixed capital formation, which, according to reproduction structure of national economy, is mainly formed in Ukrainian industry. Exactly this cycle is responsible for formed periodicity of general indicator dynamic of Ukrainian economic development – Gross Domestic Product. This could be explained with key role of industry for the modern stage of Ukrainian development. Ukraine is referred to industrial type economies.

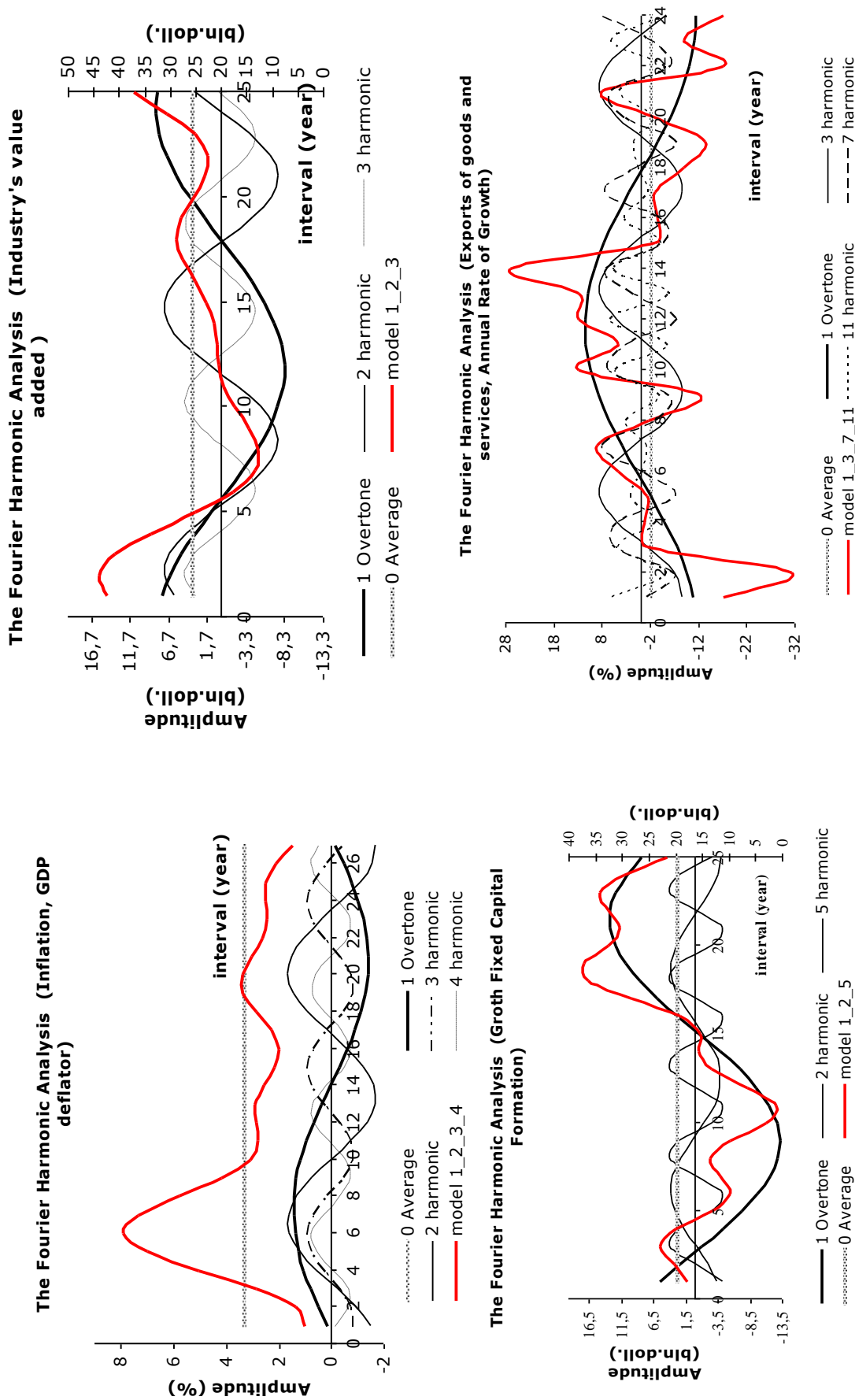


Figure 4 – Harmonic models of macroeconomic indicators of Ukraine economy development: graphic description

Source: own development

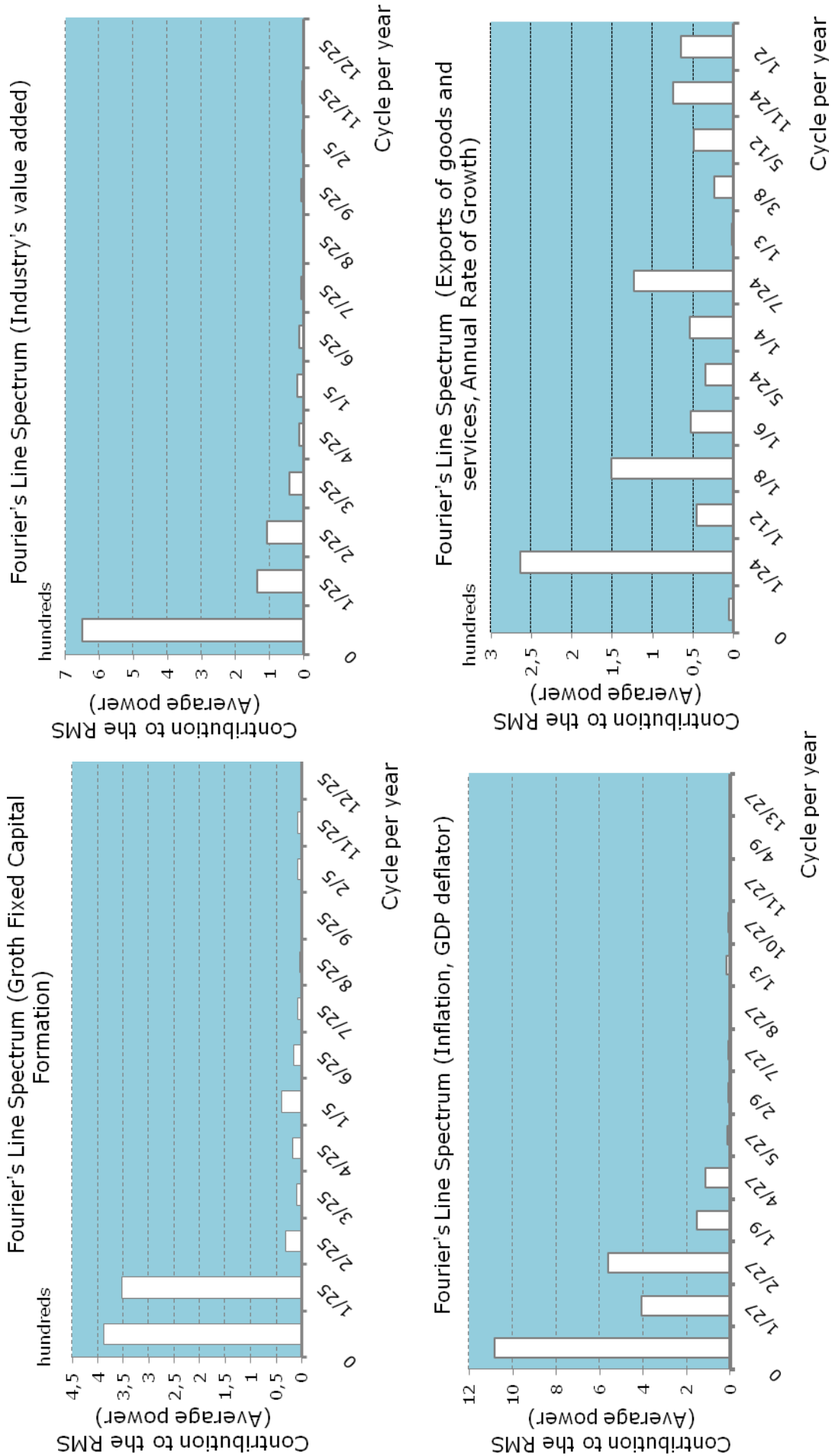


Figure 5 – Macroeconomic indicators of Ukraine economy's development: amplitude and frequency characteristics

Source: own development

For getting more detailed conclusions based on results of harmonic analysis it is expedient to compare the most important harmonics of economic dynamics that is represented in fig.6. It will make possible to contrast obviously the phase characteristics, sense connected economic time series.

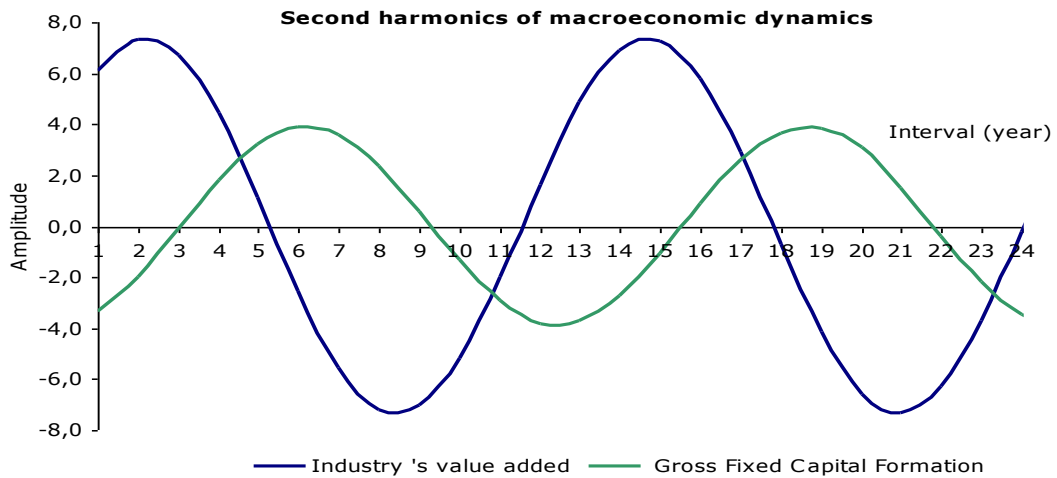


Figure 6 – The phase comparison of essential harmonics of time series of Ukrainian macroeconomic dynamic

Source: own development

Therefore, according to figure 6, the dynamic of Industrial value added moves in antiphase mode and with some time-gap with respect to Cross-fixed capital, being concentrated mainly in industry. The phase of industry production falling concurs with growth phase of Gross fixed capital dynamics. Such tendency simultaneously with high rate of fixed capital depreciation (77.3% in the 2013th according to official statistic data) is extremely negative cyclic pattern of Ukrainian economy development. This situation could be interpreted as increase of investments in industry of outdated technologies that takes negative influence on effective redistribution of the capital and reduces acting of natural renovating mechanism of the crisis.

Speaking about dynamics of Ukrainian economy, it is necessary to admit that it is submitted to certain cyclic patterns. Among them industrial cycle is considered to be key and deciding one for its development. If detected developmental tendencies and motion direction of national economy are maintained, a picture of future economical of development of Ukraine can be illustrated by next results modeled on base of harmonic analysis (fig 4, 5) dynamics of macroeconomic indicators that is represented in fig 7.

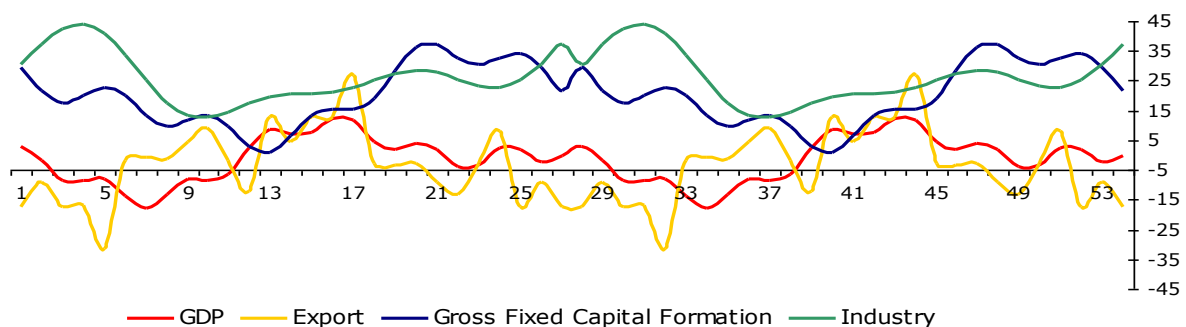


Figure 7 – Modeled cyclic dynamics of macroeconomic indicators of Ukraine during 1988-2041 (the extrapolated prognostication)

Source: own development

For deeper understanding the character and nature of cyclic processes in economy of our country, they have to be researched in context of the dynamics of global world economy. Forming the world economy, national ones function and develop as the whole and the parts, being reflected in a varying degree a global economic trends and world economic cyclic recurrence.

World economy was mainly smooth growing on average near 2.8% a year during 1988-2014 years (period of Ukraine formation and function as an independent state) being stood out against the background of buoyant phase of 5th K-wave (1998-2023) that is represented in fig.8. During this period of time world GDP was basically oscillating about its medium position, forming discrete amplitude vibration in the interval from +1,9% to -1,4% with exception of shock sudden change in a -4.9% (as a reaction to the world-wide financial crisis in 2008).

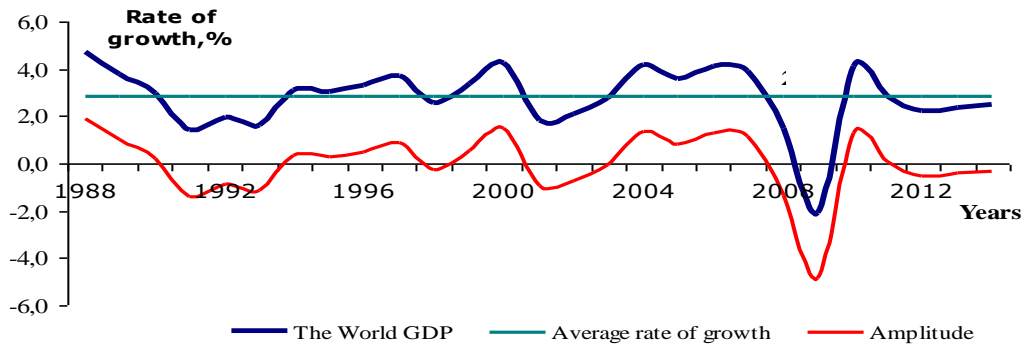


Figure 8 – Cyclic character of world GDP oscillations during 1988-2014

Source: own development based on data of World Bank Official Databases, 2016

Degree of Ukrainian economy balanced functioning and harmonically blending into the global processes of World and European economic space is to be evaluated by means of comparing analysis of the GDP dynamics of Ukraine, Poland and World for last 27 years that is represented in fig. 9.

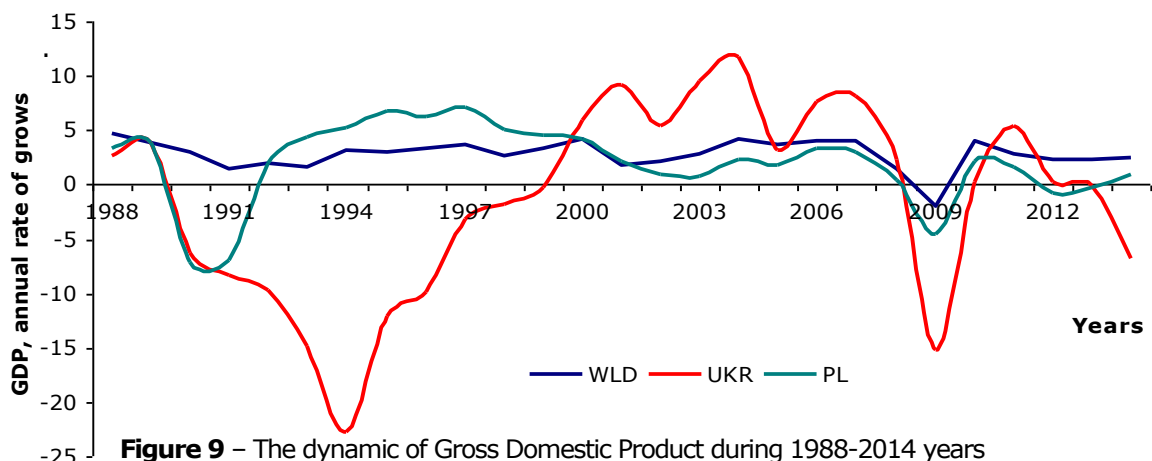


Figure 9 – The dynamic of Gross Domestic Product during 1988-2014 years

Source: own development based on data of World Bank Official Databases, 2016

In general, developmental trajectory of Polish economy in 1988-2014 years in terms of its shape, intensity and frequency of oscillations (peaks of falling and rising) approximated to the world dynamics of GDP at the most. On the contrary, during the same period the dynamics of Ukrainian economy was in discord with global trends, more intensive reacting upon crisis effects of the World economy development. Thus, during the period from 1988 to 2014 Polish economic about 18% of calendar time was in recession phase, exhibiting the moderate falling depth with maximum speed in 1990 (7.2% per annum) and with minimum speed in 2013 (0.3% per annum). Against of the 48% of total functional period with 22.8% the greatest falling peak (in 1994) characterized Ukrainian economy during analyzed time. Comparing the dynamics performance of the World, Polish and Ukrainian economies during the World financial and economic crisis of the 2008-2009, next moments are to be highlighted. So, on the Global economy's decrease in 4.5% Poland reacted with quiet enough rate of fall in a 2.1 % per annum in 2009th (comparing to 2008). Annual speed of Ukrainian economy collapse reached 15.1% per year in that period.

Dividing the analyzed period into decades gives more detailed estimation of subject matter. So, collating the World economic dynamics of the first decade (1988-1999) with the motion of Polish and Ukrainian economies, it is necessary to emphasize that the last one was developing in antiphase regimen, being displayed negative rate of growth during the whole interval against the positive dynamics of the

world and Polish economies, which were growing with close enough rates: 3% and 5% per annum accordingly that is represented in fig. 9. The next decade (1999-2008) as in context global tendencies as on a level of national economies characterizes with phase of mutual economic growth. However, as for Ukraine such essential rate of growth (7% per year on an average) is nullified with undulated dynamics of inflation rate (near 18% per year on an average), which badly influence upon life-level of Ukrainian population that is represented in fig. 10.

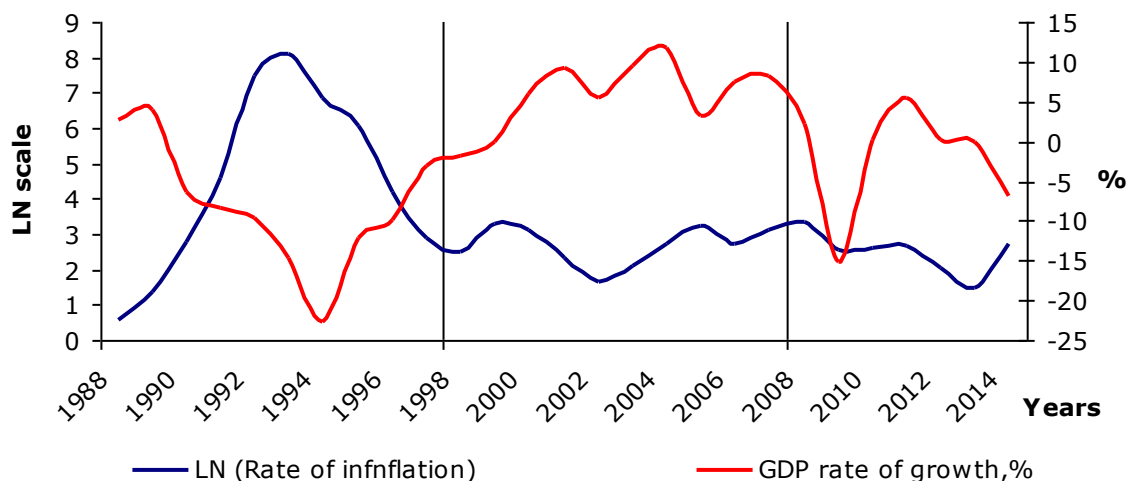


Figure 10 – The dynamics of inflation rates in Ukraine during the 1988-2014

Source: own development based on data of World Bank Official Databases, 2016

Determined unevenness of Ukrainian economic development of last two decades becomes one of deciding factors of such intensive reaction for the Global crisis of 2008-2009 and next low and damped revival (1.5% per year on average) of Ukrainian economy, which rapidly (for 4 years) transformed into nearly 7% falling of Ukrainian GDP in 2014. In conclusion, it is necessary to admit that economic development of national economy shows features of imbalance, turbulence and volatility during analyzed period.

Conclusions. As a result of the completed research of Ukrainian economy's dynamics, following statements are to be highlighted. Developmental cyclic patterns of modern market economy with its short and medium-term cycles are peculiar to evolution of Ukrainian economy. By means of harmonic analysis industrial cycle was extracted, that determined the shape and character of the national economy. Characterized and described with essential harmonics, the structure of Ukrainian development's cyclic recurrence allowed forming the whole picture of economic dynamics, and provided some conditions made possible to prognosticate its development.

Phase analysis of selected macroeconomic indicators' dynamics of Ukrainian economy makes possible to define the following. Passed through the stage of formation and connected with it deep transformational crisis (the 1990s) being accompanied with acute socioeconomic problems that realized in large-scaled oscillations concerning global developmental tendency, Ukrainian economy from the beginning of the 2000s has entered to the phase of recovering growth and now it is in some bifurcation point. Going over it will bring absolutely new tendencies to Ukraine's development. So, accomplished research could be viewed as a base for forming strategic guidelines of development of Ukraine as a part of global social economic space.

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