

MECHANISMS AND METHODS OF STATISTICAL ANALYSIS AND ACCOUNTING OF THE PHASE SHIFTS AT CYCLIC DEVELOPMENT OF ECONOMY IN THE CONDITIONS OF INCREASED UNCERTAINTY OF INSTITUTIONAL AND MARKET ENVIRONMENT

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Abstract: *The purpose of the study is to develop scientific justification (verification), and the testing of the model of cyclical fluctuations, built on the basis of such factors that would have a high level of sensitivity to the changes in the external and internal environment of the economic system. In this study there is implemented a methodology based on the use of the factor approach, also in the course of the research there were used methods of statistical analysis and forecasting, in particular, taxonomic method. There has been developed the diagnostic algorithm for cyclical fluctuations, which allows us to identify upward and downward phase of the economic cycles regardless of their "entry" into a positive or negative zone of the emerging indices by advanced development on the basis of which it is possible to forecast the short-term period with the next 1 - 2 years from the current direction of the development in the national economy.*

The analysis results show that the short-term cycles in the Russian economy are somewhat different from the classic short Kitchin's cycles, the frequency of which happens 2 - 4 years.

Keywords: *Economic cycle, uncertainty.*

1. INTRODUCTION

It is believed that the transformation processes taking place in the Russian Federation, together with the processes of phase shifts of economic cycles, are structural in nature. Perhaps, there are no economic studies, where there were no attempts to explain the state of the economy by the structural changes that are

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occurring in it [1]. Of course, the system of the cyclical development is closely related to the trends and the logics of restructuring the economic and political processes in different periods of the economic development [12]. In this connection, there is a number of issues the solution of which would help to clarify and formalize a set of concepts, methods and tools for understanding of such an important section of the economic theory as economic cycles and factors of their generation.

The great interest in the study of the theory of the cyclical development in the economy presents macroeconomic forecasting based on the generation of understanding for the nature and logics of the phase shifts inside of the generating economic cycles [20]. The vast majority of studies are focused on the fact that the nature and dynamics of the cyclical development in the past will determine the nature and dynamics of the cyclical development in the future. However, exactly this approach, in our opinion, has many controversial issues. It should be clearly understood that the cyclical development could not be described as a regularly occurring phenomenon, on the contrary the irregular shifts in phases of economic cycles become a quite natural process. Thus, the definition for the probability of occurrence of these phases and their duration has a complex function with many uncertain variables. This, in its turn, can lead to a decrease in the quality of predictive models that are based on the extrapolation methods using scenario forecasts of the development for conjunctural and institutional factors - drivers of the phase changes by a cycle [3]. The above-mentioned means that attempt to develop the considered predictive models have a whole set of risks associated with the accuracy of prediction and forecast of cyclical fluctuations [23].

In our view, the current market state has a very wide range of uncertainties and, as previously noted, transformation of macro-generated processes. The arguments presented above become particularly relevant in the context of the study of cycles in the Russian economy, characterized by congestion of the administrative methods for regulation and, accordingly, the specific nature of economic cycles. Thus, the use of traditional methods to forecast the change of cycle phases, based mainly on the static and linear extrapolation methods will not fully meet the high-predicted properties. This leads to the development of adapted to the new realities, improved mechanisms, and diagnostic methods for cyclical fluctuations [17]. At the same time, these methods must necessarily take into account the totality of macroeconomic factors affecting the change of cyclic phases [5]. These include, for example, the dynamics of growth in the world and national economy, investment activity in the considered sector of the economy, changes in the pricing environment for the products, and so on. However, the inclusion in the model of a large number of predictors can generate a number of known problems [2]. Therefore, the development of the model should be formed on the basis of a limited number of exogenous factors that characterize, in the first place, the dynamics of the expectations by the economic agents, as the most important indicator of the phase shift in the cyclical development, and evaluate

almost fully the trends of economic activity in the economy – the main drivers of phase shift in the cyclical development.

Using this approach, based on the modeling of the time expectations by the economic agents, allows us to solve a number of problems:

1. Identify highly probable periods of the phase shift for cycle by the assessment of indicators for advanced development.
2. Develop and strengthen the predictive properties of the existing models and values of cyclical development by the economic systems in the conditions of their transformation.
3. Identify or “project” against each other the cyclical fluctuations in the long, medium and short waves of the cycles by advancing development. The implementation of this approach will be ensured by the compatibility of the factors that determine shifts in the phases of cycles based on the evaluation of the expectations from the perspective of the economic agents.

2. MATERIALS AND METHODS

The importance of the use of estimation methods for indicators that characterize the expectations of the economic agents increases significantly in a period of uncertainty. In these circumstances, a discrepancy in actions of economic policy to the actual situation can significantly increase the depth of a cyclical downturn and “hold” the economic recovery. In this regard, the interest in this instrument has extremely increased alongside with its role in economic decision-making [22].

The technique applied in this study is based on the factor approach, i.e. detection of a set of factors affecting the expectations of the economic agents, and hence the activity of the economic system in general [11]. Under this approach the analyzed factors are combined into sub-indices, which are the totality of weighted average estimates of analyzed components. Based on this system of indicators that characterize definite types of activities, and the index method an integral (composite) or a composite index is calculated - “Index for cycles of advanced development.”

By the cycles of advanced development in this paper, we mean fluctuations in the expectations of the economic agents, obeying a change of short-, medium- and long-term institutional and market factors and shaping the conditions for phase generation of cyclic development in the economic system [13]. In this term, the cycles of advanced development are divided into short, medium and long term, depending on the composition of the lagged variables with signs of advanced development, within the analytical base of modeling for cyclical fluctuations [15].

As the basis for the study of cyclical development lays in the theory of expectations, the simulated cycles will have significant predicted properties forecasting turning points in the cycle, depending on the composition of the used factors and the size of their lagged values.

Structurally-logic scheme of the simulation for the cycles of advanced development is shown in Figure 1.

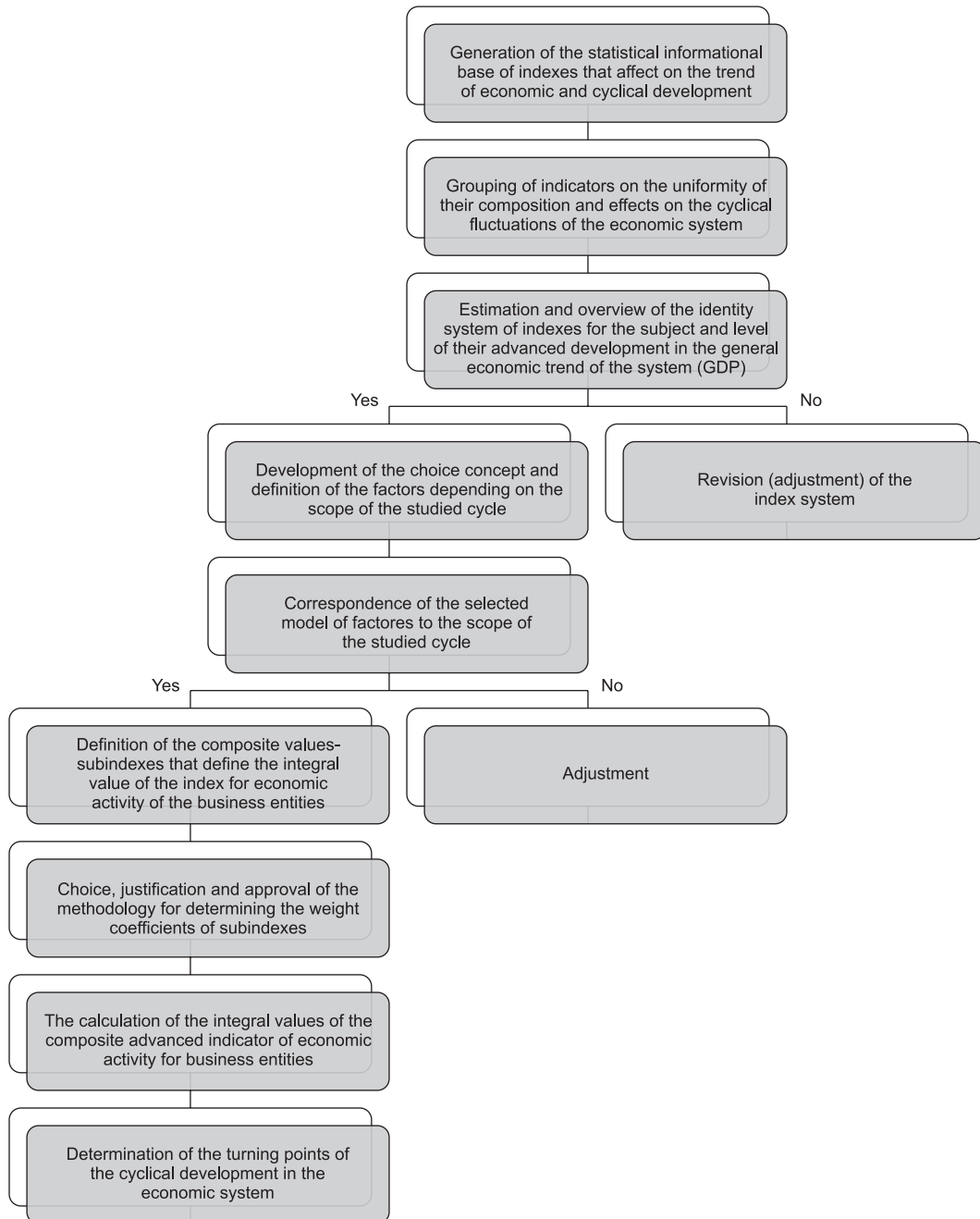


Figure 1: Structurally-logic scheme of the simulation for the cycles of advanced development
 Source: designed by the author

By determining and justifying the choice of a combination of factors, first we proceeded from R. Lucas's theory of rational expectations - the holder of the Nobel Prize 1995 [16]. The sources of disturbances in the expectations by the economic agents, according to this theory, can be found in two groups of factors - financial (price changes, fluctuations in interest rates, changes in the money supply, etc.) and real (emerging of technological innovation, changing in consumer preferences as a result of innovation in the consumer sphere, etc.). Additionally, as a base for the selection and validation of the factors we used A. Pigou's system approach, that emphasizes, as previously noted, three groups of factors which can influence the expectations of the economic agents [18]:

1. Financial
2. Real that is synchronized with the Lucas's theory
3. Psychological factors.

With reference to our theory that is carried out on the theory of the cycles by advanced development cycles, which is based on the expectations of economic agents, all the factors must be subdivided into real and financial on the one hand and psychological - on the other [19]. However, under the psychological factors in this paper we refer to the institutionally shaped reality, forming concepts and cognitive models of business entities, which have a decisive impact on the direction of the dynamics in national management models [7]. In connection with this, instead of the term "psychological" factors we offer to use the term "cultural and institutional factors".

According to the results of the estimations based on economic-mathematical modeling there were identified seven main groups of factors that have influence on the expectations and appropriate behavior models of the business entities.

The first group included the factors that characterize changes in the area of demography, and formed urban development index (I1).

The second group of factors formed the so-called human capital index (I2).

The production and the resource index includes factors that reflect the quantitative and qualitative characteristics of the emerging resource and production base in the national economy, such as inventory, turnover of motor vehicles, mining, etc. (I3)

The fourth group of factors is focused on the definition of the composite index for the quality of the institutional and cultural development in the system and includes a set of corresponding indicators, which could be related as indicators evaluating the level of development in social infrastructure, the quality of forming mental models in the society (I4).

The fifth group of factors has formed the so-called index of economic activity of business entities (I5). It includes such indicators as cash incomes, investment in fixed assets, the consumer price index and others.

The sixth group of factors formed the so-called index of research capacity. It characterizes an internal reserve of innovation development in the economy (I6).

The seventh group of factors determines the index of changes in equity (I7), showing the reaction of the general economic trends to the changes and adjustments of price indexes to the cost of capital.

All selected components were presented as continued annual growth rate (at constant prices, if the factor is expressed in monetary terms). It is necessary for compliance with a single dimension of the factors involved in the model, as otherwise the calculation of composite indexes will be disabled.

The search for solutions aimed at the identification of a system of indicators for the subject and degree of their advanced development with respect to the overall economic trend in the system (GDP), has been carried out using econometric tools.

Calculation algorithm had the following sequence:

1. On the basis of the linear correlation coefficients there were built cross-correlation functions of the resultant factor (reference number) and predefined factors (advanced component). In accordance with the methodology of the statistical analysis, cross-correlation function expresses the closeness of a connection between the levels of the time series y_t measured at time t , and different levels of the time series $x_{t-\tau}$, spaced from one each other at τ time units:

$$r_{(y_t, x_{t-\tau})} = \frac{\sum (y_t - \bar{y}_t) \times (x_{t-\tau} - \bar{x}_{t-\tau})}{(n-1-\tau) \times \sigma_{x-\tau} \times \sigma_y} \quad (1)$$

Cross-correlation is a necessary condition for calculation of the period of advance, or the so-called lag.

2. It is necessary to compare the correlation with $r_{\text{крпт}}$

$$r_{\text{крпт}} = \frac{t_{\text{крп}}}{\sqrt{t_{\text{крп}} + n - 2 - \tau}} \quad (2)$$

where,

n – volume of production, τ -lag.

$t_{\text{крп}}$ – Student's distribution (5%; $n - 2 - \tau$);

n – volume of production, τ -lag.

If $r_{(y_t, x_{t-\tau})} > r_{\text{кPHТ}}$, then the presence of significant coefficients of correlation indicates the connection between the dynamics of the corresponding index with the index of the reference number and determines its inclusion in the system of indicators for the calculation of advanced development indices.

3. RESULTS AND DISCUSSION

The results of cross-correlation analysis of the considered statistical arrays which on the one hand perform as a productive factor (reference number), on the other - the studied time series of the analyzed factors are presented in Table 1.

Table 1
The composition of the factors that are characterized by the advanced dynamics of the relative reference number (GDP), in the enlarged section of advanced indexes

S. No.	Name of the factor	The value of the lag, the number of years		
		Short-term cycle	Medium-term cycle	Long-term cycle
<i>I. Changes of urban development index</i>				
1.	Rural population	1, 2	3, 4	
<i>II. Human Capital Index</i>				
2.	Number of graduates at secondary schools		3	12
3.	Number of graduates at institutions of higher education	2		
<i>III. Production index</i>				
4.	Inventories	1		
5.	Cargo turnover of motor vehicles	1		
6.	Mining	1, 2	3	
7.	Freight rail transport	1, 2		
<i>IV. Social well-being index</i>				
8.	Number of hospitals			11
9.	Number of theaters	2		
10.	Number of cultural and leisure institutions	1, 2	3, 4	
<i>V. Economic activity index</i>				
11.	Investments in fixed assets			8, 9
12.	Consumer price index	1, 2	3	
13.	Incomes of the population	2		
<i>VI. Research capacity index</i>				
14.	Number of scientific workers	1, 2	4	
15.	Number of research institutes	1, 2		

S. No.	Name of the factor	The value of the lag, the number of years		
		Short-term cycle	Medium-term cycle	Long-term cycle
16.	Number of proposals received in the R&D			9
17.	Gross domestic expenditures on research and development	3		12
<i>VII. Changes in equity index</i>				
18.	Price of oil			9
19.	Level of refinancing rate	1	3	

Source: author's development.

The presented table shows the values of the lag, for factors that satisfy our requirements with respect to the advanced dynamics in their development relative to a reference number. Together with this, the important thing is the fact that the results obtained from the estimates and calculations, lagged values have a very wide range from 1 to 12 years. In this case, it seems clear that the factors that have a lag of 3 years and can no longer participate in the simulation of short-term cycles of advanced development. The phase shifts in short cycles are determined by the impact of factors for operational order in other words, those adjustments which activate the shifts of the reference number in the shortest prospect. The same logic is valid also for the other two types of cyclical development of the economy. In this regard, in Table 2 the indicators of the lagged variables are allocated in accordance with the feasibility of their use in modeling of short-, medium- and long-term cycles of the advanced development.

Thus, by the results of a cross-correlation analysis in the final composition of factors, from the originally defined list in the amount of 34 units, only 19 units were included. At the same time to the factors that have a short-term impact on the behavior model of the economic agents, are related those that fully conform with the existing theoretical and methodological approaches to the modeling of the so-called Kitchin's cycles. However, the rather unexpected result was that the signs of the advanced development have the factors that characterize the institutional and cultural potential of the system. The observed phenomenon certainly requires appropriate explanations and justifications.

The basis of the calculation for the weighted coefficients of sub-indices that determine the value of the composite index for advanced development is a taxonomic method. It is based on calculation of the distance between the points of the multidimensional space which dimension is defined by the number of factors involved in the model. The distances between the factors are defined by the following formula:

$$a_{rs} = \frac{1}{m} \sum_{i=1}^m |b_{ir} - b_{is}|, \quad r, s = \overline{1, n} \quad (3)$$

where, a_{rs} is a distance between factors r and s .

The final form of the matrix of distances between the factors will have the following view:

$$\begin{bmatrix} 0 & a_{12} & \dots & a_{1n} \\ a_{21} & 0 & & a_{2n} \\ \dots & & 0 & \dots \\ a_{n1} & \dots & & 0 \end{bmatrix} \quad (4)$$

After determining the distance matrix we can calculate the so-called critical distance that characterizes the maximum distance between two factors:

$$a_{\text{кpHT}} = \max_r \min_s a_{rs} \quad (5)$$

Then for each feature there is found the sum of all the distances that do not exceed the critical distance:

$$p_j = \sum_{s=1}^m a_{js}, a_{rs} a_{js} \leq a_{\text{кpHT}} \quad (6)$$

And then the weights are calculated according to the formula:

$$w_j = \frac{p_j}{\sum_j p_j} \quad (7)$$

The value of the composite index that assesses expectations of economic agents is composed from the calculated series of indicators or sub-indices. Accordingly, each component of the indicator is weighed.

In formula view the SOP calculation is as follows

$$I_i = W_k \times I_{ki} = W_\phi \times I_{\phi i} = W_p \times I_{pi} = W_n \times I_{ni} \quad (8)$$

where I_i – the value of the SOP;

i – the value of period (year in this case);

I1 (i) the index of urban development in the i -th year;

I2 (i) the index of human capital in the i -th year;

I3 (i) the index of production and resource development in the i -th year;

I4 (i) the index of institutional and cultural development in the i -th year;

I5 (i) the index of economic activity in the i -th year;

I6 (i) the index of research capacity in the i -th year;

W1, W2, W3, W4, W5, W6, W7 - the weighted coefficients for corresponding indices.

The results of calculations for the short-term cycles of advanced development in relation to the Russian economy in 1991-2015 are presented in Figure 2.

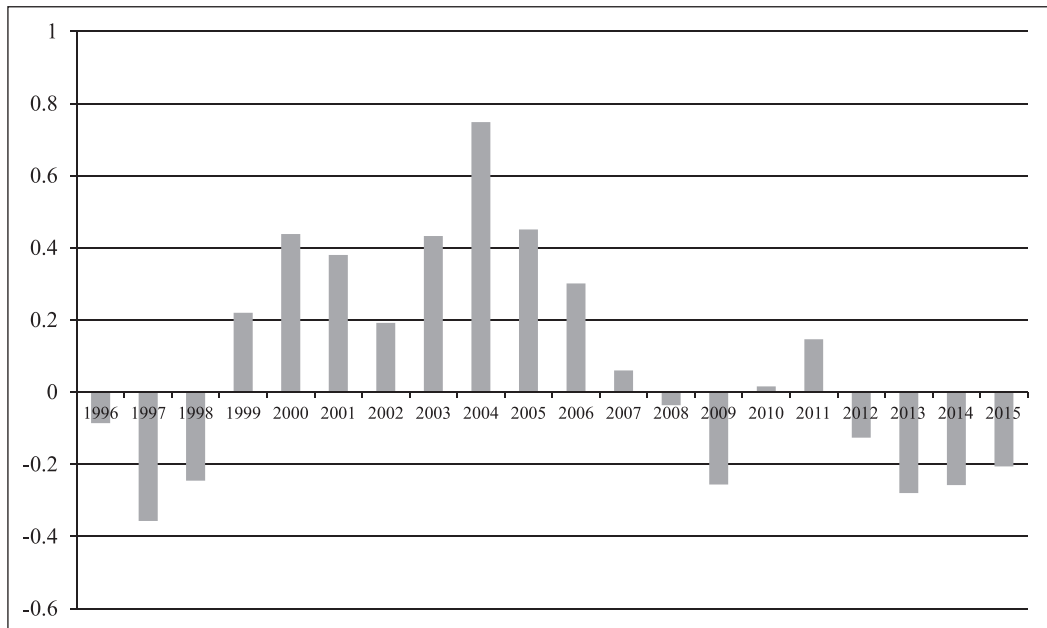


Figure 2: The cycles of the advanced development in the Russian economy in the period from 1994 to 2015 years

The important thing in the results is that the cyclical fluctuations here are short term because the lagged values of the studied factors are on average 1-2 years. In this regard, the horizon of forecasting for future fluctuations of economic conditions will also be limited to 1-2 years. Thus, we can say that the implemented approach has allowed simulating the processes of generating the so-called Russian economy business cycles (short Kitchin's cycles) in 1991-2015 formed ahead for 1 - 2 years from the current trajectory of the economic development in the national economy.

From the methodological point of view the important thing is that the current diagnostic algorithm of the cyclical fluctuations allows to identify upward and downward phases of the cycles, regardless of their "entry" into a positive or negative zone emerging indices of the advanced development.

The main feature of the diagnosis for indices of the advanced development is that in the process of norm setting for the current absolute values of the indicators that define values of the corresponding sub-indices a taxonomic method is used [25]. It is based on the principle of the ratio of the difference between the individual value of a number and the average value to the standard deviation. Thus, depending on the current absolute values of the growth rate for the investigated range of the indicators, their total values that are normalized according to the taxonomic method, will include either a positive zone or a negative one [8]. If, for example, the value of the index went into the negative territory, it would mean that in the current analyzed year the growth rates were lower than the average number. And the number of index indicates how many times this deviation is above/below the standard deviation of the test series. The higher was the modulus level of this value, the higher volatility was characteristic of this year [24]. In connection with the composite index of advanced development the negative value of the range will mean a decrease in optimism of economic agents about the further development of socio-economic and also market- institutional environment, and vice versa, if the value of the indicator was in the positive zone, this means the process of reducing overall level of pessimism. It is important to note that fluctuations in the composite index are tracked relative to the square root value of series that will demonstrate the spread of the points with respect to a number of its dispersion. In the terminology suggested by R. Lucas [10] fluctuations in the composite index of advanced development are considered because of the deviation of the real level for expectations by economic agents from its long-term trend. In case of exceeding the value of the composite index above zero (neutral) level, we can talk about the growth cycle, otherwise - of its decline.

However, the shift of the upward phase to the downward one and vice versa can be observed as well as in a positive zone of the range and negative one. That is, the phase change does not have to occur exclusively in the logic of "downward phase is in the negative zone number, upward - into the positive one" [6]. The process of cycle shift can only take place in one zone (positive or negative). Moreover, if all phases of the cycle are observed, for example, in the negative zone, it means that there is the change of pessimism to optimism, but even improved expectations of economic agents do not lead to certainty in respect to institutional and market environment in the future, and it can only mean some improvement in sentiment, that remains below the formed level of the mean-square deviation of the series.

The dynamics of short-term cycles of the advanced development in the Russian Federation, consisting of two phases, are presented in Table 2.

Table 2
Short-term cycles of the advanced development in the
Russian economy in the period from 1994 to 2015

<i>Cycle of advanced development</i>	<i>Downward phase</i>	<i>Upward phase</i>
1994 - 1997	1994 - 1995	1996 - 1997
1998 - 2002	1998 - 2000	2000 - 2002
2002 - 2009	2002-2004	2004-2009
2009 - 2013	2009 - 2011	2011 - 2013
2013-2018, 2019 *	2013-2017 *	2017-2019 *

* estimate

4. CONCLUSIONS

It is necessary to bear in mind the fact that the Russian economy, as has been previously noted, synchronously combines the principles of market and planned economy, which of course cannot fail to affect the arrhythmia and the duration of the observed cyclical fluctuations [9]. As the reduction in the share of the mechanisms for economic regulation by the tools that are related to the administrative-command system, the observed arrhythmia will be reduced, and the classic mechanisms of cyclical development are becoming more common.

The results of the analysis show that the short-term cycles in the Russian economy are somewhat different from the classic short-term Kitchin's cycles, the frequency of which dates from 2 - 4 years. The revealed duration of the cycles in the Russian economy varies within a wide range depending on the corrective activities of public authorities, as well as there is high volatility of market parameters.

Taking into account that Figure 2 displays the short-term cycles of advanced development, the real cyclical fluctuations in the economy of the Russian Federation have the corresponding meanings of years, anticipating the dating phase of cycles of advanced development for 1-3 years. Thus, it is possible to predict, according to the findings of the adjustments to the index of advanced development that in 2016 the Russian economy will enter a phase of revival (due to the fact that over the past two years (2014-2015) there was a positive trend observed in the dynamics of the cycle of the advanced development). Following the logic of extrapolating data and also the trends of the sinusoidal trajectory for the cycles of the advanced development in the Russian economy with high probability, we can assume that in 2016-2017 the revival phase enters the growth phase [21]. Considering the advanced development character of the obtained series the real growth in the Russian economy can be observed not earlier than in 2018-2019.

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