THE FOURTH INDUSTRIAL REVOLUTION IN RUSSIAN FEDERATION: ASSESSMENT OF PROSPECTS ON THE BASIS OF LONG-TERM CYCLE CREATION OF THE ADVANCING DEVELOPMENT

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Abstract. The subject of the study is the mechanisms for long-term economic cycles of advanced development, forming views and predictive assessments concerning the prospects and the horizons of the phase shifts of future economic system. The object of the study is the evolution of the national economy in the context of long-term economic cycle modeling. The authors, using the mechanisms of long-term expectations modeling from economic agents during the period from 1962 to 2000, reveal the trajectories of phase shifts in Russian economy. This made it possible not only to identify the nature of national economy cyclical development during the considered period, but also to justify scientifically the prospects and the parameters of so-called fourth industrial revolution coming to Russian Federation. The methodology of the study is based on the tools of economic and mathematical modeling of the studied set of factors, the mechanisms of cross-correlation analysis of time statistic series, generalization and grouping methods and factor analysis. It was proved on the basis of the developed methodology of advanced development cycle creation and its approbation on the system of national economy statistical data over the last 60 years, that the socio-economic crisis of the 1990=ies in the economic system was conditioned not only by the institutional changes that have taken place, but also to the fact that during this period the long-term economic cycle entered the phase of decline, which was transforming into a revival phase at the turn of the late 2000s and early 2010s, that allows us to fully justify the conclusion that the phase of long-term growth in Russian economy will come no earlier than in 2020-2025.

Keywords: long-term economic cycles, the fourth industrial revolution, technological paradigms, national economy, phase shifts, advanced development cycles, economic agents' expectations, forecasting, modeling, cross-correlation analysis.

1. Introduction. The development of the world economy in the wake of long-wave cyclical oscillations demonstrates the progressive change of technological paradigms in accordance with the theory by N. Kondratiev [1]. Russian economy, being the most important element of the world economic system, steadily follows these trends, sometimes ahead of them or, on the contrary, lagging behind. Such dissonances in the evolutionary development of the national economy are caused by a whole set of factors of institutional and conjunctural order that are transformed under the influence of both external and internal environments.

At the current time, the issues of the prospects and opportunities concerning the transition of Russian economic system to the so-called channel of the fourth industrial revolution, which is conventionally called Russia 4.0, become more and more urgent. It will be sufficient to say that according to the estimates of a number of leading experts and expert agencies it is expected that by the end of 2035 the number of robotic and automated workplaces will reach about 95%, about half of the jobs that exist today will be not necessary [2, 3].

It should be noted that Russian economy has significant potential not only in terms of synchronization, global trends, the process of entering the fourth industrial revolution, actively absorbing the global economic system, but it also has the signs of a fast-moving transition to a new type of economic order. At the same time, despite the active role of the state in this issue, expressed in particular by the development and the implementation of the state program "National Technological Initiative" [4], the most important factor, that justifies or, on the contrary, refutes the theses on the possibilities of Russian economy transition to a new reality, is the degree of economic entity readiness for this kind of transformation and change. Undoubtedly, this measure of preparedness will reach its apogee in a natural evolutionary way, combined with the measures of state influence, and Russian economy will be integrated into the global trends that provide for the replacement of a new technological paradigm. The only question is, when will this happen and what are the key factors that will contribute to this? The answer to these questions is very nontrivial and requires its complex and systematic solution and analysis.

2. Methods. One of the possible instruments that will allow us to approach the solution of the posed question may be an approach based on the evaluation and the development of long-term economic cycles applied to the national economic system. In accordance with it, and also relying on the theory by N.D. Kondratiev, large cycles are formed as the result of a violation or, conversely, the restoration of the economy equilibrium state in a long period [5]. Before the

beginning of the growth phase, as the researcher claimed, scientific and technical inventions are formed, which are passed subsequently into the real sector of economy, thereby predetermining the breakthrough in productive element improvement and the economic development of the system as a whole. In this case, the rise itself is formed as a result of capital accumulation, which makes it possible to re-equip production resources radically.

Thus, having determined the current phase of the long-term cyclical development of the economy, it is possible to foresee its future transformations and possible prospects for long-term development. In this regard, the issues revealing the prospects of Russian economy transition to the channel of the industrial revolution 4.0 can be solved using the tools of long-wave oscillation modeling for the national economic system and the identification of factors that generate current and forthcoming phase shifts in the so-called large cycle system.

Earlier, in the framework of the publication of a number of author's works devoted to the topic of economic cycle modeling on the basis of economic agent expectation development and evaluation [6, 7, 8], we presented the methodological apparatus in detail that reveals the features of cyclical fluctuation identification in the economy of short-, average- and long-term nature, based on the development and the evaluation of economic agent expectations.

The methodology used in this study is based on the use of a multifactorial approach, that is, the identification of a set of factors that affect the expectations of economic agents, and, consequently, the economic activity of the system as a whole. At this approach, the analyzed factors are first combined into subindexes, which are the sum of a set of weighted average estimates according to the components being analyzed. Based on this system of indicators that characterize certain types of activity and behavior models, and the index method, an integral (composite) index is calculated - "The index of advanced development cycles". In this case, the cycles of priority development in this paper are periodic stable fluctuations of economic agent expectations with special types of regularities that are subjected to the change of short-term, medium-term and long-term market and institutional factors.

In a generalized form, the structural-logical scheme of advanced development cycle simulation is presented on Figure 1 [8].
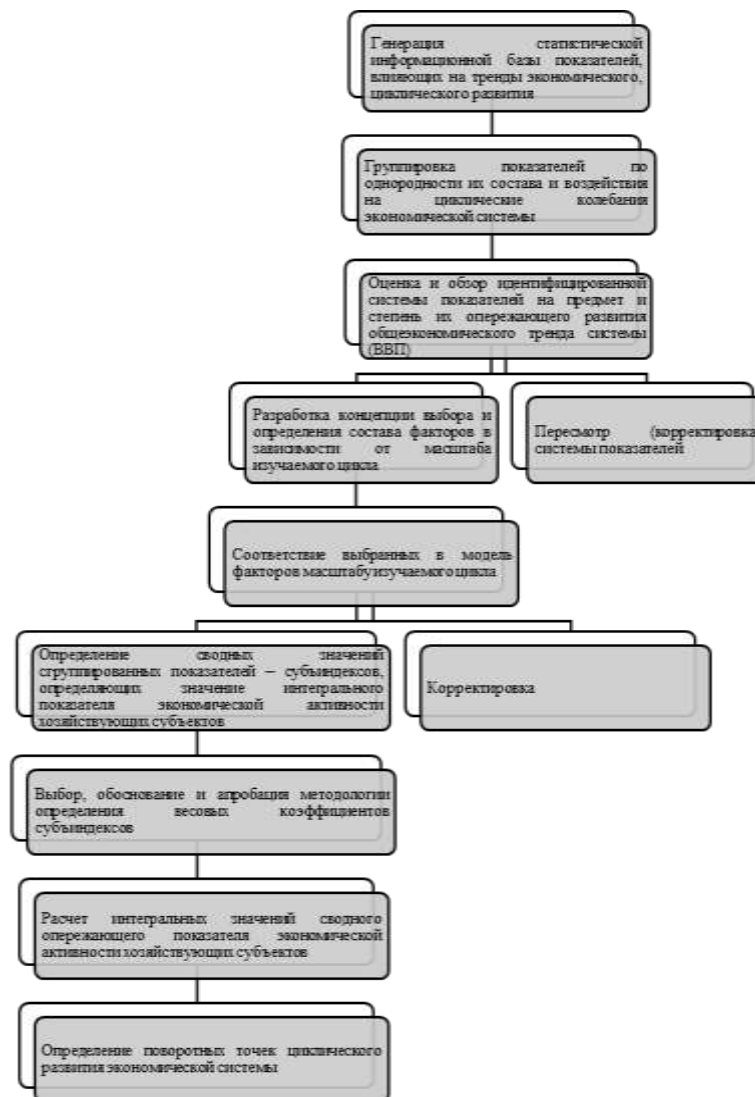
Генерация статистической информационной базы показателей, влияющих на тренды экономического, циклического развития. - Generation of statistical information base of indicators that affect the trends of economic, cyclical development. / Группировка показателей по однородности их состава и воздействия на циклические колебания экономической системы. - The grouping of indicators on the homogeneity of their composition and the impact on the cyclical fluctuations of the economic system. / Оценка и обзор идентифицированной системы показателей на предмет и степень их опережающего развития общеэкономического тренда системы (ВВП) - Evaluation and review of the identified system of indicators concerning the subject and the degree of their advanced development within the general economic trend of the system (GDP) / Разработка концепции выбора и определения состава факторов в зависимости от масштаба изучаемого цикла - The development of selection concept and the determination of the composition of factors depending on the scale of the studied cycle / Пересмотр (корректировка) системы показателей - The revision (the adjustment) of indicator system / Соответствие выбранных в модель факторов масштабу изучаемого цикла - Correspondence of model factors to the scale of the cycle under study / Определение сводных значений сгруппированных показателей - субъиндексов, определяющих значение интегрального показателя экономической активности хозяйствующих субъектов - Definition of summary values of the aggregated indicators - subindexes, determining the value of the integral indicator of economic entity activity / Корректировка - Adjustment / Выбор, обоснование и апробация методологии определения весовых коэффициентов субъиндексов - The choice, the justification and the approbation of the methodology to determine the weight coefficients of subindexes / Расчёт интегральных значений сводного опережающего показателя экономической активности хозяйствующих субъектов - The calculation of the composite leading indicator integral values concerning the economic activity of economic entities / Определение поворотных точек циклического развития экономической системы - The determination of the turning points in the cyclical development of the economic system

Figure 1 - Structural-logical scheme of advanced development cycle modeling

The search for solutions aimed at the identification of the system of factors for the subject and the degree of their advanced development relative to the general economic trend of the system (IPP) was implemented through the use of cross-correlation analysis tools [9].

The results of the cross-correlation analysis of the statistical series under consideration, which are the resultant factor (the reference series) on the one hand, and the time series of the analyzed factors on the other (52 factors of institutional and conjuncture order were analyzed) are presented in Table 2. The aggregated data of the table contain the results of cross-correlation analysis, which made it possible to identify from a large set of statistical factors of institutional and market order (52 factors took part in the evaluations) those characterized by a leading effect on the so-called reference factor - industrial production index. The values in the cells indicate a lag value demonstrating the level of advance of a particular factor relative to IPP.

Table 2 - Composition of factors characterized by advanced dynamics of the relative reference series (IPP) in the context of enlarged leading indices (empty cells indicate the absence of a leading factor effect for a corresponding short-, medium- and long-term economic cycle)

	Factor name	Lag meaning, number of years		
		Short-term cycle	Average cycle	Long-term cycle
I. Urban development change index				
.	Rural population number	1, 2	3, 4	13
II. Human Capital Index				
.	Number of graduates from secondary schools		3	12, 10
.	Number of graduates from universities	2		
III. Production index				
.	Commodity stocks	1		
.	Cargo turnover of motor transport	1		
.	Extraction of minerals	1, 2	3	10
.	Transported cargo by rail transport	1,2		
IV. Index of social well-being				
	Number of hospitals			8, 11

.				
.	Number of theaters	2		
0.	Number of institutions of cultural-leisure type	1, 2	3, 4	
V. Index of economic activity				
1.	Investments in fixed assets			8, 9
2.	Consumer price index	1, 2	3	
3.	Money incomes of the population	2		
VI. Index of research capacity				
4.	Number of scientists	1, 2	4	11
5.	Number of research institutes	1, 2		
6.	Number of proposals received in the field of R&D			9
7.	Internal costs of research and development	3		12
VII. Capital change index				
8.	Oil price			9
9.	Interest rate level	1	3	

The table presents the values of lags for the factors that satisfy our requirements regarding the outstripping dynamics of their development relative to the reference series. At that, it is important that the lag values obtained from the results of estimates and calculations have a very wide range, from 1 to 12 years.

The index method of analysis provides for the decision of a choice issue, and the substantiation of subindex weight coefficient method determination. In our study, the method of taxonomic analysis was used, as the most methodologically "advanced" method of weight coefficient determination. It is based on the determination of distances between the points of a multidimensional space, the dimension of which is determined by the number of factors participating in the model.

The implementation of the above methodological procedures allows us to proceed to the final stage - the development of the so-called summary index of advanced development (IAD). The value of this indicator, which estimates the expectations of economic agents, consists of calculated series of indicators, or subindices.

In the form of a formula, the calculation of IAD is the following one:

$$I_i = W_1 \cdot I_{1i} + W_2 \cdot I_{2i} + W_3 \cdot I_{3i} + W_4 \cdot I_{4i} + W_5 \cdot I_{5i} + W_6 \cdot I_{6i} + W_7 \cdot I_{7i},$$

where I_i - the value of the advanced development index (ADI);

i– the period value (year in our case);

I_{1i}– the index of urban development in the i-th year;

I_{2i} – the index of human capital in the i-th year;

I_{3i} – the index of production and resource development in the i-th year;

I_{4i} – the index of institutional and cultural development in the i-th year;

I_{5i} – the index of economic activity development in the i-th year;

I_{6i} – the index of scientific and research potential in the i-th year;

I_{7i} – the capital change index;

$W_1, W_2, W_3, W_4, W_5, W_6, W_7$ – the weight ratios of the corresponding indices.

3. Results And Discussion. Based on evaluation and calculation results, according to the outlined methodological approaches, the results were obtained that determine the nature and the trends of long-term cyclical development of the national economy (Figure 2).
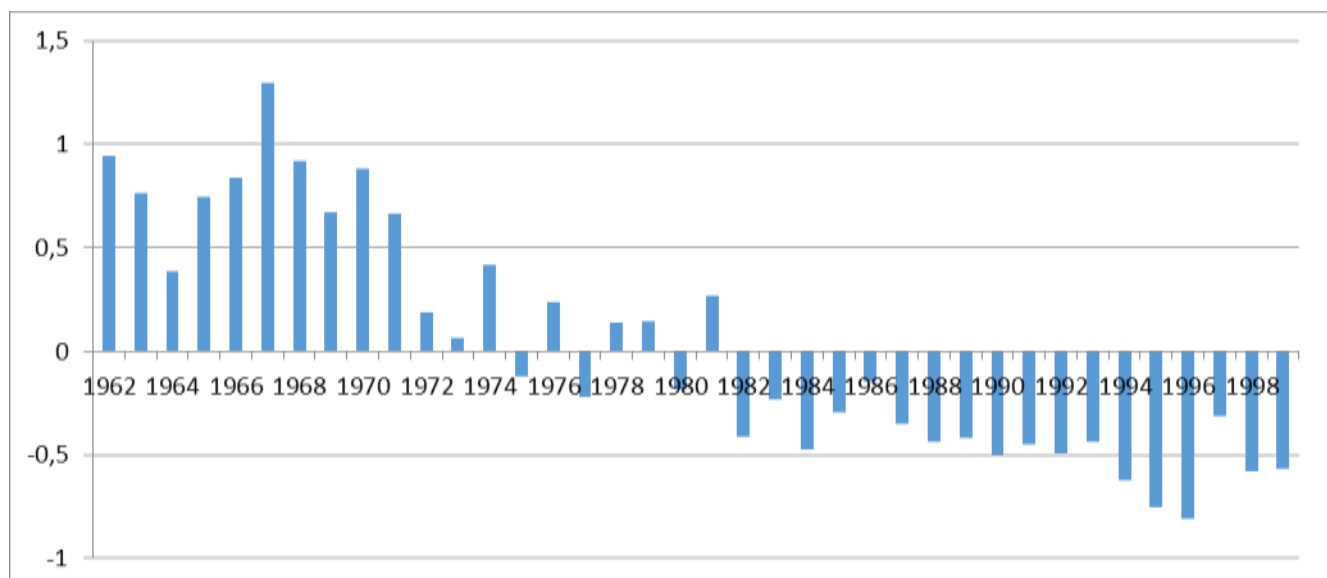
Figure 2 – Long-term cycles of advanced economic development during the period from 1951 to 1999

According to the obtained data on the development of summary advanced development index trajectory, the possible overcoming of economy depressive state, from the point of view of the theory of long waves, dates back to the period of 1997-2000 (and this, despite the default of 1998 that took place in Russian economy). Thus, one can assume (projecting the data about advanced development on a real time trend) that the phase of a new long-term cycle development in Russian economy, characterized by the revival and the development of new technologies corresponding to the sixth technological order, took place at the turn of the late 2000-ies - the beginning of 2010-ies. Taking into account that this period of technological changes (the embryonic phase in Glaziev's terminology [11,12]) lasts for about 10-15 years, the growth phase in Russian economy will not come before 2020-2025.

4. Conclusions . The results of the conducted experimental evaluations demonstrate that the dynamics and the speed of phase transformations in long-term cycles of advanced development are most affected by the index of social well-being that takes into account the qualitative characteristics of the institutional and cultural environment development that determines the process of social behavior mental model formation predisposing to the corresponding "self-development". The second important index, which forms institutional shifts in the long-term cyclical development of the economy, was the index, which identifies human potential quality. This is in substantial agreement with the generally accepted scientific approaches used in the theory of long waves, and based on the fact that the concept of technological paradigms makes the basis for the generation of long-term cycles of economic development. The main idea of this concept is that "technological conjugation generates synchronism in the evolution of the reproducing integrity of production, which creates the material basis for cyclical fluctuations. The development and the expansion of each technological process is conditioned by the development of the entire group of associated technological systems" [12]. Given that these shifts are formed largely as the result of labor resource quality improvement, the latter act as a core element in the evolution of technological structures and, therefore, in long-term cyclical fluctuations.

Projecting these waves on the revealed character of the long-term cyclical development change of the USSR economy, we can clearly observe a noticeable lag in the change of the fourth technological order to the fifth. So, if for the economies of the developed countries the beginning of the fifth technological order received an impulse of its development during the early 1970-ies (digital technologies), then for the administrative-command economy of the USSR such a transition occurred 10-15 years later, during the period of 1980-1985 (Figure 2). At the same time, the trajectory of the composite leading development index at the turn of the late 1990-ies and early 2000-ies demonstrates a significant revival that, according to the previously presented methodological approaches to forecasting, predetermines the transition from the phase of depression to the phase of real cycle revitalization during the period of 2010-2015. Thus, it can be assumed with a high degree of certainty that in the case of advanced development tendencies preservation noted during the period 1997-2000 (Figure 2), the transition of Russian economy to the stage of the sixth technological order is taking place relatively synchronously with respect to the developed countries.

The revealed trend of long-term cycles of economic development shift in Russian Federation at the turn of 2010-2015 is also confirmed by the fact that one of the key indicators characterizing the effectiveness of such transformation launch mechanism, assessing the degree and the quality of scientific and research potential advanced development, clearly demonstrates the signs of the downward trend break in the composite index during the period from 1996-2002. In accordance with the fundamentals of the developed methodology of forecasting, this means the increase of demand for R&D products with the lag of 10+ years.

5. Summary. The implemented approach clearly demonstrated that the study of the nature and the paradigm of long-term cyclic oscillations requires a comprehensive combination of theoretical and empirical methods. The analysis of the cyclical development of the economy makes it possible to determine the phase shifts of long-wave cycles on the basis of a combination of methods of economic and mathematical processing of statistical information array and structural and logical schemes for the historical development of the national economy.

An important result of the research was that it was proved on the basis of the developed methodology for advanced development cycles and its testing on the system of national economy statistical data over the last 60 years that the social and economic crisis of the 1990-ies in the economic system was conditioned not only by the institutional changes that had taken place, but also by the fact that in this period the long-term economic cycle entered the phase of decline, which is transforming at the turn of the late 2000-ies - early 2010-ies into the phase of recovery, that allows to justify the conclusion that the phase of long-term growth in Russian economy will come no earlier than in 2020-2025.

The implemented estimations testify in many respects that the national economy of Russian Federation is being developed in the wake of world tendencies. Based on the conclusion that the change of the new technological paradigm is forecasted in the period of 2020-2025, and also guiding by the average values of the cycle phase length (8-10 years), it is expected that by 2030-2035 Russian economy will enter the phase of an active long-term growth. Thus, there is every reason to believe that the fourth industrial revolution will completely overwhelm Russian economy during this period, which essentially synchronizes with the conclusions that by the end of 2035 the number of robotic and automated workplaces in the world will reach about 95%, and about half of the jobs that exist today will not be demanded.

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