Integration of Structural and Evolutionary Approaches to Assessment of Structural Changes in Industrial Sector Russian Economy

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Abstract. Industrial economic changes in the economy are a complex and multi-level dynamic process characterized in different periods by a certain balance between modernization and innovative development. This involves the redistribution of key industrial resources in various industries and sectors of the economy in certain proportions. This study attempts to assess industrial changes in the Russian economy from the standpoint of structural and evolutionary approaches using empirical data from 1889 to 2018. These data characterize not only the quantitative parameters of the structural dynamics but also the qualitative, evolutionary characteristics of the economic system. Unlike previous studies, this article focuses on the following features. Firstly, a scientific justification is made for integrating of structural and evolutionary approaches, which together make it possible to assess the causal relationships of processes leading to economic transformations, including industrial changes. Secondly, within the framework of the study, the authors formulate a hypothesis about the relative invariance of structural changes. The empirical analysis of data on the distribution of resources of the Russian industry in the ultra-long-term period, the results of modeling structural changes at the macro level, based on the integration of structural and evolutionary approaches, as well as the application of the provisions of the resource concept, allow the authors to formulate several statements. Contrary to the estimated judgments that structural shift is irreversible, this article confirms that in certain time periods, individual elements of the system to the parameters of the system characteristic of the period before the start of structural changes. The authors conclude that one of the key factors of the inertia of structural changes is the evolutionary parameters of the system.

Keywords: Evolutionary changes; Industrial changes; Relative invariance; Shift; Structural dynamics

1. Introduction

The industrial landscape is being defined by the fourth wave of progress, the basic concept of which is based on the growing convergence of various new technological areas - digital manufacturing, nanotechnology, biotechnology, and the development of new materials - and their complementarity in production (UNIDO, 2019). In this case, we are talking about advanced production, which refers to "smart" factories and, in general, "smart" industry. The new industry format involves the use of the industrial Internet of Things, technologies for analyzing large amounts of data, advanced robotics, the artificial intelligence of cloud computing, and additive production. At the same time, new

technologies arise based on traditional industrial production, which is the basis for the modernization and technological development of the economy. On the one hand, the success of new technologies depends on the current economic conditions, the level of technological development, and the institutional characteristics of the industry. On the other hand, the implemented industrial policy is one of the most important conditions for the transformation of industry and the transition to a new type of technological development of the economy. In modern studies, two fundamental approaches to analyzing economic transformation processes and industrial changes can be distinguished, the difference of which lies in the assessing economic systems and factors that determine the quantitative and qualitative changes in its elements over time. Structural and evolutionary approaches to assessing the dynamics of economic processes arose almost simultaneously in the early 1980s in the studies of L. Pasinetti and R. Nelson (Garbellini & Wirkierman, 2010; Nelson & Winter, 2002) in connection with the need for scientific justification of the uneven and disproportionate dynamics of economic changes. Common within the framework of these approaches is going beyond the issues of the equilibrium state of the economic system. However, these approaches are distinguished by the view of the economic system as an "adaptive, developing system, with continuously emerging new elements (Scazzieri, 2018)" in the framework of the evolutionary approach and "a structurally invariant system, the elements of which arise as a result of structural changes that determine evolutionary dynamics (Scazzieri, 2018)" from the point of view of the structural approach. Under the evolutionary approach, newly emerging structures are seen as continuously evolving, and their complementarity arises from historical or evolutionary linkages. From this point of view, the economy is characterized by a high degree of interdependence of its elements, with developed mechanisms of positive feedback (Tatiana & Mikhail, 2020). The key thesis of the evolutionary approach is the assumption that the previous development of the system determines economic dynamics, and the historical conditions for the development of any economic system affect the promising type of evolutionary dynamics. Within the framework of the structural approach, the key point is that the emergence of new elements of the economic system is due to the asymmetry between the existing elements of the system, as well as the direction of structural transformation, within which certain macroeconomic and sectoral proportions should be formed. Despite the obvious differences between the presented approaches, as well as the available assessments regarding the alternativeness of their application for the study of economic dynamics, this article attempts to assess the industrial transformation of the Russian economy by integrating the provisions of the evolutionary and structural approaches and substantiating their complementary nature.

The purpose of this article is to assess the structural dynamics of industrial changes in the Russian economy in the long term, including through the integration of structural and evolutionary approaches. A comparison of structural and evolutionary approaches is presented in Table 1.

The structural approach involves stages of transformation of the economic system or directions of evolutionary change, which depend on parameters such as technological progress or the level of capital accumulation. The rules of transformation of the industrial system are determined not only by sectoral, structural proportions but also by such characteristics as the level of technology and innovation, the maximum possible level of capital accumulation, its concentration, proportions in the distribution of resources such as labor and capital. Nevertheless, within the framework of the structural approach, the process of structural transformation is decisive, which depends to a certain extent on the evolutionary characteristics of the economy, in contrast to the evolutionary approach, which assumes that the process of development is predetermined by the historical characteristics of the economic system, which contribute to the structural transformation or make it impossible. Despite these differences in evolutionary and structural approaches, the application of the historical

context of the development of the economic system, which is used in various aspects, is common to them. In this regard, this study attempts to assess industrial changes in the Russian economy from the standpoint of structural and evolutionary approaches using an array of data for the period from 1889 to 2018, characterizing not only the quantitative parameters of structural dynamics but also the qualitative, evolutionary characteristics of the economic system. At the same time, the integration of the approaches used is ensured, among other things, by applying a structural approach to the analysis of evolutionary parameters of economic dynamics in the ultra-long-term period. Unlike previous studies, this article focuses on the following features. First, there is a scientific justification for integrating structural and evolutionary approaches, which together allow for the causal relationships of processes leading to economic changes. Secondly, within the framework of the approaches used, a justification is made for the limited invariance of structural changes.

Table 1 Typology of structural and evolutionary approaches

Parameters	Structural approach	evolutionary approach
The economic system is considered as	structurally invariant system, the elements of which arise as a result of structural changes that determine evolutionary dynamics	adaptive, evolving system, with continuously emerging new elements
The role of technological progress and innovation in the process of structural change	determining	is secondary to the evolutionary parameters of the system
Dynamics Modeling Methods	production function, model of structural shifts, balance methods	evolutionary models, including the Lotka-Volterra model
Economic dynamics depends on	parameters of asymmetry between elements of the current system	prior development
The main task within the framework of the approach	substantiation of the disproportionate dynamics of economic changes	
The degree of interconnection between the elements of the system	Average	High
Structural invariance	Unlimited	limited by prior development (relative)

2. Methods

2.1. Research method and data

To model the dynamics of structural changes in the Russian economy, which determine the trends of industrial transformations, calculations will be made in the article. The calculations will make it possible to obtain absolute and relative indicators of structural dynamics in the extractive and manufacturing sectors of the Russian industry. For this purpose, it is expedient to calculate the mass of the structural shift, the index of the structural shift, and the rate of the structural shift. The mass of a structural shift is defined as the difference between the shares of a structural indicator in the current and base periods. The main difference between this indicator and simple statistical indicators is that "the content of the concept of the mass of a structural shift is a certain set of economic entities with given economic interests and needs, the form is a change in quantitative indicators in physical and value terms over a certain period of time» (Krasil'nikov, 2000).

The calculation of the structural shift mass index is carried out according to the formula:

$$M = P - P_0 \qquad\qquad (1)$$

M – the mass of structural shift in the industry,

P – the value of the indicator in the current period,

P_0 – the value of the indicator in the base period.

The calculation of this indicator provides an assessment of the absolute indicators of structural changes in the sectors of the industrial sector of the economy. The assessment of the relative indicators of structural changes is provided by the calculation of the index of structural shifts, which is the ratio of the mass of the structural shift to the base value of the indicator for a certain period of time.

$$I = \frac{P - P_0}{P_0} = \frac{M}{P_0} \qquad (2)$$

I – structural shift index expressed in relative terms,

The structural shift index provides comparability of structural changes in the industry and provides identification of those periods in which shifts were more intense, determines time lags, identify the correlation between different indicators. Also, with the help of indices, it is possible to compare various indicators, in our case, indicators that characterize capital and labor resources in structural changes.

To assess the intensity of structural changes, the rate indicator is used, which reflects the change in the structural indicator per unit of time. The structural shift index is calculated as the ratio of the mass or structural shift index to a certain period. Using this indicator, it is possible to determine the asynchrony of shifts, compare various structural shifts, including between industries, and identiy structural shifts' inertia. The calculation is made according to the formula:

$$V = \frac{M}{T} \text{ or } V = \frac{I}{T} \qquad (3)$$

V – speed of structural shift,

T – structural shift time.

Within this study's framework, the structural shift rate is determined by the ratio of the structural shift index to the shift period, which in most cases is five years.

It is assumed that at different stages of the technological development of the economy, the intensity and speed of structural changes will be uneven both within a particular industry and in an intersectoral aspect. Since the evolutionary parameters of the economy influence these indicators. At the same time, the unevenness of structural changes both in time and intersectoral aspects will be determined by the limited invariance of structural changes. It is also necessary to separately highlight such a parameter as inertia, the strength of which can vary significantly both in different economies and in industries, even though, in general, inertia is an ntrinsic property of socio-economic systems of any level. In this regard, the study of the evolutionary dynamics of industrial changes through the assessment of indicators of structural changes will make it possible to identify the parameters of the inertia of the economic system, as well as to identify the factors that determine the trends of inertia.

2.2. Theoretical fundamentals

The Oxford Structural Transformation Guide treats such categories as "structural transformation" and "structural change" as synonyms. Structural transformation, or structural change, involves the movement of productive resources (natural resources, land, capital, labor resources, inventions) from low-productivity to high-productivity economic activities (Monga & Lin, 2019). Note that structural transformation, or structural changes, is the process by which you change the shape or type of the structure. Under this approach, a steady process of structural change can provide permanent static and dynamic effects to the economy.

We consider it appropriate to consider the structural shift as a reversible phenomenon. Historical analysis of trends in industrial change suggests that such processes and anti-shift are possible that lead the system to its original state, which in parameters corresponds to

the state characteristic before structural changes occur. So, for example, deindustrialization caused by a series of negative industrial shifts in fact, leads the system to its original state, including in terms of industrial output, employment in certain industries, and many others (Varlamova & Larionova, 2020).

On the one hand, industrial shifts in the export-import structure are determined by the internal characteristics of the distribution of resources, the model of industrial changes, and on the other, are influenced by structural shifts occurring in the world economy. Industrial changes in the technological structure are also determined by the internal potential of the technological development of industries, the technological structure of production, and the dynamics of scientific and technological progress at the global level (Surjandari et al., 2022). Studying such shifts becomes an even more urgent task in the context of industrial changes provided by protectionist measures to support domestic industry (Ha-Joon, 2012; Shafaeddin & Pizarro, 2007; Williamson, 2004).

Based on the assumption that the structural shift is aimed at changing the proportions in a certain structure, the emerging contradiction within the industrial shift is represented by two processes: the process of expansion from the point of view of the shift and the process of contraction from the point of view of the anti-shift. As part of the industrial transformation of the economy, the shift will be represented, for example, by an increase in the share of enterprises and types of economic activity in high-tech production, an increase in the share of the active part of the capital, and the share of highly skilled labor. The anti-shift is determined by the reduction in the share of low-tech industries, the share of the passive part of fixed capital, and, accordingly, the share of low-tech labor.

Thus, analysis of structural change phenomena such as structural shift, anti-shift, structural crisis allows us to conclude that structural shift is a reversible phenomenon. That is, it is possible to change the proportions of the structure to the state of the previous structural shift. Such a phenomenon as anti-shift involves the movement of elements of the structure or the entire structure in the direction opposite to a given vector of structural changes. An important conclusion is the invariance of structural changes, including the presence of a certain set of options for structural changes in specific historical conditions. Nevertheless, it should be noted that in a particular historical period, the set of options for structural changes is limited, allowing us to assume the limited invariance of structural changes.

3. Results and Discussion

3.1. Results

The data show that there are divergent trends as well as individual periods with the highest structural shifts. It should be noted that for all the indicators under consideration, there is a significant structural shift between 1990 and 1997, which is associated with the transformational processes of the domestic economy, a deep decline in industrial production, and inflationary processes. The latter determines the high values of mass, index, and rate of structural shift over a given period. Therefore, it is considered inappropriate to use them to analyze structural changes in the system of industrial development of the economy (Table 2).

Table 2 Mass, index and rate of structural shift by indicators of turnover, fixed capital and profit of industrial enterprises of Russia for the period from 1885 to 2018 (million rubles)

Period	Mass of structural shift			Structural Shift Index			Speed of structural shift		
	T	FC	P	T	FC	P	T	FC	P
1889-1885	478	216	45	0.35	0.36	0.38	0.07	0.07	0.08
1894-1890	480	244	63	0.26	0.29	0.37	0.05	0.06	0.07
1899-1895	1 392	803	102	0.54	0.67	0.39	0.11	0.13	0.08
1904-1900	404	321	-18	0.09	0.15	-0.05	0.02	0.03	-0.01
1909-1905	780	471	69	0.17	0.19	0.20	0.03	0.04	0.04
1928-1910	12 488	7 060	202	2.27	2.40	0.45	0.13	0.13	0.11
1934-1929	19 636	17 530	-	0.70	1.54	-	0.14	0.31	-
1985-1960	300 000	388 000	29 200	1.50	4.85	0.82	0.10	0.19	0.05
1997-1990	16254 00000	2957555	9017 4700	2709	4.90	1137.13	387.00	0.70	162.45
2002-1998	51610 00	1894252	4525 14	3.02	0.48	-51.59	0.60	0.10	-10.32
2007-2003	12114 360	7605083	2304 037	1.43	1.16	3.75	0.29	0.23	0.75
2012-2008	13512 488	14573657	1635 095	0.55	0.84	0.69	0.11	0.17	0.14
2018-2013	27299 980	28670306	5768 797	0.67	0.79	1.85	0.13	0.16	0.37

T – turnover of industrial enterprises, FC – fixed capital of industrial enterprises, P- profit of industrial enterprises.

The dynamics of the structural shift mass show positive trends in the analyzed parameters for the entire period, with the highest growth rate from 1960 to 2018 (Figure 1). The highest rates of structural changes in the value of fixed capital are typical for the period from 1998 to 2018. It should be noted that if the mass of structural shift indicator shows multiple indicators increases, then the structural shift index indicates the presence of multidirectional trends in the analyzed indicators. Maximum values of the structural shift index in terms of turnover of industrial enterprises are observed in 1928-1910, 2002-1998, 2007-2003.

To assess the strength of structural changes, and the presence of inertia tendencies in the dynamics of structural shifts, the rate of structural shift is estimated, which is presented by calculations in Table 3. On the one hand, the inertia of a structural shift is rather difficult to assess since. for a qualitative assessment, the calculations must be supplemented by analysis and comparison with the institutional characteristics of the economy taken by political decisions. On the other hand, assessing the relative rate of structural shift allows for determining the intensity of structural changes, which is relatively low in terms of such indicators as the cost of fixed capital and the turnover of industrial enterprises. The analysis of the rate of a structural shift, firstly, allows us to conclude that the dynamics of structural changes are characterized by inertia in all the analyzed indicators. Secondly, the speed of structural change confirms the existence of a structural crisis in the transformational period of the economy.

Modeling of structural shifts in terms of mass, index, and speed in terms of the distribution of the value of fixed capital between the active and passive parts of fixed capital is carried out for the period from 2003 to 2018, which is associated with limited statistical data. There are significant changes in the distribution of active and passive parts of fixed capital. If for the period from 2003 to 2007 the cost of groups is almost equivalent, then in the period from 2008 to 2018 there is a significant (almost 2 times) excess of the cost of machines and equipment over the cost of buildings and structures. In relative indicators, namely, the structural shift index, the difference is not so significant, while the most intense changes in the passive part of the capital are characteristic of the period from 2003 to 2007, for the active part of the capital - from 2013 to 2018. Similar dynamics are observed to the rate of structural shift. At the same time, it should be noted that the rate of structural shift according to the indicator in question is high. In general, this can be seen as a positive trend since the growth of labor investment, which is characterized, among other things, by an increase in the cost of machinery and equipment, is decisive within the framework of the trends of new industrialization.

The changes in mass, index, and rate of structural shifts in the years of the first three five-year plans from 1928 to 1938, as well as in the period from 2003 to 2018, show slight changes in investment in industry and investment in fixed assets. The rate of a structural shift in the second period decreases relative to the period from 1928 to 1933. Nevertheless, the structural shift index for the period from 1928 to 1938 is higher than in the period from 2008 to 2018.

Similar dynamics can be traced to the rate of structural shift. If in the first period, according to the indicator of investment in industry, the rate of structural shift is 0.27 and 0.21, then in the period from 2008 to 2018, 0.08. The exceptions are the index, and the rate of structural shift between 2003 and 2007, and are 1.77 and 0.35, respectively

The distribution of the structural shift in terms of the employed in industry by manufacturing and mining industries indicates that both in terms of the mass of the structural shift, and in terms of the index and rate of the structural shift, the highest values are observed in the manufacturing industry. The structural shift index for the period from 1900 to 1908 for the manufacturing industry was 0.26 in relation to 0.17 for the mining industry, and 0.28 to 0.09 for the period from 1908 to 1913. At the same time, the difference in the rate of structural shift between the manufacturing and mining industries is smaller: 0.03 and 0.02 for the period from 1900 to 1908, 0.06 and 0.02 for the period from 1908 to 1913.

The structural shift in the number of employees in the industry from 1992 to 2018 is negative. The maximum value of the structural shift index is observed from 1999 to 2014 and is -85.61; for comparison, this indicator in 2013-2018 amounted to -0.07. The rate of the structural shift in this period, except 1999-2004, is not high, and is in the range of values from -0.01 to -0.07. However, it should be noted that over the entire period, the rate of structural shift has a negative orientation.

The index and the speed of structural shift in the average monthly accrued wages are characterized by a positive direction and have higher values. But the indicator of the number of people employed in the industrial sector of the economy is not. From 2003 to 2007, the structural shift index is 1.10, which is significantly higher than the negative indices in terms of the number of employees. It is necessary to take into account the fact that this indicator is calculated without taking into account the rate of inflation, so the data obtained can be overestimated.

The analysis of data on structural shifts in the use of key resources in the industrial sector of the economy provides several conclusions. Firstly, at the present stage of economic

development, the most significant structural changes of a positive orientation are observed from 2003 to 2007 in almost all analyzed indicators characterizing the use of resources in the industrial sector of the economy. Secondly, the highest positive values of structural changes are characteristic of such an indicator as wages, against the background of high negative shifts in the indicator employed in the industrial sector of the economy.
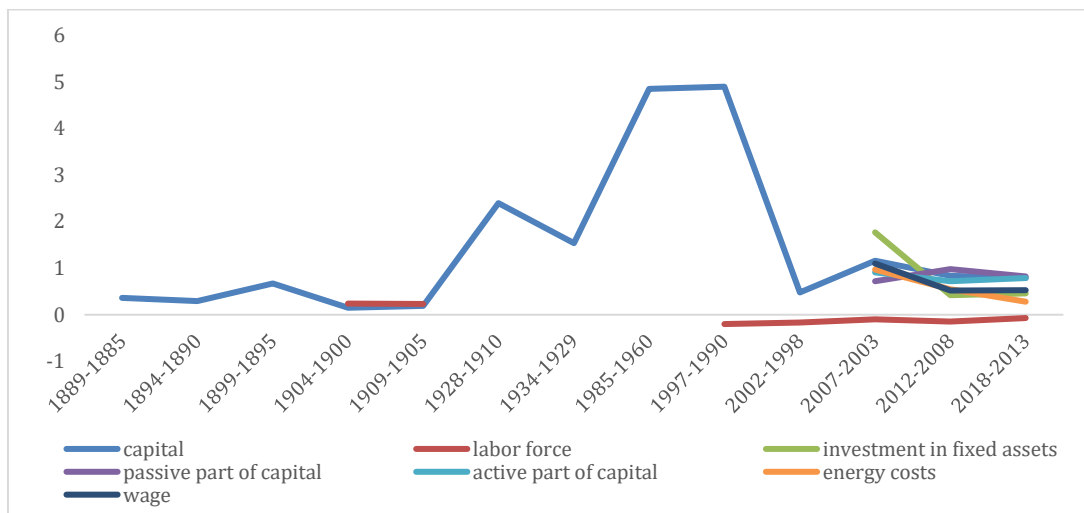
Figure 1 Structural shift index for the period from 1885 to 2018 (labore force - 1913-1900 and 1913-1908, 1995-1992, 1999-1995, 2004-1999, investment in fixed assets - 1933-1937 / 1932-1928)

As a positive trend, we can consider the growth of the structural shift index in terms of the active part of capital against the background of the decline in the index in the passive part of capital. The downward trend is the decline in the fixed capital value index (Figure 2). It can be assumed that a significant structural shift in this indicator from 1905 to 2002 can compensate for the decline in the structural shift index in the subsequent period. However, data on the level of depreciation of fixed assets indicate the need for an increase in fixed investment and, accordingly, a positive increase in the index and the rate of structural shift.

The highest rate of structural change is observed for the period 1985-2002 in terms of the value of fixed capital, as well as for investments in fixed capital in 2003-2007. The analyzed data indicate a decrease in the rate of a structural shift in the analyzed indicators from 2003 to 2018, which can generally indicate slowing dynamics of structural changes in sectors of the industrial sector of the economy. According to figure 2, the index of structural shift in terms of fixed capital value repeats the dynamics of the curve describing the stages of industrial development: the phase of primary industrialization, the phase of industrialization and deindustrialization of the Russian economy and structural changes aimed at increasing the industrial potential of industrial sectors.

3.2. Discussion

The main conclusion that made it possible to obtain the approach used in this article is that in the Russian economy, one of the key characteristics of industrial changes is inertia, which manifests itself in a low rate of structural changes according to the main criteria of the industry. At the same time, one of the main reasons for such dynamics is the evolutionary component of the development of the domestic economy. Although the rate of structural changes increases, such dynamics is more likely to be associated with the influence of general macroeconomic trends, as well as restrictions in the process of changing the qualitative characteristics of resources in the short term. The data obtained also confirm the formulated hypothesis that the structural shift is a reversible phenomenon. Modeling

structural changes over a long time in terms of indicators characterizing both quantitative and qualitative characteristics of the resources of the Russian industry indicates that in certain periods there is a return of individual elements of the system to the system parameters characteristic of the period before the start of structural changes. The use of indicators that characterize the qualitative characteristics of the resources of Russian industry, such as the structure of fixed capital, and wages, makes it possible to more comprehensively assess the dynamics of structural changes, as well as to substantiate the relativity of the invariance of structural changes. The integration of structural and evolutionary approaches in the framework of studies of structural changes in the Russian economy has made it possible to obtain results that differ from previous studies. Unlike previous studies, including Hyytinen and Maliranta, Mondelaers, in this article, results are obtained that describe qualitative changes in the economy, including changes in the technological and resource components.

4.   Conclusions

This study substantiates that the integration of structural and evolutionary approaches to assessing industrial changes makes it possible to determine both the range of changes and the options for changes. The structural approach makes it possible to determine the range of structural changes depending on the policy in specific historical conditions. The evolutionary approach, in turn, provides an understanding of the set of options for changes depending on the structural characteristics of the system, as well as the parameters of the institutional environment. The article obtained significant theoretical results, confirmed by empirical analysis. But additional studies of the features of structural dynamics are needed. One of the main areas of further research may be the assessment of structural changes at the level of individual industries, as well as enterprises of the industrial sector of the economy, according to indicators characterizing the change in economic and technological parameters of production under the influence of macro shifts. At the same time, an important component of such a study, in our opinion, is taking into account the institution of ownership in the distribution of resources of Russian industry, as well as an empirical assessment of the evolutionary conditions for the functioning of domestic companies.

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