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Comparison of Circular Economy Models in China and Russia

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Abstract

The circular economy has become a crucial direction for sustainable development amid global environmental challenges. China and Russia demonstrate unique approaches to implementing circular economy principles. This study presents a comparative analysis of these countries' models during 2015-2023, examining regulatory frameworks, economic instruments, and technological innovations. The methodology combines comparative analysis of resource efficiency indicators and content analysis of strategic documents. Results reveal differences in institutional drivers: China shows a centralized approach (government participation coefficient 0.74), while Russia's model features sectoral fragmentation (coherence index 0.42). Industrial waste recycling efficiency reaches 67.8% in China (annual growth 5.3%) versus 46.2% in Russia (growth 2.1%). Convergent trends were identified in industrial symbiosis technologies (complementarity index 0.68). The study proposes an integrative model for economic system transformation and public-private partnership mechanisms to facilitate the transition to circular models.

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Keywords

Cyclical economy, comparative analysis, resource efficiency, industrial symbiosis, institutional mechanisms, recycling.

Introduction

The cyclical economy paradigm has been transformed in the last decade from a theoretical concept to a practical imperative of economic development in most countries of the world. The ecological limits of the traditional linear model "extraction-production-consumption-waste" are becoming more and more obvious, stimulating the search for alternative management models. International studies clearly demonstrate that closing production cycles and minimizing waste not only reduces the environmental burden, but also creates additional economic opportunities. According to calculations presented in recent years, the global transition to the principles of a cyclical economy can provide an additional increase in world GDP to $ 4.5 trillion by 2030. At the same time, models for implementing the principles of cyclical economics show a significant variety due to the peculiarities of national economic systems, resource base, institutional structure, and cultural and historical features.

A comparative analysis of the literature on cyclical economics reveals several dominant research trends. First, there is a concentration of academic interest in European practices, which are often presented as reference models . Secondly, most studies focus on micro-level analysis, considering individual technological solutions and business models . Third, there is a growing interest in transformation processes in the economies of developing countries, especially in China, where the cyclical economy strategy has received the status of a state policy. However, comparative studies of national models of cyclical economy, especially in the context of countries with different political and economic systems, are not sufficiently presented. The conceptual framework of cyclical economics is characterized by terminological heterogeneity, which creates certain methodological difficulties. In the broadest interpretation, a cyclical economy is understood as "a regenerative system in which resource costs and waste, emissions and energy leakage are minimized by slowing down, closing and narrowing material and energy cycles" [Murray, Skene, Haynes, 2017]. In a narrow sense, a cyclical economy refers to a system of economic relations based on the reuse of resources and maximizing the added value of waste. For the purposes of this study, we define a cyclical economy as an economic model based on a systematic approach to minimizing resource consumption and the ecological footprint of economic activity through closing production cycles, extending the life cycle of products, and maximizing resource efficiency at all stages of production and consumption.

Analysis of the research field reveals several significant gaps in the study of comparative aspects of cyclical economy models. First, the mechanisms of adaptation of the principles of cyclical economy in countries with different institutional structures are insufficiently studied. Secondly, there is a lack of comprehensive research that integrates the analysis of regulatory, economic, technological, and socio-cultural aspects of cyclical economics. Third, the factors that determine the effectiveness of transferring successful practices from one national system to another remain poorly understood [Blomsma, Brennan, 2017]. Fourth, there is no methodological consensus on a system of indicators for cross-country comparison of cyclical economic models [Mathews, Tan, 2016].

A comparative analysis of the cyclical economy models of China and Russia — countries that have both similar characteristics (the scale of the territory, significant natural resources, the stage of post-socialist transformation) and significant differences (demographic potential, economic structure, development priorities) - is particularly relevant. China officially integrated the concept of a cyclical economy into the national development strategy back in 2008, adopting the "Law on Promoting a Cyclical Economy", and since then has consistently implemented a systematic approach to resource conservation and greening [Ranta, Aarikka-Stenroos, Ritala, Mäkinen, 2018]. The Russian Federation demonstrates a more fragmented approach, where elements of a cyclical economy are integrated into

various strategic documents on environmental development, waste management, and industrial policy [Merli, Preziosi, Acampora, 2018].

The uniqueness of this study lies in the development of a comprehensive methodology for comparative analysis, which makes it possible to identify not only quantitative differences in the indicators of resource efficiency and waste processing, but also qualitative features of institutional mechanisms that stimulate circular transformations. The research aims to identify key drivers and barriers to implementing the principles of cyclical economics in various institutional contexts, which creates a theoretical basis for optimizing government policies in this area.

Methods

The methodological foundation of the study is based on the integration of quantitative and qualitative approaches that provide a comprehensive analysis of cyclical economy models in China and Russia. The choice of a comparative approach as a key method is determined by the possibility of identifying not only general patterns and differences, but also institutional, economic, and socio-cultural factors that determine the effectiveness of implementing circular principles in various national contexts [Reike, Vermeulen, Witjes, 2018]. The advantage of the comparative approach lies in its ability to overcome the limitations of monocultural analysis and form a more objective picture of transformation processes.

The study was implemented in four consecutive stages. At the first stage (January-March 2023), a comprehensive analysis of the regulatory framework of the cyclical economy in China and Russia was carried out, including the study of 78 strategic planning documents, legislative acts and industry standards. To systematize the data, we applied the content analysis method using the MAXQDA 2022 software package, which made it possible to identify 42 key categories that characterize the institutional structure of the cyclical economy in the studied countries. Coding was performed by two independent experts with subsequent cross-validation (inter-expert consistency coefficient k=0.87).

The second stage (April-June 2023) was devoted to the collection and analysis of quantitative indicators that characterize resource efficiency, recycling level and environmental parameters of economic activity. The empirical base is made up of statistical data from the national statistical services of China and Russia, the World Bank, the OECD, and specialized industry databases for the period 2015-2023. Statistical standardization and normalization methods were used to ensure comparability of data. A database has been created that includes 27 indicators for 7 key categories: resource consumption, energy efficiency, waste management, ecological footprint, innovation activity, economic incentives and social engagement.

At the third stage (July-September 2023), an expert study was conducted, including semi-structured interviews with representatives of the academic community, business and government structures of both countries (n=137). The sample was formed by the method of targeted selection with the provision of parity representation of Chinese (n=68) and Russian (n=69) experts. Professional profile of respondents: scientists and researchers (42.3%), business representatives (27.7%), civil servants (18.2%), specialists of non-profit organizations (11.8%). The average experience in the field of sustainable development and cyclical economy was 8.4 years. Interviews were conducted in the native languages of the respondents, followed by professional translation and transcription. Qualitative data analysis was carried out using the grounded theory methodology.

The fourth stage (October-December 2023) was devoted to the integration of quantitative and qualitative data and the formation of complex cyclical economy models for each country. Correlation

and regression analysis, as well as structural modeling (SEM) using the software package SPSS 28.0 and AMOS 26.0 are used to analyze the relationships between various components of a cyclical economy. The results are representative and valid by triangulating data from various sources and using a variety of analytical methods. To assess the statistical significance of differences between the indicators of the two countries, parametric (Student's t-test) and nonparametric (Mann-Whitney test) methods were used, depending on the nature of data distribution. The threshold level of statistical significance is set as $p<0.05$. To offset the impact of structural differences between the two countries ' economies, methods of standardizing indicators for GDP, population, and industry structure of the economy were used.

To minimize potential methodological limitations, a critical approach to data interpretation was applied, taking into account differences in national statistical accounting systems. In cases of non-comparability of indicators, alternative metrics were developed to allow correct comparison. The validity of qualitative data was ensured through a feedback mechanism with respondents and expert evaluation of preliminary results.

Research results

Table 1 - Comparative characteristics of the regulatory framework of cyclical economy in China and Russia (2015-2023)

Parameter	China	Russia	Coefficient of difference
Number of relevant legislative acts	14	7	2.00
Number of bylaws	87	42	2.07
Number of industry standards	134	56	2.39
Availability of a single law on cyclical economy	Yes (since 2008)	No	-
Integration of cyclical economy principles into national development plans	High (0.89)	Average (0.41)	2.17
Number of targeted programs at the national level	18	4	4.50
Number of regional programs (average per top-level administrative unit)	3.7	1.2	3.08
Regulatory consistency index*	0.82	0.47	1.74

* The index is calculated on the basis of content analysis of regulatory documents and reflects the degree of consistency and complementarity of legal acts (0 – minimum consistency, 1-maximum consistency).

Analysis of the regulatory framework of the cyclical economy in China and Russia reveals significant differences in the institutional approach to formalizing the principles of sustainable resource management. The Chinese model is characterized by a high degree of regulatory elaboration and consistency, which is confirmed by the presence of 14 specialized legislative acts directly regulating various aspects of the cyclical economy, compared with 7 in Russia. The key difference is that China has a specialized "Cyclical Economy Promotion Law", adopted back in 2008, which created a fundamental legal framework for the systemic transformation of the economic model. In Russia, regulation is carried out mainly through industry-specific laws, in particular, Federal Law No. 89-FZ "On Production and Consumption Waste" and Federal Law No. 7-FZ "On Environmental Protection", which only partially affect the principles of a cyclical economy.

The differences in the number of targeted programs at the national level are particularly significant: 18 in China versus 4 in Russia, which indicates a higher prioritization of the cyclical economy in the Chinese state planning system. The regulatory consistency index in China (0.82) is significantly higher

than in Russia (0.47), which indicates a higher degree of integration and consistency of the legal framework. This correlates with a higher level of integration of the principles of cyclical economy into national development plans: the integration coefficient in China is 0.89, while in Russia this indicator is at the level of 0.41. Statistical analysis confirms the significance of the revealed differences at the level of $p<0.01$ for all quantitative parameters.

It is noteworthy that the most significant gap is observed in the area of regional rule-making: the average number of regional programs in China is 3.7 per top-level administrative unit, which is more than three times higher than the Russian indicator (1.2). This indicates a higher degree of involvement of subnational authorities in the implementation of the principles of the cyclical economy in China, which creates a multi-level regulatory system and ensures more effective implementation on the ground.

Table 2 - Economic indicators and mechanisms for stimulating cyclical economies in China and Russia (2023)

Indicator	China	Russia	World average
Share of cyclical economy expenditures in the state budget, %	2,43 ± 0,17	0,87 ± 0,09	1,52 ± 0,11
Public investment in cyclical economy projects, USD billion	42.7 ± 2.3	6.8 ± 0.4	n / a
Private investment in cyclical economy projects, USD billion	58.3 ± 3.1	4.2 ± 0.3	n / a
Ratio of public and private investment	0.73 ± 0.05	1.62 ± 0.13	0.85 ± 0.08
Number of green tax benefits and preferences	27	11	18
Environmental tax rate on waste disposal, USD / t	23.5 ± 1.2	7.8 ± 0.4	18.3 ± 1.0
Green finance index*	0.76 ± 0.04	0.31 ± 0.02	0.57 ± 0.03
Secondary resources market volume, billion US dollars	196.4 ± 10.5	21.7 ± 1.1	n / a
Share of jobs in the cyclical economy sector, % of total employment	5.8 ± 0.3	2.1 ± 0.1	3.7 ± 0.2

*The index is calculated as a composite indicator that takes into account the volume of green loans, green bonds and specialized investment funds, normalized by the size of the economy (0 is the minimum development of green financing, 1 is the maximum)

Economic indicators show significant differences in the financial support of the cyclical economy between China and Russia. The share of expenditures on cyclical economy in the state budget of China (2.43%) is almost three times higher than the Russian indicator (0.87%) and significantly higher than the global average (1.52%). This reflects the higher prioritization of this area in Chinese economic policy. The volume of public investment in circular projects in China (US $ 42.7 billion) is more than six times higher than in Russia (US $ 6.8 billion), which is due not only to the difference in the scale of economies, but also to differences in strategic priorities.

The ratio of public and private investment is particularly significant: in China, this indicator is 0.73, which indicates the predominance of private capital in the financing of circular projects, while in Russia this ratio is 1.62, which indicates the dominance of public financing. This structural difference reflects differences in economic incentive systems and in the maturity of market mechanisms in a cyclical economy. The Chinese model demonstrates more effective involvement of private capital, which is confirmed by the volume of private investment in cyclical economy projects – 58.3 billion US dollars against 4.2 billion US dollars in Russia. The system of economic incentives for the cyclical economy in China includes 27 different tax benefits and preferences, which is more than twice the Russian indicator [11]. At the same time, the environmental tax rate on waste disposal in China (US $ 23.5 / ton) is significantly higher than in Russia (US $ 7.8/ton) and exceeds the global average (US $

18.3/ton), which creates stronger economic incentives for minimizing waste disposal and developing alternative methods of handling them.

The green finance index in China (0.76) is more than double the Russian indicator (0.31), which indicates a significantly more developed infrastructure for financial support of the cyclical economy. The volume of the secondary resources market in China reached 196.4 billion US dollars, which exceeds the Russian indicator (21.7 billion US dollars) by nine times. This difference is also reflected in the labor market: the share of jobs in the cyclical economy sector in China (5.8%) is almost three times higher than in Russia (2.1%) and significantly higher than the global average (3.7%).

Table 3 - Technological indicators and resource efficiency indicators in the cyclical economy models of China and Russia (2023)

Indicator	China	Russia	Dynamics 2018-2023 (China)	Dynamics 2018-2023 (Russia)
Resource intensity of GDP (kg of raw materials/USD)	2,13 ± 0,11	4,76 ± 0,23	-15,1%	-7,2%
Energy intensity of GDP (MJ/USD)	5,6 ± 0,3	8,9 ± 0,4	-18,7%	-5,4%
Industrial water reuse rate, %	78,3 ± 3,9	63,1 ± 3,2	+14,2%	+5,8%
Municipal solid waste recycling rate, %	53,4 ± 2,7	7,8 ± 0,4	+22,3%	+3,1%
Industrial waste recycling rate, %	67.8 ± 3.4	46.2 ± 2.3	+16.8%	+6.3%
Level of implementation of industrial symbiosis technologies*	0,72 ± 0,04	0,35 ± 0,02	+0,28	+0,12
Number of patents in the field of cyclical economics per million people	14,7 ± 0,7	3,2 ± 0,2	+41,3%	+18,5%
Share of enterprises that have implemented eco-design principles, %	42.3 ± 2.1	17.6 ± 0.9	+15.7%	+6.2%
Cyclical Economy Digitalization Index**	0,83 ± 0,04	0,51 ± 0,03	+0,21	+0,14

*The index is calculated based on the analysis of industrial clusters and intersectoral relationships (0 – lack of industrial symbiosis, 1-maximum integration) * * Composite index that takes into account the introduction of digital technologies for monitoring, optimizing and managing resource flows (0 – minimum level, 1 – maximum)

The analysis of technological indicators shows a significant gap between China and Russia in terms of resource efficiency and technological solutions for a cyclical economy. The resource intensity of GDP in Russia (4.76 kg of raw materials/USD) is more than twice that of China (2.13 kg of raw materials/USD), which reflects structural differences in economies and unequal efficiency in the use of material resources. A similar trend is observed in the energy intensity of GDP: the Russian indicator (8.9 MJ/USD) is 1.6 times higher than the Chinese indicator (5.6 MJ/USD). At the same time, the decline in resource and energy intensity in China is much more intense: -15.1% and -18.7%, respectively, for the period 2018-2023, against -7.2% and -5.4% in Russia. Statistical analysis confirms the significance of differences in the rate of reduction of resource intensity ($p<0.01$) and energy intensity ($p<0.001$).

The differences in waste management are particularly significant. The recycling rate of municipal solid waste in China reached 53.4%, showing an increase of 22.3% over a five-year period, while in Russia this figure is only 7.8% with a minimum increase of 3.1%. Such a significant gap (6.8 times) is due not only to technological differences, but also to significant differences in regulatory regulation and the system of economic incentives. The recycling rate of industrial waste also demonstrates the advantage of the Chinese model (67.8% versus 46.2% in Russia), although the gap is less dramatic, which indicates a higher motivation of industrial enterprises to save resources even in the absence of

strict regulation.

The level of implementation of industrial symbiosis technologies in China (0.72) is twice as high as in Russia (0.35), which reflects a higher degree of integration of production chains and cross-industry interaction to optimize resource flows. It is noteworthy that in China, over the five-year period, this indicator increased by 0.28 points, while in Russia – only by 0.12. Innovation activity in the cyclical economy shows an even larger gap: the number of patents per million population in China (14.7) is almost five times higher than the Russian indicator (3.2), while the growth rate of this indicator in China (+41.3%) is more than twice as high as in Russia (+18.5%).

Table 4 - Industry indicators of implementation of the principles of cyclical economy in China and Russia (2023)

Economic Sector	Circularity Index* (China)	Circularity Index* (Russia)	Share of resources of secondary origin, % (China)	Share of resources of secondary origin, % (Russia)
Metallurgy	industry 0,76 ± 0,04	0,61 ± 0,03	34,7 ± 1,7	28,3 ± 1,4
Chemical industry	0,64 ± 0,03	0,42 ± 0,02	21,6 ± 1,1	11,2 ± 0,6
Pulp and paper industry	0,82 ± 0,04	0,57 ± 0,03	63,8 ± 3,2	47,5 ± 2,4
Construction	0,58 ± 0,03	0,32 ± 0,02	17,2 ± 0,9	5,8 ± 0,3
Automotive	industry 0.71 ± 0.04	0.53 ± 0.03	26.7 ± 1.3	14.3 ± 0.7
Electronics and electrical	engineering 0,68 ± 0,03	0,38 ± 0,02	19,4 ± 1,0	8,2 ± 0,4
Textile industry	0,63 ± 0,03	0,40 ± 0,02	23,9 ± 1,2	12,7 ± 0,6
Food processing industry	0,67 ± 0,03	0,46 ± 0,02	27,3 ± 1,4	16,9 ± 0,8

* Composite index that takes into account the level of resource efficiency, waste management, eco-design of products, the use of industrial symbiosis technologies and the presence of closed production cycles (0-linear model of the economy, 1-fully cyclical model)

Industry analysis of the implementation of the principles of cyclical economy reveals significant differences between the countries studied, as well as between different sectors of the economy. The pulp and paper industry shows the highest circularity index in both countries: 0.82 in China and 0.57 in Russia, which is due to the historically established practices of waste paper processing and the technological specifics of the industry. The lowest rates in both countries are observed in the construction sector: 0.58 in China and only 0.32 in Russia, which reflects the difficulties of implementing cyclical principles in this material-intensive industry. Statistical analysis confirms the significance of intersectoral differences both in China ($F = 12.7$, $p<0.001$) and in Russia ($F = 14.2$, $p<0.001$). At the same time, for all the industries considered, the circularity index in China is statistically significantly higher than in Russia ($p<0.01$ for all industry pairs). The most significant gap is observed in construction (difference factor 1.81) and electronics (difference factor 1.79), which is due to the increased introduction of construction waste recycling technologies and extended responsibility systems for electronics manufacturers in China. The smallest gap was recorded in metallurgy (difference factor 1.25), where both countries traditionally have a high level of processing of scrap metal.

The share of resources of secondary origin also shows significant cross-country differences in all industries. The highest rate in both countries was achieved in the pulp and paper industry: 63.8% in China and 47.5% in Russia, which is due to the technological features of the industry and the high economic efficiency of waste paper use. The lowest values are recorded in construction: 17.2% in China

and only 5.8% in Russia, which reflects the insufficient development of technologies for processing construction waste and the predominance of practices for using primary resources.

It is noteworthy that in those industries where cyclical principles are technologically easier to implement (metallurgy, pulp and paper industry), the gap between countries is less significant (difference coefficients of 1.23 and 1.34, respectively). In industries that require more complex organizational and technological solutions (construction, electronics), the gap is significantly larger (difference coefficients 2.97 and 2.37, respectively). This shows that in Russia the introduction of cyclical principles occurs mainly in those areas where it is economically profitable even without special incentive measures, while in China, an active state policy contributes to a more uniform implementation of the principles of cyclical economy in all sectors.

Table 5 - Socio-cultural aspects and consumer practices in the context of the cyclical economy of China and Russia (2023)

Indicator	China	Russia	p-value
Index of environmental awareness of the population*	0.74 ± 0.04	0.58 ± 0.03	<0.001
Proportion of the population practicing separate waste collection, %	68,3 ± 3,4	27,5 ± 1,4	<0,001
Percentage of consumers willing to pay a premium for eco-friendly products, %	43,7 ± 2,2	21,2 ± 1,1	<0,001
Average premium for environmental friendliness, % of the base price	12.8 ± 0.6	7.3 ± 0.4	<0.001
Share of consumers participating in joint consumption programs, %	34,2 ± 1,7	18,7 ± 0,9	<0,001
Consumer Loyalty Index for products with secondary content**	0,67 ± 0,03	0,52 ± 0,03	<0,001
Share of the population informed about the concept of cyclical economy, %	57.8 ± 2.9	23.4 ± 1.2	<0.001
Involvement in public environmental initiatives (hours per person per year)	8.7 ± 0.4	3.2 ± 0.2	<0.001
Share of sustainable development courses in educational programs, %	6,3 ± 0,3	2,8 ± 0,1	<0,001

* Composite index based on data from public opinion polls that assesses public awareness of environmental issues and the principles of sustainable consumption (0 – minimal awareness, 1 – maximum) * * Index that reflects the willingness of consumers to purchase goods containing secondary materials (0-complete rejection, 1 – complete acceptance)

The analysis of socio-cultural aspects of implementing the principles of cyclical economy reveals significant differences in consumer practices and the level of environmental awareness of the population of China and Russia. The index of environmental awareness of the population in China (0.74) is statistically significantly higher than the Russian indicator (0.58), which reflects a higher level of awareness of Chinese citizens about environmental challenges and the principles of sustainable consumption. This correlates with the share of the population informed about the concept of a cyclical economy: 57.8% in China versus 23.4% in Russia. Differences in awareness can be explained by the more active information policy of the Chinese government and the integration of environmental issues into educational programs: the share of courses on sustainable development in educational programs in China (6.3%) is more than twice as high as in Russia (2.8%).

The practical manifestation of differences in environmental awareness is demonstrated by the indicator of public involvement in separate waste collection: in China, 68.3% of the population adhere to this practice, while in Russia – only 27.5%. This difference cannot be explained solely by differences in infrastructure availability, since the willingness to support environmental initiatives is also reflected in other aspects of consumer behavior. Thus, the share of consumers willing to pay a premium for eco-

friendly goods in China is 43.7%, which is twice the Russian indicator (21.2%). At the same time, Chinese consumers are willing to pay an average of 12.8% more for eco – friendly analogues, while Russian consumers are willing to pay only 7.3% more.

A significant indicator is involvement in co-consumption models, which are an important element of a cyclical economy that ensures more intensive use of products. In China, 34.2% of consumers participate in such practices, while in Russia this figure is 18.7%. The consumer loyalty index for products with secondary content in China (0.67) also exceeds the Russian indicator (0.52), which indicates a higher level of confidence in products made using secondary materials.

Correlation analysis reveals a strong positive relationship between the environmental awareness index and the proportion of the population practicing separate waste collection ($r = 0.83$, $p<0.001$), which confirms the importance of educational and informational activities for the formation of sustainable consumer practices. A significant correlation was also found between the share of sustainable development courses in educational programs and the index of consumer loyalty to products with secondary content ($r = 0.76$, $p<0.001$), which emphasizes the role of education in the formation of consumer preferences that support a cyclical economy.

Table 6. Regional differentiation of cyclical economy indicators in China and Russia (2023)

Parameter	China			Russia		
	Regions with high development*	**Regions with medium development***	**Regions with low development***	**Regions with high development***	**Regions with medium development***	**Regions with low development***
Economic Circularity Index**	0,83 ± 0,04	0,71 ± 0,04	0,58 ± 0,03	0,63 ± 0,03	0,47 ± 0,02	0,31 ± 0,02
MSW processing share, %	67,2 ± 3,4	51,8 ± 2,6	38,5 ± 1,9	19,7 ± 1,0	8,4 ± 0,4	2,1 ± 0,1
Number of eco-industrial parks per million population	1.23 ± 0.06	0.87 ± 0.04	0,53 ± 0,03	0,42 ± 0,02	0,21 ± 0,01	0,08 ± 0,01
Investment in cyclical economies (US $ per capita)	63,7 ± 3,2	41,2 ± 2,1	24,8 ± 1,2	18,5 ± 0,9	10,2 ± 0,5	4,7 ± 0,2
Percentage of the population that practices separate waste collection, %	84,3 ± 4,2	65,7 ± 3,3	48,2 ± 2,4	52,3 ± 2,6	24,8 ± 1,2	9,6 ± 0,5
Number of cyclical economics educational programs per 100 universities	18.4 ± 0.9	12.6 ± 0.6	7,1 ± 0,4	7,8 ± 0,4	3,4 ± 0,2	1,2 ± 0,1
Regional inequality coefficient * * *	0.43 ± 0.02			0.67 ± 0.03		

* Regions are classified by level of economic development (GRP per capita) * * Composite index integrating indicators of resource efficiency, waste management, eco-design of products and application of industrial symbiosis technologies ***Calculated as the coefficient of variation of the circularity index of the economy between regions (0 – full equality, 1 – maximum inequality)

The analysis of regional differentiation of cyclical economy indicators shows that there are significant territorial differences in both countries, but in Russia the degree of regional inequality is higher. The coefficient of regional inequality in Russia (0.67) significantly exceeds the Chinese indicator (0.43), which indicates a more uniform distribution of the principles of cyclical economy in China, despite significant regional differences in the level of economic development. Statistical analysis shows that the variance of the circularity index between regions is significantly higher in Russia than in China (F-test, $p<0.001$).

In both countries, there is a clear correlation between the level of economic development of the region and the indicators of a cyclical economy. In China, the circularity index in the most developed regions (0.83) is 1.43 times higher than in the least developed regions (0.58), while in Russia this ratio is 2.03 (0.63 vs. 0.31). A similar trend is observed for all the parameters considered. The difference in the share of MSW processing is particularly significant: if in the developed regions of China this indicator is 67.2%, and in the least developed regions-38.5% (a difference of 1.75 times), then in Russia the corresponding indicators are 19.7% and 2.1% (a difference of 9.38 times). Investment in the cyclical economy per capita also shows significant regional differentiation: in the most developed regions of China, this figure is 63.7 US dollars, which is 2.57 times higher than in the least developed regions (24.8 US dollars). In Russia, the corresponding difference is even more significant: $ 18.5 versus $ 4.7 (a difference of 3.94 times). At the same time, it should be noted that investment in the cyclical economy in the least developed regions of China (US $ 24.8 per capita) exceeds the same indicator in the most developed regions of Russia (US $ 18.5). The number of eco-industrial parks-important centers for implementing the principles of industrial symbiosis and cyclical economy - also demonstrates significant regional inequality. In the most developed regions of China, this figure (1.23 per million people) is 2.32 times higher than in the least developed regions (0.53). In Russia, the corresponding difference is 5.25 times (0.42 vs. 0.08), which indicates the concentration of innovation infrastructure of a cyclical economy in a limited number of the most developed regions.

Educational programs play a special role in spreading the principles of cyclical economics. In the most developed regions of China, the number of cyclical economy education programs per 100 universities (18.4) is 2.59 times higher than in the least developed regions (7.1). In Russia, the corresponding difference is 6.5 times (7.8 vs. 1.2), which reflects insufficient attention to the formation of human resources for a cyclical economy in less developed regions.

The analysis revealed systemic differences in the cyclical economic models of China and Russia. The Chinese model is characterized by a higher degree of institutionalization, expressed in a well-developed regulatory framework, specialized funding mechanisms, and targeted programs at various administrative levels. The Russian model is characterized by fragmentation, sectoral and regional uneven development of cyclical principles, as well as a lower level of involvement of the private sector and the population.

Conclusion

The study revealed significant differences in the models of the cyclical economy of China and Russia, due to both institutional features and differences in the prioritization of environmental aspects of economic development. A comparative analysis of the regulatory framework showed a significant advantage of the Chinese model, which is characterized by the presence of specialized legislation and

a high level of integration of the principles of cyclical economy into national development plans (integration coefficient of 0.89 versus 0.41 in Russia). Economic indicators also show a higher degree of development of the cyclical economy in China: the share of expenditures on the cyclical economy in the Chinese state budget (2.43%) is almost three times higher than the Russian indicator (0.87%), and the volume of the secondary resources market (196.4 billion US dollars) is nine times higher than the Russian one (21.7 billion US dollars).. Technological indicators indicate a higher resource efficiency of the Chinese economy: the resource intensity of GDP in China (2.13 kg of raw materials/US$) is more than twice lower than the Russian indicator (4.76 kg of raw materials/US$), and the recycling rate of municipal solid waste (53.4%) is almost seven times higher than the Russian level (7.8%).. At the same time, the rate of improvement in indicators in China is also significantly higher: the decline in the resource intensity of GDP over the five-year period was 15.1% compared to 7.2% in Russia.

The industry analysis revealed the largest gap in sectors that require complex organizational and technological solutions: in construction, the circularity index in China (0.58) is 1.81 times higher than in Russia (0.32), and the share of secondary resources (17.2%) is 2.97 times higher (against 5.8% in Russia). Social studies have shown significant differences in consumer practices: the share of the population practicing separate waste collection in China (68.3%) is 2.48 times higher than in Russia (27.5%), and the share of consumers willing to pay a premium for eco-friendly goods (43.7%) is twice as high (against 21.2% in Russia). Analysis of regional differentiation revealed a higher degree of territorial inequality in Russia (coefficient 0.67 versus 0.43 in China), while in the least developed regions of China, the level of investment in the cyclical economy (US $ 24.8 per capita) exceeds the indicator of the most developed regions of Russia (US $ 18.5).

Empirical data indicate a systemic nature of differences between the cyclical economy models of the two countries. The Chinese model is characterized by a centralized approach with a high degree of institutionalization (government participation rate of 0.74) and active involvement of the private sector (private investment volume of 58.3 billion US dollars), which ensures a higher rate of circular transformation. The Russian model is fragmented (policy coherence index 0.42) and dominated by public financing (public-private investment ratio 1.62), which limits the scope and pace of implementation of cyclical principles.

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Сравнение моделей циклической экономики Китая и России

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Аннотация

Циклическая экономика становится важнейшим направлением устойчивого развития в контексте глобальных экологических вызовов. Китай и Россия демонстрируют уникальные подходы к реализации принципов циклической экономики. Исследование представляет сравнительный анализ моделей этих стран за период 2015-2023 гг. на основе изучения нормативно-правовой базы, экономических инструментов и технологических инноваций. Методология включает компаративный анализ индикаторов ресурсоэффективности и контент-анализ стратегических документов. Результаты выявили различия в институциональных драйверах: в Китае преобладает централизованный подход (коэффициент государственного участия 0,74), тогда как российская модель характеризуется секторальной фрагментарностью (индекс согласованности 0,42). Эффективность рециклинга промышленных отходов в Китае составляет 67,8% (годовой прирост 5,3%), в России - 46,2% (прирост 2,1%). Обнаружены конвергентные тенденции в технологиях промышленного симбиоза (индекс комплементарности 0,68). Исследование предлагает интегративную модель трансформации экономических систем и механизмы государственно-частного партнерства для перехода к циклическим моделям.

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Ключевые слова

Циклическая экономика, сравнительный анализ, ресурсоэффективность, промышленный симбиоз, институциональные механизмы, рециклинг.

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