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Resource recycling as a key condition for maintaining the growth potential of the economy (a view from the perspective of the neo-industrial paradigm of modern development)

El reciclaje de recursos como condición clave para mantener el potencial de crecimiento de la economía (una visión desde la perspectiva del paradigma neoindustrial del desarrollo moderno)

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Contents

ABSTRACT:
The article considers the neo-industrial paradigm of modern development as the theoretical and methodological basis for solving the fundamental question of the geosphere limits to economic growth, with the socio-economic aspect of this paradigm seen in organic unity with the ecological one. The paper claims it is necessary to create a new raw material base for social reproduction with unused production and consumption waste. Resource recycling is seen as the key condition for maintaining the growth potential of the economy.
Keywords: geosphere limits to economic growth, economic growth, neo-industrial paradigm of modern development, waste resources, resource recycling, decoupling.

RESUMEN:
El artículo considera el paradigma neoindustrial del desarrollo moderno como la base teórica y metodológica para resolver la cuestión fundamental de los límites de la geosfera al crecimiento económico, con el aspecto socio-económico de este paradigma visto en unidad orgánica con la ecológica. El documento afirma que es necesario crear una nueva base de materia prima para la reproducción social con la producción no utilizada y el desperdicio de consumo. El reciclaje de recursos se considera la condición clave para mantener el potencial de crecimiento de la economía.
Palabras clave: límites de la geosfera al crecimiento económico, crecimiento económico, paradigma neoindustrial del desarrollo moderno, recursos de desecho, reciclaje de recursos, desacoplamiento.

1. Introduction

1.1. Setting the problem

One of the most striking features of the global financial and economic crisis of 2008-2009 was the concensus on the need to restore the economic growth. The International Monetary Fund, the Environmental Protection Program (UNEP), political parties from around the world called for "returning the economy back to the growth trajectory to ensure its stability" (Jackson, 2013, 110). For instance, famous German politician and publicist Ralf Fücks in his book explains that the "zero" growth of the economy is pointless since from the economic and socio-political point of view, it "generates a lot of difficulties: capital flight, emigration of active citizens, slowing down the pace of innovation, infrastructure decline and the aggravation of already difficult problems in the pension and health care systems (Fücks, 2016, 104).

In this context, the scientific community is more actively discussing issues related to the substantial changes in the model, the origins of driving forces and factors of economic growth, taking into account the so-called concept of "decoupling" (absolute and relative) and its "agreement" with environmental constraints on the "finite" planet (Spence, 2013; Grigoriev, 2014; Gubanov, 2012, etc.). This deals with various manifestations of the growing ecological impact caused by national economies (carbon dioxide emissions, climate change, reduction in arable land, depletion of natural sources, etc.), which in turn clearly points, on the one hand, to the signs of self-destruction of the current economic order (Schwab, 2017, 78-79), and on the other hand, to the need to develop new conceptual approaches to economic development which would help to solve environmental and resource problems of the 21st century (Jackson, 2013, 129).

The authors of this article believe that in this context, the neo-industrial paradigm of modern development is to become the main scientific and practical issue. Developed by the Russian economic school (Gubanov, 2012), this paradigm is based on the fundamental natural and social laws, the well-known principles of humanistic development (the unity of the scientific and technological revolution and the progress of the economic system, human reproduction, healthy environment, labor saving measures, etc.) and the idea of the inclusive society, based on the dominance of social capital (the aggregate capital of the society) over private capital which pursues the goal of making profit. The most important feature of the new industrialization – digital, knowledge intensive, technological – lies in the fact that it establishes the unity of socioeconomic and ecological principles. This makes it possible to achieve "green" life standards and effective recycling in the economy (Gubanov, 2014, 6; Popov, 2015, 26). In the neo-industrial economy, the growth of real GDP is not subject to harsh environmental constraints, its potential is based on the level of social and economic development which accounts for environmental factors in the economic development mechanisms as fully as possible, and emphasizes the interconnection and interdependence of the state's economic policy with its environmental, scientific, technical and social policies (Kormishkina, 2017).

Contributing to the discussion outlined above, the authors of the article attempt to consider it from the perspective of resource-based growth of the economy, in line with the idea that belongs to the classics of political economy which states that "labor is impossible without raw materials, the economic development of society is impossible without it" (Marx, 1956).

1.2. Relevance of the Problem

The current stage of the development of the world economy, including the Russian one, is characterized by a virtually general slowdown in the economic growth, mainly due to the depletion of natural resources and deterioration of the ecological situation, in other words, an increasing ecological footprint. According to some experts (P. Suknev), the global ecological footprint has doubled over the past 40 years, and is now 30% higher than our

planet's self-repairing ability (Jackson, 2013, 289). According to the estimates of G.G. Malinetsky, if the level of per capita consumption of the BRICS countries alone equals that of the USA, this will require the natural resources of five such planets as the Earth (Malinetskiy, 2014, 17).

It should be noted that if the ecological footprint continues to increase, this in turn will lead to more active competition in the global market of raw materials. Exhaustion of natural resources contradicts the desire of the society for further economic growth in the situation of its slowdown (Kamenik, 2012). Recent and current events in Iraq, Libya, Syria, Ukraine and other countries confirm the accuracy of this conclusion.

The logic of the analysis suggests that the raw materials model of economic development the world worked out has reached a deadlock. On the one hand, the growing scarcity of natural resources has already acted as "brakes" for the growth of real GDP. At the same time, this does not refer to energy carriers, hydrocarbons, only (there is still some "reserve" and alternatives linked with the idea of renewable energy resources implemented today), but mainly to mineral raw materials which are the material basis of all final products. Specialists believe the amount of the world reserves of energy resources will last for 40-50 years (for coal – more than 100 years); however, the period of resource availability for many types of mineral raw materials is only 10-20 years (Lipina et al., 2018, 134). On the other hand, it is known that currently only 2% of the total amount of natural resources extracted in the world is used; the remaining 98% go to waste. In addition, all products with a short period of use (from 0.5 to 5 years) also become waste (Kamenik, 2014, 179).

However, in modern economic conditions with the production management methods and technologies used, production and consumption wastes are either destroyed or accumulated in huge areas (special landfills, waste deposits, etc.), contributing, in addition to environmental pollution, to a large number of valuable raw materials being removed from the economic turnover. Moreover, there is often the same amount of valuable components (iron, copper, lead, tin, tungsten) as well as valuable elements (cadmium, bismuth, selenium, tellurium, rare-earth and noble metals) in the waste as in the extracted natural resources.

Considering the above, a new long period of economic growth can be initiated only by timely creation of a new raw material base for the reproduction of the economy, the material basis of which should be formed by production and consumption waste (Kormishkina et al., 2017). The authors of this article believe that this conceptual approach can give a new neo-industrial answer to the geospheric challenges of the modern era.

1.3 Literature Review

People have known about the geosphere limits to the economy for a long time, even as early as the end of the 18th century. This question was raised by T. Malthus in the highly influential work "An Essay on the Principle of Population" (1798). He put forth the thesis that population growth always outpaces the growth of the resources necessary for subsistence and housing. Although Malthus's ideas have been repeatedly criticized and severely condemned for several reasons, certain provisions of his theory still interest the scientific community (G. T. McCleary, J.L. Simon, E. Boserup, F.A. Hayek, M. Spence, etc.).

In the 1970s the issue of the geosphere limits was raised, but in a different form, in the report to the Club of Rome "Limits to Growth", prepared by a group of scientists under the supervision of Donella and Dennis Meadows. It justified the idea that an ecosystem that goes beyond its resource base inevitably moves toward collapse (Meadows, 1972). The key provisions and conclusions of this report served as the theoretical and methodological basis for creating new concepts of economic growth, including: the theory of "zero" growth that confirmed the negative impact of high rates of GDP growth on the environment (D.H. Meadows and D.L. Meadows, J. Randers, J. Forrester, G. Malinetsky, etc.); institutional models of economic growth which link the growth of environmental problems with drawbacks in the system of state and public institutions (G. Myrdal, H. de Soto, R. Nureyev); "new growth theories" that, on the one hand, take into account the research findings on

sustainable development issues in the framework of the neo-Keynesian, neoclassical, institutional and left radical approaches and, on the other hand, recognize the compatibility of economic growth with measures aimed at protecting the environment (Lucas, 1988; Romer, 1996).

It is important to note that by the beginning of the 21st century, the discussion on the geosphere limits to the economy has already turned into a heated debate over two interrelated environmental problems affecting the intensity of economic activities – climate change and energy security (or the so-called "peak oil").

For example, P. Sukdev, the well-known in scientific circles economist of Deutsche Bank, writes: "Nowadays many experts point to the ongoing economic crisis triggered by the crisis in the production of fuel, food and finance and the parallel development of the ecological and climate crisis, suggesting that there is a common cause – a flawed economic model" (Jackson, 2013, 288). This discussion resulted in the emergence of a "new green course" (2008), which was not only quickly recognized by scientists and politicians from different countries (Krugman, 2009; Meadows, 2012; Jackson, 2013; Spence, 2013; Fücks, 2016; Bobylev, 2011, 2012; Porfiryev, 2012; Lipina, 2018, etc.), but also received strong international support (UNEP Global Green New Deal Program 2009).

Recognizing the advantages of the "green" project as a way to address the identified environmental problems, at the same time scientists emphasize the importance of restoring and/or maintaining the long term potential for economic growth in the world and attempt to identify its new sources, "pillars", "drivers" and factors (Spence, 2013). For instance, German politician and publicist Ralf Fücks in his book "Green Revolution: Economic Growth without Environmental Damage" (2016) argues that "the current European debt crisis has clearly demonstrated the fully insane criticism of growth... The question is not whether Europe needs an economic growth, but how to increase the growth potential and in what direction to move?". He proposes to "... focus not on increasing or decreasing GDP, but on the raw-material aspect of the economy".

In this context, the neo-industrial paradigm of modern development is getting wider professional and public recognition. This paradigm has been explored in the Russian journal "Economist" by many of its authors since the early 2000s. (Gubanov, 2014, 2016; Tatarkin and Andreeva, 2016, etc.). S.S. Gubanov, the ackowledged founder of this concept, sees the key feature of neo-industrialization not only in the development of high, technetronic technologies of production and final consumption, not just the technological progress of tools and productive forces, but reaching historically a qualitatively new stage of social development, when "the economy gradually transforms from the nature's antagonist into its ally, that is, it starts functioning as recycling" (Gubanov, 2012).

The neo-industrial paradigm of modern development makes it possible to determine a new type of economic growth which is characterized by the dominance of social rather than private capital (profit) in the economic system. This implies active rather than passive attitude of society to the environmental aspects of production and social life, preserving the environment and improving the quality of life (Kormishkina, 2016).

In this regard, one should mention the international initiative "3R" (Reduce, Reuse, Recycle) launched in 2004 at the G8 summit by Prime Minister Junichiro Koizumi representing the government of Japan. This initiative implies an integrated approach to solving the problem of increasing production waste and energy efficiency. In this regard, recycling of resources can be viewed as a key condition for maintaining the growth potential of the economy in the long term by creating a new raw material base of social reproduction. The authors of this article define recycling of resources in a broad sense as an environmentally oriented closed system of commodity production which can bring production and consumption waste back into economic circulation through reuse, including a set of measures to minimize waste generation (Kormishkina et al. 2016, 1117). So, a new definition – "waste resources" becomes the focus of scientific attention (Kamenik, 2012, 2015; Humphreys, 2011).

1.4 Stating the Hypothesis

In conditions of the increasing ecological footprint and the impending shortage of natural resources, to maintain the potential for economic growth, it is necessary to create a new raw material base for the reproduction of the economy. This new, supra-global task of the 21st century which is still not fully understood by society can be solved by new industrialization that would enable to reach new advanced levels of modern development. It would also enable the society to struggle for protecting the environment and improving the quality of life, and the economy's orientation towards recycling. In line with the neo-industrial paradigm, economic growth must be innovative, ecological and inclusive. At the same time, resource recycling is not only the key condition for maintaining the growth potential of the economy in the long term, but also an indicator of the development of a particular country.

2. Methodology

The integrative approach that is based on objective economic laws and leading trends of the modern era develops the provisions of well-known economic theories and concepts (the concept of sustainable development, the neo-industrial paradigm of modern development, the theory of economic growth, the concept of socially responsible behavior of economic systems, the theory of social capital, the "new green course", the concept of "decoupling", etc.). Consideration of these ideas in their unity and interaction enables to conduct research and to identify critical situations within the framework of the indicated problem.

The integrative approach chosen as the methodological basis for the research is implemented according to the following theoretical and methodological principles:

- general principles of the movement towards sustainable growth of the economy and the environment, towards the neo-industrial development are determined by the interpretation of the definitions of "sustainable development" and "neo-industrial development" in a broad sense;

- the principles of humanistic and inclusive development predetermined by the actions of the social capital and the idea of inclusive society;

- the principles of public-private partnership which contribute to the dominance of the aggregate capital of society over private capital (profit) in the economic system.

Regression analysis which primarily aims at constructing an econometric model that allows estimating the values of the dependent variable from the values of independent variables.

Solving regression equations allowed us to empirically assess the influence of individual factors on the dynamics of GDP. The data on the change in the indices of the corresponding variables were used as variables and response. Calculations were done with Statistica program. Before constructing the regression, we made a correlation analysis and determined the multicollinearity of factors. The adequacy of the model was assessed with computational and graphical methods by estimating the residuals of the regression model for normality. The methodological basis for constructing the model was the well-known Cobb-Douglas production function, presented by the authors of the idea in the article "Theory of Production" (Cobb, Douglas, 1928), supplemented by G. Renshaw (2005, 516-526) and adapted taking into account the recycling component (Pittel, Amigues, Kuhn, 2005).

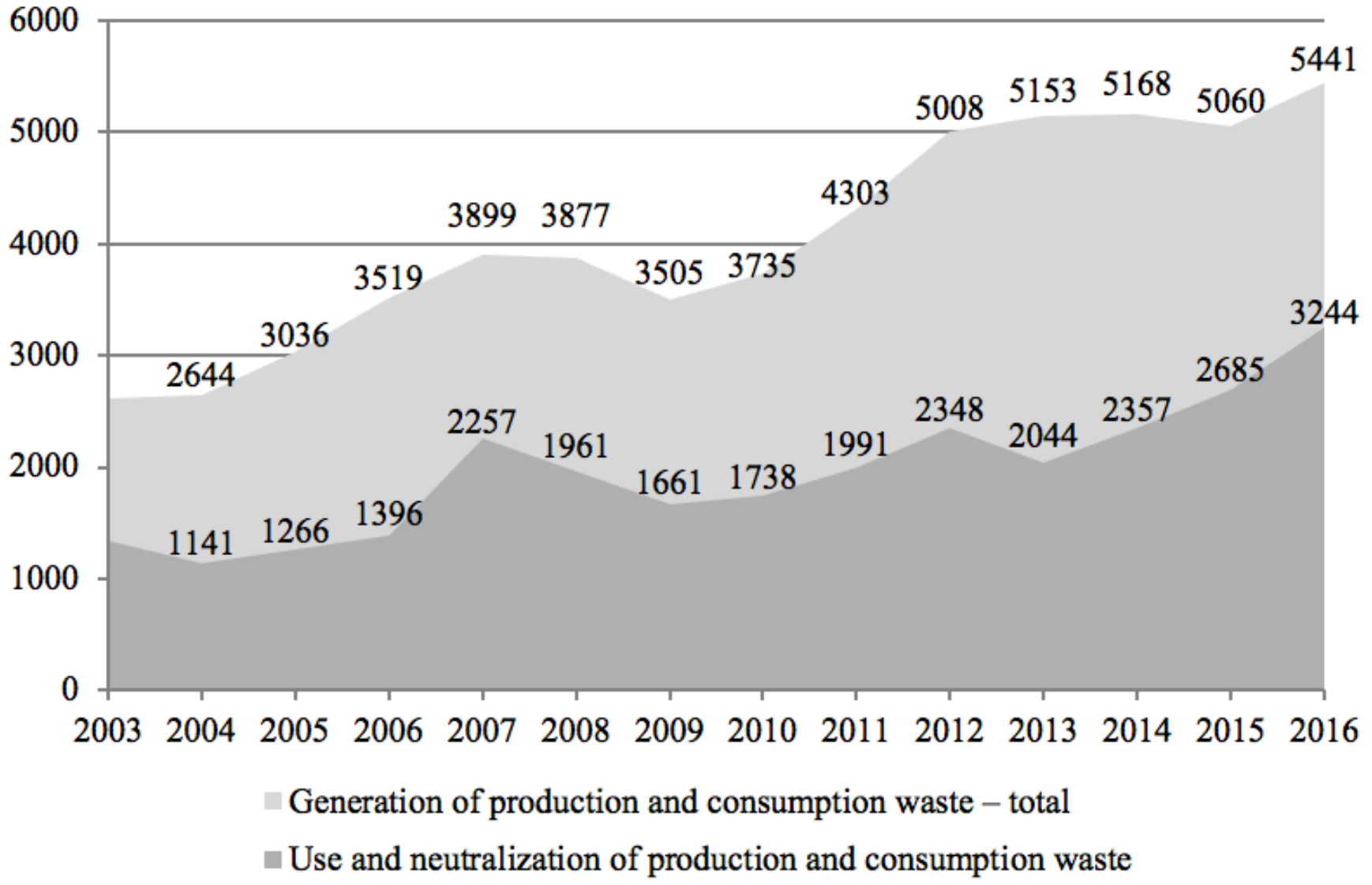
3. Results

As it was noted above, the beginning of the 21st century saw a widespread decline in GDP growth rates and crisis signs in the economy, including a noticeable depletion of the natural resource base (not only in the world, but also in Russia). At the same time, the accumulation of industrial and domestic waste in the environment accompanied by air, soil, underground and surface water pollution and other phenomena dangerous for eco-systems persisted. For instance, the official statistics of Russia claims that in 2009-2016 the economy of the country experienced an increase in the production and consumption waste by almost 1.5 times; since 2012, their annual growth exceeds 5 billion tons (Fig. 1).

Figure 1

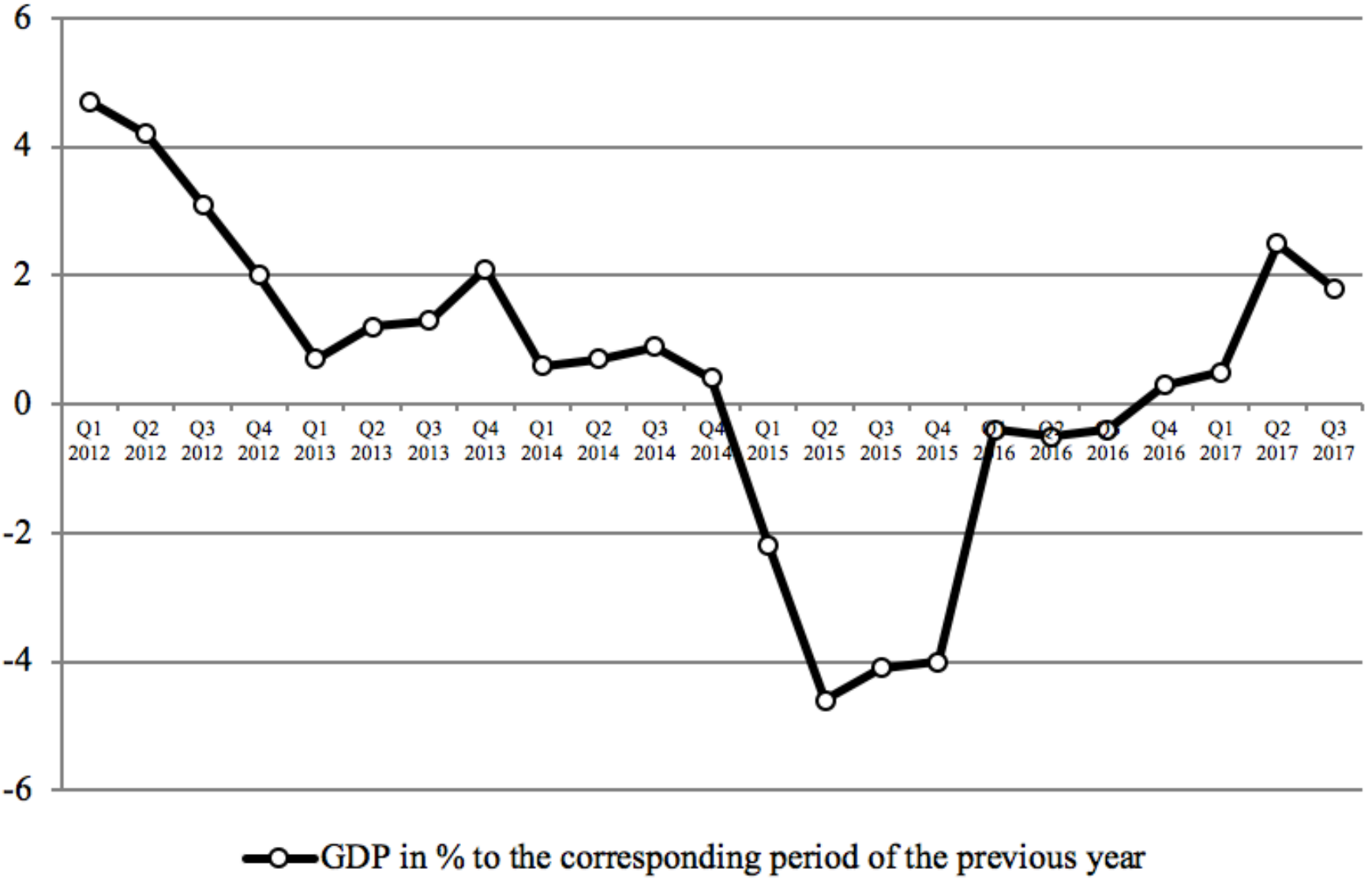
Dynamics of accumulation, use and neutralization of production and consumption waste in Russia, million tons (compiled according to the data of the Federal

State Statistics Service (gks.ru)



However, the rate of hazardous waste generation (15-16% per year) outstrips manifold the dynamics of Russia's GDP (Figure 1a).

Figure 1a
Russia's GDP growth in 2012-2017 (quarterly)



According to the Federal Service for Supervision of Natural Resources, the low level of use and neutralization of waste (on average by 48% per year) leads to its accumulation in the environment. At present moment, Russia has accumulated 90-120 billion tons of production and consumption waste, and the damage to the economy from the accumulated pollution is estimated at 4.6% of GDP (Kormishkina et al., 2016).

At the present stage of society's development when virtually all ecosystems on the planet have been affected by human activity, the problem of handling waste as unused raw materials can be estimated as one of the most pressing ones from the perspective of wildlife preservation and the task to "go beyond the ecological limits" (Meadows, 2012).

According to the European Environment Agency, most industrialized countries currently start to pay more attention to the issues of waste neutralization as a way of intensive reduction of the burden on the reproduction of the mineral resource base and the natural resource intensity of the economy, as well as to the basics of the production cycle.

Today's priorities in the field of waste management in Europe can be identified according to the data presented in Table 1 (Lipina, 2018, 147).

Table 1
Solid waste management in Europe, %

European countries	**Landfilling (depositing)**	**Incineration**	**Composting**	**Re-use (recycling, regeneration and recovery)**
Germany	30.2	12.3	17.9	37.1
Austria	20.4	13.3	22.9	29.7
Finland	65.2	3.0	4.2	27.6
Norway	59.0	17.0	5.0	20.0
Netherlands	13.1	36.6	31.3	19.0
Belgium	37.3	31.2	16.3	12.4
Denmark	5.3	54.3	29.6	10.4
Italy	62.9	5.9	8.8	9.9
Ireland	90.3	–	0.5	9.2
United Kingdom	86.2	5.7	3.0	5.1
France	40.3	28.6	8.9	3.5
Spain	74.6	21.0	3.1	1.2

As one can see from the data in Table 1, in the developed economies of Europe, the recycling of production and consumption waste shows all characteristics of a formed industry and waste is seen as a special reserve of raw materials. Unfortunately, Russia still remains the world leader in landfilling (depositing) of rubbish.

It is important to note that waste, which mostly consists of unused raw materials, has certain specifics, unlike natural resources. Going through numerous stages of the cycle (raw materials – product – waste – raw materials – product – waste – raw materials ... etc.), the

waste makes a complete circle of transformations. In other words, this forms a closed resource cycle, in which it is not necessary to repeatedly involve new natural resources into economic turnover. This can be done by means of industrial reproduction of raw materials from waste. In this context, waste represents a resource with an incomplete form of consumption. Giving the definition to such a situation, one can use the term "waste management" (Kamenik, 2012).

In addition, one should consider the terminological vagueness of the very process of industrial reproduction of raw materials and waste. This process aims at not the extraction of new resources from nature, but their industrial production from the resources that are already available, though being in the form of waste after their primary consumption. This process of special conversion of one form of resources to another for industrial reproduction of raw materials can be defined as "resource recycling". This conceptual approach is the basis for determining the content of "recycling" in a broad sense (paragraph 1.3 of this article).

It should be mentioned that in the neo-industrial paradigm of modern development which claims the priority of socially responsible behavior of the state, business and society, domineering interests of social capital over the "egoistic impulses" of private capital (Gubanov, 2014, 6-7), resource recycling acts as an indicator of a higher level of socio-economic development. This means that it can be considered as one of the most important factors of the neo-industrial type of economic growth, since it meets the established criteria of the latter – innovation, inclusiveness, and being eco-friendly (Kormishkina et al., 2014, 1116-1117). This theoretical proposition can be justified by the following:

1. Industrially reproduced raw materials base obviously cannot exist without appropriate innovative technologies which will be increasingly demanded by the society in the future. In addition, it should also be taken into account that all products obtained as a result of industrial reproduction of raw materials are high-tech, and, therefore, these are competitive products, the demand for which will also grow.

2. Raw materials that are commercially reproduced from waste can be exported. According to the official data of the Bureau for International Recycling (BIR), about 600 million tons of materials are processed annually in the world, and 1/3 of them is exported; secondary resources today already cover 40% of the needs of the world industry; the annual turnover of the processing sector is USD 160 billion; private companies annually invest USD 20 billion in scientific research in the field of recycling.

3. Creation of a closed cycle economy is the goal of real economy of the 21st century. This facilitates creating a large number of jobs, which is in line with the principle of social inclusion (the principle of social capital). This policy is being actively implemented in the most advanced industrialized countries. The growth of income through the creation of new high-tech jobs enhances the accessibility of social goods to more people, including such benefits as education, health, higher qualifications, clean environment, etc.

4. The active development of resource recycling contributes to the reduction of environmental costs and losses, which, undoubtedly, are a public rather than a private concern. These are serious environmental challenges that are inherent in the traditional (natural) use of resources: CO2 emissions, global warming, changes in the water cycle, ocean acidification, pollution of water sources, etc. In this context, resource recycling seems to be a key condition for introducing a new social philosophy, opposing the philosophy of private profit typical of the export-raw material model of the Russian national economy.

This, in our opinion, justifies the need to consider recycling of resources as a key condition for the country's non-industrial development which would allow it to go beyond the ecological limits, and hence, would mean new growth potential of the economy.

It should be noted that the Russian Federation actually started implementing the integrated approach to solving the problem of increasing waste and energy efficiency only in 2014 after introducing amendments to Federal Law No. 458-FZ "On Production and Consumption Wastes" (1998). Despite the fact that the regulatory and legal acts adopted in recent years reflect the inclination of the state institutions to solve the existing problems in the field of

handling industrial and domestic waste, many of these challenges have not been dealt with. For example, recycling standards are introduced without proper definition of the term "utilization". In Russian legal and regulatory framework, this concept combines all the above-mentioned methods of dealing with production and consumption wastes (Table 1) without indicating their priority.

Thus, despite the fact that the last version of Federal Law No. 458 of December 22, 2014 (Article 4) recognizes production and consumption waste as an item of property (this is undoubtedly important for the implementation of resource recycling), the cost estimation procedure representing the economic aspect of this concept has not been developed. In addition to that, in 1996 the Russian legislation eliminated statistic reporting on forms 14-VR (secondary resources), 14 Forests (wood waste), 9 SN (ferrous scrap), 17 SN (non-ferrous scrap). This, in turn, explains the backlog of our country from the leading economies of the world in the field of resource recycling.

Moreover, the low technological level of waste processing enterprises does not contribute to the development of the resource recycling sector in the Russian economy. At present, the vast majority of waste sorting plants (WSP) in the Russian Federation sort components using mainly manual labor. At best, they use magnetic separation to deal with metal scrap. Only in 2011 the first WSP using an automated system for sorting components with optical technology appeared in Saratov. The second similar plant was launched in Kostroma in 2013.

The high share of manual labor involved in the collection and preparation of many types of industrial and household waste to be used as secondary resources does not stimulate the development of resource recycling.

It is important to note that the WSPs in Russia mainly use imported components and assemblies (for example, a preliminary shredder, a bag breaker, a large fraction separator, a metal separator, a fuel cell shredder (RDF), a press, etc.). At the same time, a number of Russian manufacturers of waste sorting equipment (OAO Stankoagregat, Moscow; OAO Autopark No. 1 Spetstrans, St. Petersburg; OAO Lipetsk Experimental Plant Gidromash; OOO Ecomashgroup, Tver; the Megalion Group of Companies, Tver, etc.) are ready to launch production of some components and assemblies, provided there is guaranteed demand and relevant support of these investment projects by the state. Besides, in our opinion, additional measures will be required to stimulate R&D to increase the competitiveness of Russian equipment used in waste processing. It is clear that the funds coming from recycling charges in the so-called "tax maneuver" will not be enough for these purposes.

The indicated problems related to production and consumption waste management in the Russian economy explain a significant backlog of our country from developed economies. In addition, the conducted analysis of the relevant indicators within the scope of the investigated area also revealed that the situation varies greatly in different subjects of the Russian Federation. It can be said that the highest degree of processing, use and neutralization of industrial and household waste in comparison with the volumes of its generation in the regions (about 90% and above) fall for the republics of Mordovia and Altai, as well as Irkutsk, Kaluga, Astrakhan, Sakhalin, Ulyanovsk regions and the Krasnoyarsk Territory.

On the contrary, such regions as the Chechen Republic, the Republic of Tuva, the Republic of Kalmykia, the Republic of Ingushetia, the Republic of Crimea, the Republic of Karelia, Arkhangelsk, Amur and Kursk regions demonstrate a low level of use and neutralization of production and consumption waste in comparison with the volumes of their generation for these regions (about 5% or less). The growing volumes of non-recycled waste in these regions not only cause irreparable environmental damage to these areas, but also reduce the growth potential of their economies, say nothing of the neo-industrial transformation potential.

It is worth mentioning that even at the current level of resource recycling in the Russian economy, there is a correlation between GDP growth and waste use and neutralization, as the built econometric model proves. The variables used in the model are presented in Table 2. To build this model, the authors used the data provided by the Federal State Statistics Service of the Russian Federation for several years, found at the official website of the

agency.

Table 2
Variables used in the logarithmic model and their description

Variable	Index	Source
Y	Real GDP of the Russian Federation (2005=100)	gks.ru
K	Fixed assets in comparable prices (2005=100)	gks.ru
L	Average annual number of employed in the economy (2005=100)	gks.ru
R	Use and neutralization of waste, 2005=100	gks.ru

In line with the approach proposed by K. Pittel, J.P. Amigues, T. Kuhn (2005), to evaluate the dynamics of the waste processing impact on economic growth, the authors of this article used the Cobb-Douglas function (1).

$$Y = AL^{\alpha}K^{\beta}, \quad (1)$$

where Y is production volume; A is technical coefficient; L is labor costs; K is capital costs; α is coefficient of labor elasticity; β is coefficient of capital elasticity.

The transformation of the classical function included adding one more factor – recycling (R) (2). It should be noted that this study is based on the hypothesis of mutual influence of economic growth and resource recycling. On the one hand, economic growth creates prerequisites for additional waste use due to increased costs; however, recycled waste itself represents resources for a new process of reproduction and can facilitate GDP growth.

$$Y = AK^{\alpha}L^{\beta}R^{\gamma}, \quad (2)$$

where γ is coefficient of output elasticity of recycling.

To construct the multiple linear regression, for expression (2) we found the logarithm (3) and the result was used to build the model.

$$LnY = \alpha LnK + \beta \, Ln \, L + \gamma \, Ln \, R \quad (3)$$

Interestingly, the correlation matrix did not show there is multicollinearity between such indicators as LnK and LnR, which may indicate that these variables can be included in the model. At the same time, the logarithm of labor has a strong correlation with other two factors, which shows that one of them should be excluded from the model. As a result, two models were built: including and excluding labor as a factor of changes in GDP.

Table 3
Analysis of variables for multicollinearity

Variable	Correlations (Model) Marked correlations are significant at p < ,05000 N=12 (Casewise deletion of missing data) CumulativePe					
	Means	Std.Dev.	lnY	LnK	LnL	LnR
lnY	4.794189	0.084907	1.000000	0.850117	0.896294	0.767525
LnK	4.785106	0.127021	0.850117	1.000000	0.680185	0.390372
LnL	4.638180	0.006862	0.896294	0.680185	1.000000	0.737967
LnR	4.618661	0.006336	0.767525	0.390372	0.737967	1.000000

Having constructed the regression model, we found that the level of statistical significance for LnL is below 5%, and the standardized BETA coefficient is the lowest among the variables used. Taking into account the data in Table 4, this fact also indicates the accurate use of labor in the model, since keeping it can lead not only to a result with an error of > 5%, but also more than one-fold affect the influence on the response of similar factors.

Table 4

Regression analysis of the dependence of gross domestic product and factors of economic growth

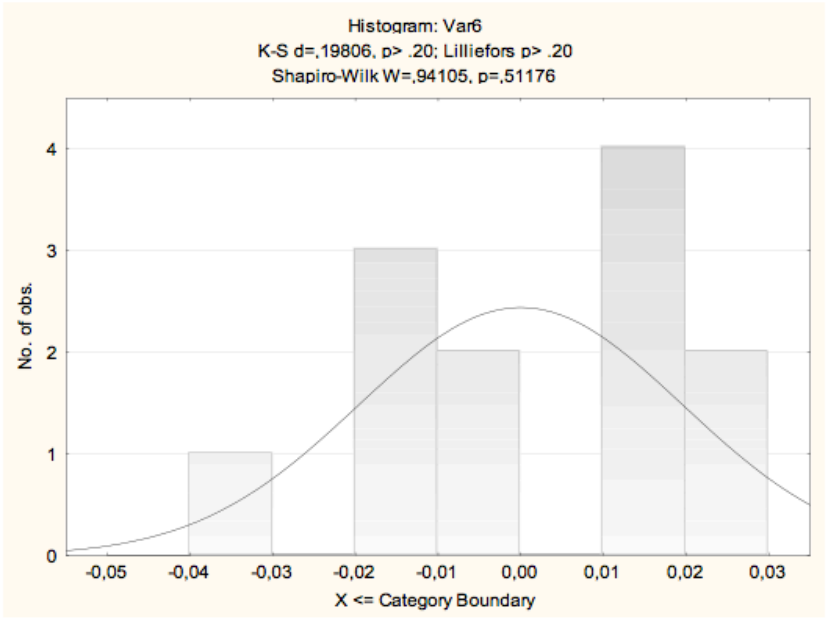
Variable	**Parameters of regression models**	
	1	**2**
Constant	–34.9764*** (7.04)	–29.0980*** (5.73)
LnK	0.3492*** (5.83)	0.4341*** (7.76)
LnL	3.3970* (2.24)	
LnR	4.8376*** (3.71)	6.8883*** (6.14)
Number of observations	12	12
F-statistics	78.826***	79.809***
R^2	0.955	0.973

Levels of statistical significance: 10%–*; 5% – **; 1% – ***; The value of t-statistics is shown in the brackets.

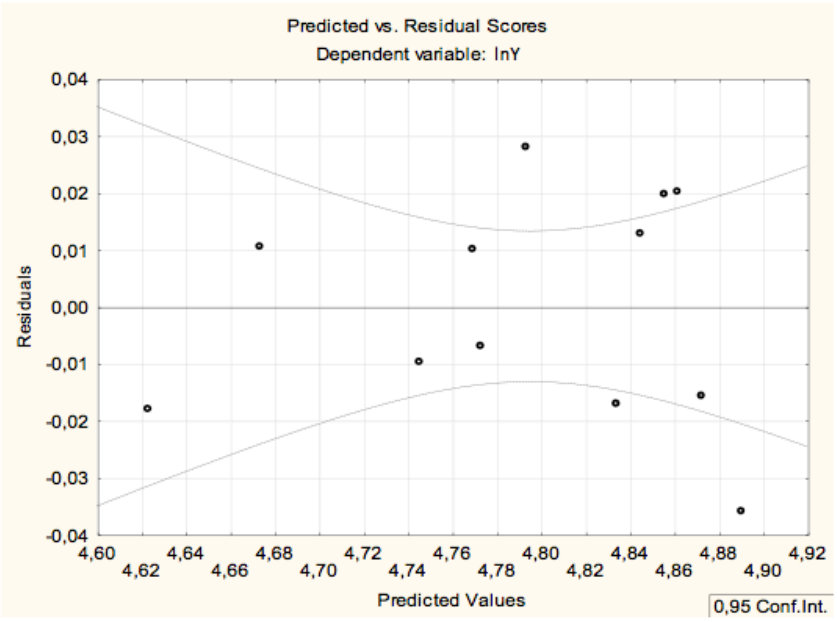
Study of the residuals of the two-factor regression model as a whole allows us to claim that the residuals are distributed normally, and the model is accurate. Calculation methods show there is a normal distribution since according to the Shapiro-Wilka and Kolmogorov-Smirnov criteria p> 0.2 (Fig. a). Graphic methods illustrate the normal distribution: 1) on a normally probability graph, the points are along or on a hypothetically normal straight line (Fig. b); 2) on the box plot, the median is in the center, and the chart itself is relatively symmetrical (Figure d); 3) the predicted values and residuals (Fig. c) are located randomly and non-systematically on the chart, which also confirms the normal distribution of residues. In general, the histogram of the residuals (Fig. a) does not demonstrate a strict correlation with the bell curve, but this fact can be due to the number of observations. In view of the above, we can claim that the residuals in the regression model are normally distributed and

it is possible to continue studying this model.

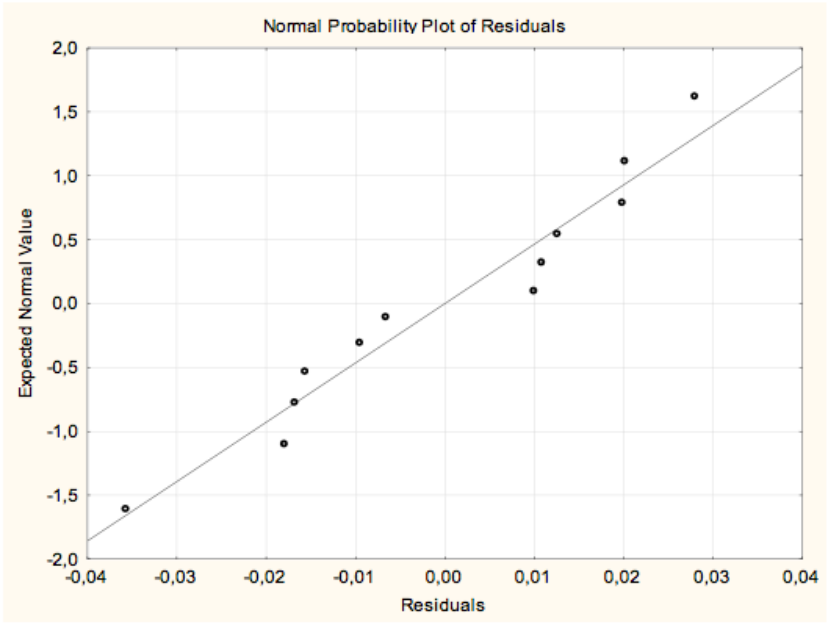
Figure 2
Residual Analysis



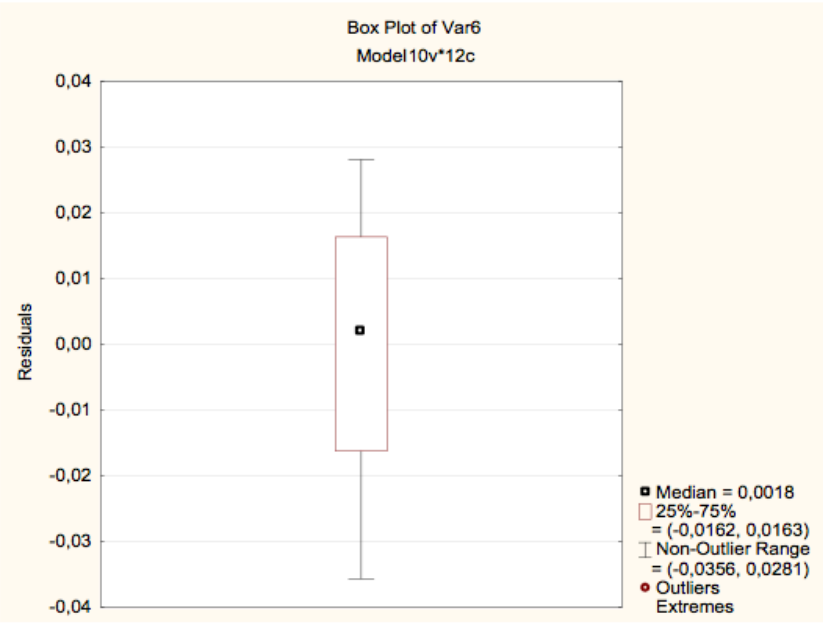
(a)



(b)



(c)



(d)

The models constructed in this study have a strong degree of mutual influence of the waste use and neutralization index and the index of economic growth in Russia. The obtained results make it possible to claim that regarding the economic development of modern Russia, the effect of the capital index on GDP dynamics has not been as significant as recycling of resources. However, one should pay attention to the fact that using more detailed statistics, more observations, including monthly and quarterly ones, would enable a more accurate analysis of the mutual influence of resource recycling and economic growth.

4. Discussion

In the framework of the today's challenge of finding ways to restore the economic growth and maintain it in the long-term perspective in a situation when mankind is consuming planet resources faster than the nature can reproduce them, scientific community, in our opinion, should focus on the possibility of transforming the foundations of civilizational development – the economy transfer from the traditional (natural) resources to industrial reproduction of raw materials. This new raw material base should include production and consumption waste, the reserves of which are enormous today. At the same time, resource recycling, representing the essence of the process of industrially creating raw materials from waste resources by means of new industrialization, is an adequate response to the indicated

dilemma of economic growth, an opportunity "to go beyond the limits of natural limits" (Meadows, 2012).

In this regard, it is important to say that Russia's returning from the side of the road on the main path of modern development today is impossible without abandoning the raw materials export model of the national economy, which leads to negative trends and processes, including those in the area of operation and recovery of the mineral resource base and the environment. Bringing the Russian economy in accordance with environmental and humanitarian challenges of the era, determining its prospects for future economic growth, in our opinion, can be done only within the framework of the neo-industrial policy. Such an approach means the increasing socio-economic attractiveness of resource recycling technologies, the development and expansion of which contributes to the formation of the closed-loop economy that can continue to develop without violating environmental limits or fully depleting resources (Jackson, 2013, 70).

The authors of this article believe that the following urgent measures should be taken at the current stage of Russia's socioeconomic development for promoting and effective functioning of the resource recycling industry:

(1) *improving the regulatory and legal framework* in the field of waste management. It should be noted that a fundamental change at the state level in the attitude towards the problem of waste management in the Russian Federation has been observed since 2014 when the federal law "On Production and Consumption Wastes" (1998) was supplemented with Article 4 "Waste as an item of property". This can be described as an important step for the transition to a modern waste management scheme. There is a need for a further gradual and systematic development of the relevant legal mechanisms aimed at increasing the responsibility of producers to ensure the eco-friendly end of the product life cycle;

(2) *devising a new economic mechanism* whose specific feature will be the inclusion of waste resources in the economic development of the country, which implies:

modernization of pricing, which means determining the total amount of production costs, including the cost of processing waste;

adherence to the principle of economic responsibility of the producer and consumer of the product;

adherence to the principle of social justice, which in this case means that the payment for waste processing is attributed to the consumer of the product (the one consuming it pays for its processing);

(3) *creating a favorable macro environment*, the main components of which should be:

a) state guarantees in the form of subsidies for reimbursement of a part of interest expenses on loans and borrowings attracted by private investors for the implementation of projects related to:

the development of new technologies and/or adaptation of existing waste processing, in line with the "Zero Waste" concept (choosing and localization of the best technological practices for neutralizing and recycling waste, for example, pyrolysis);

construction, technical re-equipment or reconstruction of the production capacities of waste recycling enterprises;

b) providing a set of benefits and preferences (for example, privileges on loans and taxes on connecting to the engineering and transport infrastructure) for enterprises that recycle waste through "green" technologies and supply secondary raw materials with improved environmental qualities, and, on the contrary, creating conditions in which it becomes economically unprofitable for the waste owner to store waste;

c) stimulating the use of waste products in Russia's production and exports of secondary raw materials not demanded by domestic producers;

(4) *designing effective resource recycling management*. Considering the importance and scale of the problem, recycling management should be based on the principles of public-private partnership. Recycling management is not a self-regulating system; it should include

the state, business, and society. Modern trend for business self-regulation is not applicable in this case;

(5) *training specialists* for the implementation of the state program of industrial reproduction of raw materials.

5. Conclusions

The global financial and economic crisis of 2008-2009 made people realize that the fundamental foundations of civilization's development should be revised, in particular, concerning the resource (raw materials) factor. It can be stated that new approaches and "supports" should be implemented in the area of resource provision to restore economic growth and further social and economic development.

One should understand and accept the fact that it is no longer possible to "go beyond the ecological limits" without creating a new raw material base which will be formed by waste resources. In this regard, resource recycling, with production and consumption waste representing its material basis, enables to "go beyond the ecological limits" (Meadows, 2012), which means that it is a key condition for restoring and maintaining the economic growth potential in the long term.

In modern Russia, resource recycling is the demand of the society, a priority direction of the neo-industrial modernization of the economy, as well as a relevant development trend for business.

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