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DEVELOPMENT OF CIRCULAR ECONOMY IN MODERN CONDITIONS

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ABSTRACT

The concept of a circular economy in the world arose in response to growing consumption and, as a result, to the accumulation of a mass of waste that cannot be quickly processed in the natural environment and has a harmful effect on the environment. The introduction of a circular economy along with the modernization of production will provide Ukrainian society with double benefits. First, the reuse of already consumed resources allows you to obtain significant benefits both in terms of savings in their purchase and in reducing the costs of waste disposal. Secondly, the burden on the environment is reduced and the problems of waste disposal are solved, which positively affects the country's ecosystem.

The essence and types of decoupling as a strategic basis for the development of the green economy are analyzed. The actualization of the use of decoupling for Ukraine in the context of highlighting issues of its environmental and economic security is shown. Calculations of the integral decoupling factor for Ukraine were carried out.

Based on the results of the calculations, conclusions were made regarding the effectiveness of the system of nature management and management of the socio-economic development of the state, directions for solving problems and prospects for further research were determined. The conducted analysis made it possible to draw conclusions that at this stage of economic development there is an urgent need to transition to an inclusive and circular economy. The results of the conducted research can be used in the development of the strategy of green economy and sustainable development of countries.

Keywords: *circular economy, environmental safety, balanced development, decoupling, efficiency*

1. INTRODUCTION

The development of circular economy models is currently being promoted in many countries around the world to counter global environmental threats, especially climate change. The development of the circular economy also has enormous potential for creating new business models that can ensure sustainable economic growth and create attractive employment opportunities at the regional level.

At the current stage of Ukraine's economic development, solving environmental problems is extremely relevant and important (Podlevska, Krasovska, 2017). The burden on the environment increases linearly with the growth of society's needs.

In today's world, rapid technological development and population growth, as well as active human activity, have a significant impact on the environment, requiring us to be conscious and responsible about our consumption of resources and emissions of unnecessary waste. Each of us can act in the interests of the environment by consciously choosing products and services, including by considering environmental safety labels on packaging, using environmentally friendly materials in our homes and workplaces. In order to preserve natural resources and ensure the environmental safety of our planet, we need to focus on promoting conscious consumption and appropriate behavior, considering the impact of human activity on the environment and minimizing the negative impact of our activities on the environment.

Due to the growing environmental concerns, it is necessary to pay more attention to and promote more conscious consumption and environmental behavior. This may include changing consumer habits, raising environmental awareness, and introducing green technologies. Rising levels of environmental pollution, climate change, and other environmental issues stem from major global challenges. The transition to a more environmentally friendly lifestyle can help reduce the negative impact of people on nature and ensure the sustainability of life on the planet.

One of the solutions is to conduct an expanded information campaign to build environmental awareness and skills in environmental behavior among the general population. To achieve this goal, it is necessary to implement various approaches, such as the use of mass media, trainings and seminars, and the development of web resources containing materials on environmental issues and advice on ecological consumption. Other solutions will also be relevant: the use of environmentally friendly technologies and materials, support for environmental policies by governments and businesses, reducing the use of plastic packaging and waste, and supporting green initiatives.

Ukraine also faces the problem of low resource and energy efficiency in industry and construction. This has serious consequences for the country's economy, environment, and social well-being. First, low resource efficiency potentially leads to unnecessary consumption of fuel, water and other materials in production processes, which in turn affects the competitiveness of Ukrainian enterprises. In addition, this leads to an excessive burden on natural resources, which can cause their depletion and environmental problems. Second, low energy efficiency in construction and industry leads to high energy consumption for heating, cooling, and lighting. This, in turn, leads to higher energy costs and environmental pollution. Insufficient insulation of buildings and outdated production technologies lead to energy loss and increased emissions of harmful substances.

To solve these problems, more work is needed to create new energy efficiency standards and environmental regulations in construction and industry. This means establishing mandatory requirements for energy efficiency in buildings, using environmentally friendly materials and technologies in production, and raising awareness of the importance of energy conservation and rational use of resources among businesses and other market participants. In addition, it is important to conduct research and development on energy efficiency and introduce innovative technologies that reduce energy and resource consumption, disseminate information on reducing energy and resource consumption opportunities, and the benefits of energy efficient technologies and environmentally friendly materials. It is also necessary to create favorable conditions for the use of energy efficient technologies and materials. For example, taxes can be imposed

on the use of materials and technologies that are harmful to the environment, and benefits and subsidies can be provided for the use of energy efficient technologies and materials. In general, the efficient use of resources and energy in industry and construction is an important component of the country's sustainable development.

Addressing the problem of low resource and energy efficiency is a comprehensive approach that includes the development and implementation of new technologies, creation of favorable conditions for the use of energy efficient materials and technologies, and information and education among industrial enterprises.

In addition, it is important to develop global trends in sustainable development and energy, such as the transition to renewable energy, reduction of carbon emissions, energy efficiency, etc. Ukraine's participation in such initiatives as the Paris Agreement and the UN Sustainable Development Goals requires the country to change its approach to resource and energy use, as well as to introduce modern technologies that ensure the sustainability of the nation's development.

One of the ways to solve the existing environmental problems and, as a result, to increase the competitiveness of the national economy in the long run is intensive, maximally efficient, waste-free resource consumption, as well as systematic reduction of all types of anthropogenic pressure on the environment through the "green" modernization of modern industries and the introduction of new technological processes (Ukraine 2030).

The development of modern innovative entrepreneurial activity and the creation of innovative enterprises is one of the main directions of economic development and its movement towards a circular, innovative economy.

Innovation, as „a key element of economic activities of the present time" (Minster, 2015, p.ix), is essential for overcoming the significant challenges which the mankind is facing, especially related to economic development and welfare of almost entire, growing global population (Mašić B., Vladušić Lj., 2018).

Only those countries that implement resource-saving, innovative and waste-free technologies, systematically reduce all types of environmental pollution can achieve high production rates without deteriorating the state of the ecological system. It is the circular economy that represents a new economic model associated with green growth and ensures the movement from mass consumption to responsible consumption.

In order to determine how successfully a country is moving towards sustainable development and the implementation of the circular economy, scientists use decoupling analysis of the economy (Podlevskyi, Podlevska, 2021). The circular economy adheres to three main principles, namely, the reduction, reuse, and recycling of resources. Preference is given to reducing the use of materials, i.e. the theory of decoupling is an important factor in the circular economy that significantly affects its development. Decoupling makes it clear whether an economic activity is efficient in terms of minimizing environmental damage. The task of decoupling is to assess the difference between anthropogenic pressure on the environment and resource consumption from economic growth.

Decoupling theory is a basic theory proposed by the Organization for Economic Cooperation and Development to describe the decoupling between economic growth and resource consumption or environmental pollution (OECD, 2002). This means that economic growth can be decoupled from resource consumption or environmental pollution to realize decoupling. In the development of the circular model of economic growth, the decoupling effect is precisely that

economic growth occurs with the help of resource-saving technologies and, accordingly, a reduction in the impact of emissions into the environment.

2. LITERATURE REVIEW

The problems of implementing a circular economy are in the focus of attention, first and foremost, of governments, international organizations, foundations, and financial institutions that predict the emergence of new promising markets. However, this issue is also of interest to both economic and environmental scholars. Among the scientists who have considered the essence, basic principles of the circular economy and ways to improve waste management are H. Nguyen, M. Zils, M. Stuchtey (Nguyen, Stuchtey, Zils, 2014), N. Pakhomova, P. Williams (Williams, 2005) and many others.

The problems of the "circular economy", global changes and their impact on national economies have been studied by Zvarich 2019, Loyko 2019, and others, who identified the basic principles of sustainable development in the national economy, environmental and economic problems, and proposed ways to solve them, including through the use of best foreign practices. Waste management has become the main subject of research by leading scientists (V. Mishchenko, H. Vyhovs'koyi 2009), who studied the European experience and directions of state policy on solid waste management.

Interesting, in the context of our study, are the views of foreign scholars on the definition of the "circular economy". In the context of the development of the circular economy, the authors' definition is worthy of attention (Korhonen J., Nuur C., Feldmann A., Eshetu Birkie S. 2018): "...a sustainable development initiative aimed at reducing the linearity of societal production and consumption systems. Applying material cycles, renewable and cascading energy flows to a linear system. The circular economy promotes the development of high-value material cycles alongside more traditional recycling and develops systemic approaches to cooperation between producers, consumers and other public actors in the field of sustainable development."

The definition of the "circular economy" as an economic system based on the creation of innovative enterprises that act as entities that create high-tech and knowledge-intensive products in the circular economy is defined by (Kirchherr J., Reike D., Hekkert M. 2016): "an economic system based on business models that replace the concept of "end of life" with the reduction, alternative reuse, recycling and recovery of materials in the production/distribution and consumption process, operating at the micro level (products, companies, consumers), meso-level (eco-industrial parks) and macro-level (city, region, nation and beyond), in order to achieve sustainable development that creates environmental quality, economic prosperity and social justice for the benefit of present and future generations."

The definition of the "circular economy" in the context of the decoupling phenomenon given by (Peters et al. 2007) is worthy of attention: "the main idea is to close material loops, reduce the amount of input materials and reuse or recycle products and waste to achieve a higher quality of life by increasing the efficiency of resource use".

The analysis of the scientific literature on the circular economy shows that the following terminology is used worldwide: green economy, circular economy.

3. AIM OF THE RESEARCH

The purpose of this study is to determine the existence of the decoupling phenomenon as an important factor in the circular economy, which significantly affects its development in Ukraine, as well as to analyze the decoupling values of the index of balanced development of Ukraine and determine the degree of environmental orientation of economic development.

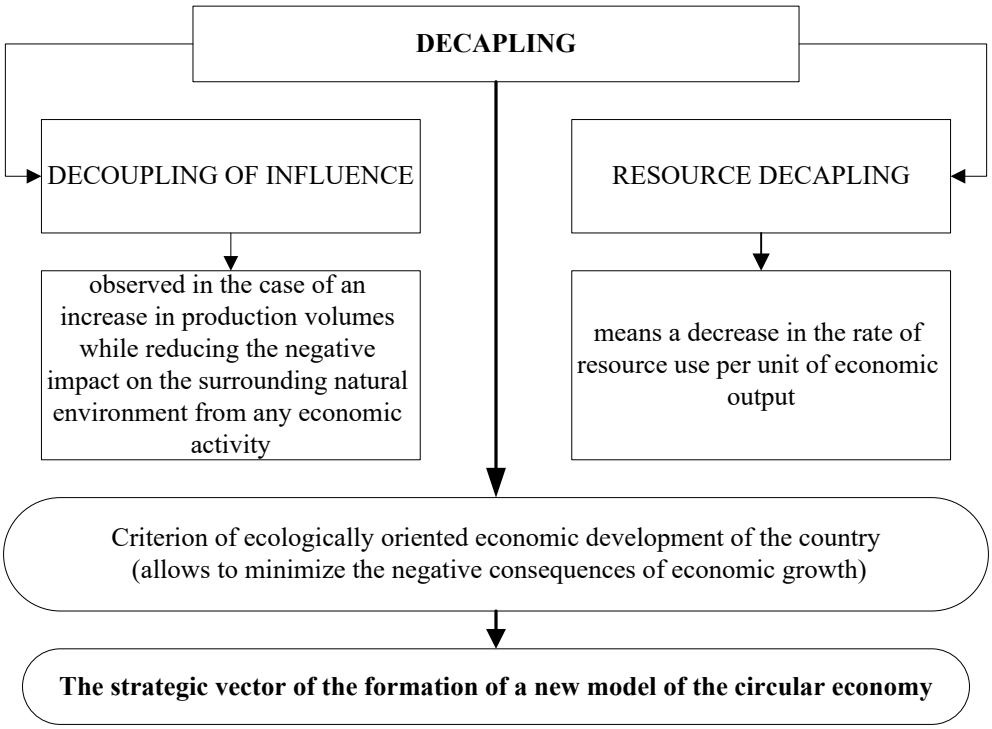
4. METHODS

The environmental threats and challenges that Ukraine faced before February 24 have not been resolved on their own, but have only become deeper. The war has had a global impact on Ukraine's environment. It has resulted in the decline and deterioration of natural ecosystems, chemical and industrial pollution, mining, and devastating damage to biodiversity.

The Ukraine Recovery Conference, which took place on July 4-5 in Lugano, Switzerland, was an important contribution to the future of environmental restoration. One of the conference programs to be implemented in the future is "Rebuilding a Clean and Protected Environment." Switzerland's experience in environmental policy is exemplary. Switzerland will invest in projects that will reduce greenhouse gas emissions, as Ukraine's reconstruction will require intensive use of various sectors: mining, industry, transportation, and others, which will be accompanied by an increase in carbon emissions. Therefore, Switzerland's experience and support are valuable to us in terms of implementing green economic principles and transitioning to a circular economy in the process of rebuilding the country without harming the global environment.

Effective waste management is another reform on the path to European integration. The first step has already been taken. In June, the Verkhovna Rada adopted a framework draft law on waste management (No. 2207-1-d). Addressing the issue of waste is especially important now, when its amount is growing significantly as a result of the military operations. A large amount of construction waste is generated during the cleanup of territories, rubble removal, and restoration of residential buildings and businesses. Therefore, in the context of the new model of the "circular economy", decoupling should become a key principle that provides for meeting growing needs while minimizing the consumption of natural capital (UNEP, 2011), and it is decoupling that allows us to assess the effectiveness of institutions in minimizing environmental damage. Fig. 1 shows the types of decoupling as a basis for implementing a circular economy model.

Figure 1. Decoupling as a basis for the formation of circular economy model



Source: (Tur, O.M., 2012)

The definition of resource decoupling should help to solve the problem of shortages and respond to the challenge of sustainability and intergenerational equality to reduce the rate of resource depletion while reducing costs by increasing the efficiency of resource use. Domestic scientist O. Tur (Tur, O.M., 2012), in continuation of foreign developments, proposed to calculate resource decoupling using the following formulas:

Resource decoupling factor:

$$\text{Decoupling Index} = \frac{N_E}{DF_E} / \frac{N_B}{DF_B} = \frac{N_E}{N_B} / \frac{DF_E}{DF_B} = \frac{I_N}{I_{DF}} \quad (1)$$

$$\text{Decoupling Factor} = 1 - \text{Decoupling Index} \quad (2)$$

where N_B, N_E – the amount of natural resources consumed (mineral, forest, land, water, and other resources) in the final (end of measurement) and baseline (beginning of measurement) periods, in natural units;

$\frac{N_E}{N_B}$, I_N – growth rate, or an index of the physical volume of natural resources consumed;

I_{DF} – GDP physical volume index (or another macro indicator).

The author interprets the obtained values as follows:

1. If $DF \geq 1$ then the growth rate of resource consumption or pollutant emissions is not lower than the rate of economic growth, which demonstrates dependence. At the stage of full dependence, the higher the decoupling factor, the higher the dependence of economic development on resources and the greater the environmental damage.

2. If $0 < DF < 1$, the growth rate of resource consumption or pollutant emissions is lower than the growth rate of economic growth, indicating relative decoupling, which shows relatively efficient use of resources or relatively low environmental damage.

3. If $DF \leq 0$, then the increase in resource consumption or pollutant emissions is less than 0, which is absolute decoupling and means that resource consumption or pollutant emissions are decreasing with economic growth.

In our work, for further calculations of decoupling indicators by environmental impact factors and by resource factors, among a wide range of indicators that exert pressure on the environment and reflect the level of resource use, we have selected the following: emissions of pollutants into the atmosphere from stationary and mobile sources, volumes of wastewater disposal (discharge), volumes of waste generation of hazard classes I-III, mineral resources extraction, volumes of used water consumption and volumes of waste disposal.

We used the following formula to calculate the integral decoupling factor:

$$F = 1 - \left(\sqrt[n]{\frac{N_{E1}}{N_{B1}}} * \frac{N_{E2}}{N_{B2}} * \ldots * \frac{N_{En}}{N_{Bn}} / \frac{DF_E}{DF_B}\right) \quad (3)$$

where n is the number of types of pollution, 1, 2, ... n are the types of pollution.

The decoupling effect at the macroeconomic level occurs when economic growth does not deteriorate primarily the environmental component (indicators of negative environmental impact).

The results of the calculation of the decoupling factor can be interpreted as follows (Tur, O.M., 2012):

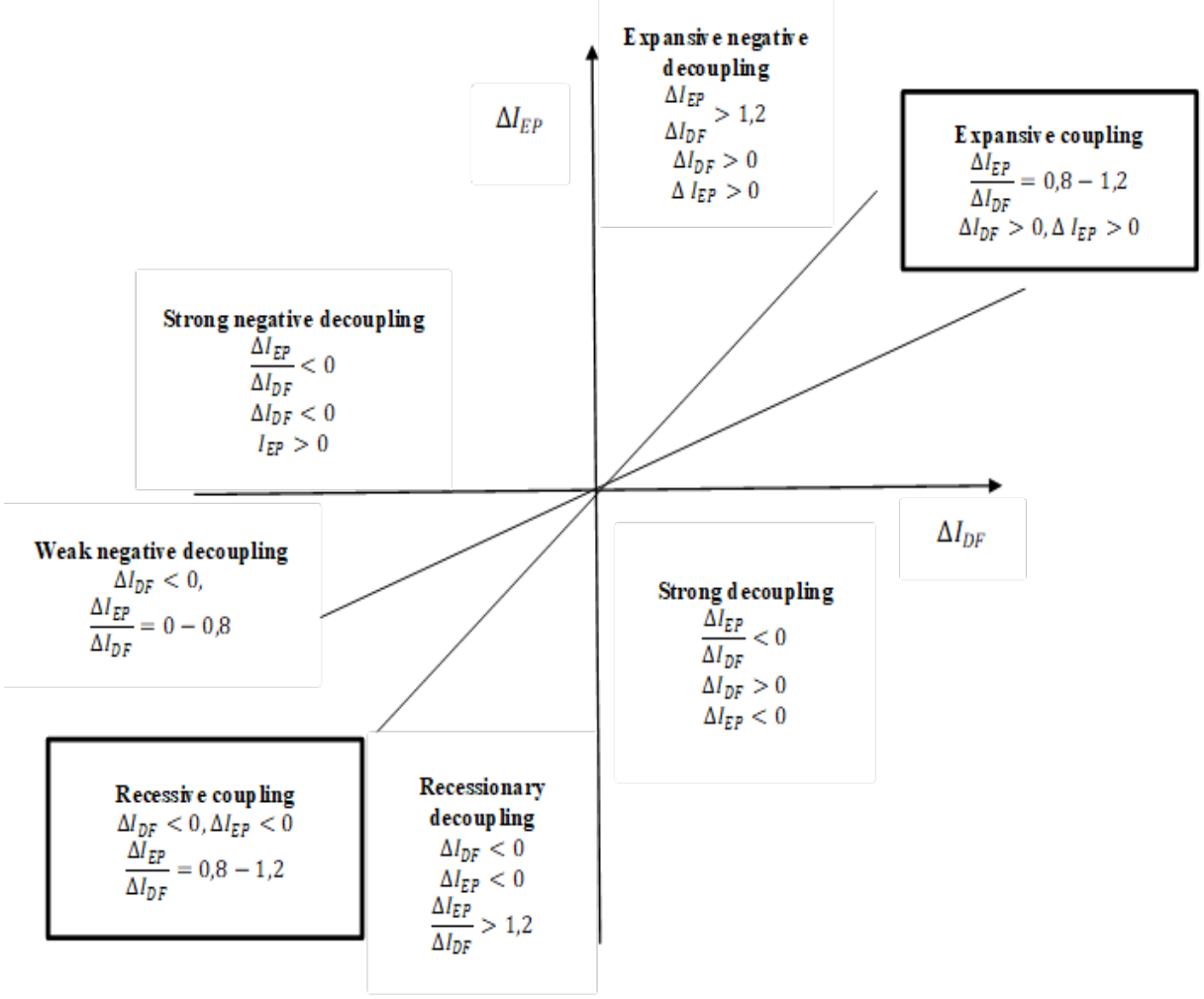
1. Decoupling Factor > 0 and this indicator is growing in the dynamics - there is a decoupling effect, i.e. there is a decrease in anthropogenic pressure on the environment or natural resource savings with GDP growth;

2. Decoupling Factor < 0 and decreases in the dynamics - economic growth leads to a significant increase in anthropogenic pressure or depletion of natural resources;

3. Decoupling Factor = 0, indicates the equality of economic growth and anthropogenic pressure or natural resource use, and is possible under the following conditions: a) GDP growth and anthropogenic pressure (resource consumption) are both equal to 100%, b) GDP growth and anthropogenic pressure (natural resource consumption) are greater than 100%, c) GDP growth and anthropogenic pressure (natural resource consumption) are less than 100%.

There are also eight logical levels of the decoupling index. Thus, the GDP growth rate and the indicator of anthropogenic pressure on the environment (or the amount of consumed resource) can be coupled, decoupled, or negatively decoupled. These values will be coupled if the value of the decoupling index is in the range from 0.8 to 1.2. Such a relationship between the indicators can be positive or negative, so depending on this, expansive coupling and recessive coupling are distinguished (Tapio P., 2005).

Figure 2. Degrees of decoupling index



Source: (Tur, O.M., 2012)

The decoupling index should be divided into three subcategories:

- weak decoupling, when GDP growth outpaces the growth rate of environmental pressure (0 < Decoupling Index < 0.8);

- strong decoupling - is observed when GDP growth is increasing and environmental pressure is decreasing (Decoupling Index < 0);

- recessive decoupling - when the GDP and environmental pressure rates are decreasing (Decoupling Index > 1.2).

Similarly, negative decoupling includes three subcategories:

- Expansive negative decoupling, when GDP growth and environmental pressure are increasing (Decoupling Index > 1.2);

- strong negative decoupling - is observed when GDP growth is decreasing and environmental pressure is increasing (Decoupling Index < 0);

- weak negative decoupling - occurs when both indicators decrease simultaneously (0 < Decoupling Index < 0.8).

Another method we will use to assess the decoupling effect is to determine the correlation between national production and environmental emissions. The multivariate linear regression model is the most common type of dependence between indicators. This process of constructing mathematical dependencies between a factor attribute and a dependent variable allows not only to determine the existing close relationship between these indicators, but also to predict one variable (y) based on other variables (x). Thus, regression analysis allows you to draw reasoned conclusions about the development of a given economic process, based on and supported by specific mathematical calculations.

The simplest form is linear multivariate regression, which describes a linear relationship between the data under study:

$$Y=a_0+a_1 x_1+...+a_n x_n \quad (4)$$

Where y is the dependent variable, function;

a_0, a_n - regression coefficients;

x_1, x_n - dependent variables.

In this case, GDP was chosen as the resultant indicator, and the following indicators of anthropogenic impact were chosen as factor variables:

x_1 - emissions of pollutants into the atmosphere, thousand tons;

x_2 - wastewater discharge (discharge), million m3;

x_3 - generation of hazardous waste of I-III categories, thousand tons;

x_4 - fresh water consumption, million m3;

x_5 - volume of waste disposal of hazard classes I-IV, thousand tons.

x_6 - volume of mineral resources extraction, thousand tons

To characterize the closeness of the relationship between the selected indicators, a linear correlation coefficient is used, which takes values from +1 to -1. A positive value of the correlation coefficient indicates a direct relationship between X and Y, and a negative value indicates an inverse relationship.

5. CUSTOMER CHURN MODELING RESULTS

It is known that the level of each economic indicator is formed under the influence of many factors and conditions, and depending on the combi**T**nation of these conditions, the value of the indicator changes. Correlation analysis is used to study the relationships between indicators that are stochastic in nature. Let's calculate the correlation coefficient. The results of the calculations are presented in Table 1.

A positive correlation coefficient ($r > 0$) indicates a "direct" relationship between the attributes (i.e., one where an increase in the value of one attribute increases the value of the other attribute), and a negative correlation coefficient ($r < 0$) indicates an "inverse" relationship (i.e., one where an increase in one attribute leads to a decrease in the other attribute). The assessment of the closeness of the relationship between the studied attributes is evaluated using the Chaddock scale.

Table 1. The results of determining the decoupling effect in Ukraine for 2010-2021 based on the calculation of the correlation coefficient between GDP and indicators of anthropogenic impact on the environment

Decapping effect indicators	Correlation, r_{xy}	Communication
$Y = 1112,78 - 0,996X_1 - 0,7402X_2 - 2,568X_3 + 1,783X_4 + 0,0162X_5 - 0,0389X_6$ Coefficient of determination R^2=0,901 – in 90,1% of cases, a change in GDP leads to a change in pollutant emissions		
1. The decoupling effect on emissions of pollutants into the air	-0,85602	close connection
2. The decoupling effect on discharged natural waters	-0,82774	close connection
3. The decoupling effect on hazardous waste generation	-0,87011	close connection
4. The decoupling effect on the use of fresh water	-0,80511	close connection
5. The decoupling effect on waste utilization	-0,8063	close connection
6. The decoupling effect on the extraction of mineral resources	-0,83702	close connection

Source: compiled by the author based on own calculations

The calculation of the decoupling effect in Ukraine for 2010-2021, based on the calculation of the correlation between GDP and indicators of anthropogenic impact (Table 1), shows the presence of the decoupling effect during the study period.

Further calculations will be carried out in accordance with the approach to calculating the decoupling factor described above.

Table 2. Indicators of the decoupling factor in Ukraine for 2010-2021[1]

Indexes	Years										
	2011	2012	2013	2014	2015	2016	2017	2018	2019	2020	2021
Indicators of decoupling by environmental impact factors											
Decoupling factor for the formation of hazardous waste	0,022	0,132	0,167	0,255	0,316	0,347	0,350	0,378	0,422	0,476	0,515
Decoupling factor for emissions of pollutants	0,062	0,156	0,214	0,247	0,308	0,301	0,406	0,354	0,380	0,448	0,453
Decoupling factor for discharged natural waters	0,212	0,327	0,454	0,504	0,573	0,546	0,553	0,544	0,626	0,666	1
Decoupling factor for extraction of mineral resources	*-0,416*	*-0,265*	*-0,197*	0,0267	0,1964	0,1657	0,203	0,202	0,2689	0,334	-
Integral decoupling factor	**0,757**	**0,867**	**0,911**	**0,937**	**0,9589**	**0,956**	**0,9665**	**0,963**	**0,9769**	**0,986**	**0,926**
Indicators of decoupling by resource factors											
Decoupling factor for the use of fresh water	0,025	0,090	0,149	0,174	0,267	0,259	0,284	0,243	0,299	0,350	0,405
Decoupling factor for waste disposal	*-0,007*	0,158	0,159	0,280	0,355	0,407	0,291	0,278	0,299	0,395	1
Integral decoupling factor	**1**	**0,996**	**0,993**	**0,985**	**0,968**	**0,964**	**0,972**	**0,977**	**0,972**	**0,960**	**0,872**

Source: calculated by the author based on statistical data

[1]Excluding the temporarily occupied territory of the Autonomous Republic of Crimea, the city of Sevastopol and a part of temporarily occupied territories in the Donetsk and Luhansk regions.

Analyzing the data obtained, we draw the following conclusions: the integral decoupling factor for both environmental impact and resources in the period 2011-2021 in Ukraine had a positive value, which was in the range of $0 < DF < 1$, i.e. the growth rate of resource consumption or pol-

lutant emissions is lower than the rate of economic growth, which indicates relative decoupling, which shows a relatively efficient use of resources or a relatively low degree of environmental damage.

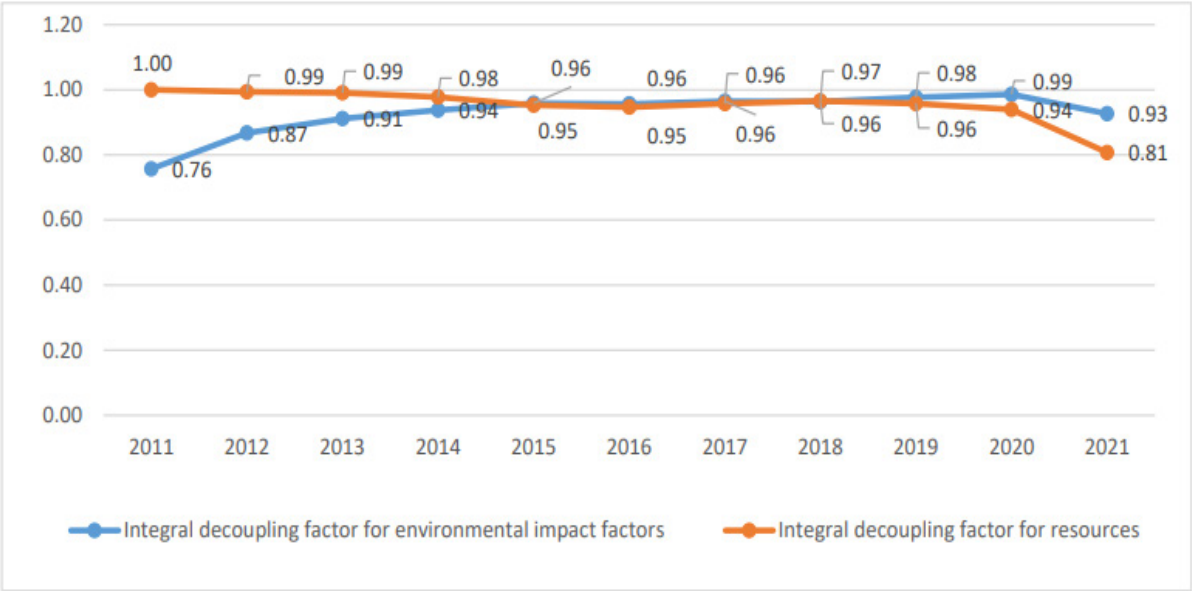
It is worth noting that the decoupling factor for mineral resources extraction in 2011-2013 and the decoupling factor for waste disposal in 2011 demonstrate a negative value, which indicates a situation where economic growth leads to a significant increase in anthropogenic pressure or depletion of natural resources.

As for the ratio of the indices of physical volume of consumed resources to the index of physical volume of GDP for the first four factors (emissions of pollutants into the atmosphere, discharge of waste water, generation of hazardous waste of I-III categories, and the volume of waste disposal of I-IV hazard classes), starting from 2013, it has been in the range of 0-0.8, i.e. we can speak of the presence of weak decoupling.

It is worth noting that the decoupling index for pollutant emissions and water discharge during 2011-2012 demonstrates an expansive relationship when GDP and environmental pressure increase.

As for the ratio of the indices of physical volume of consumed resources to the GDP index for mineral resources extraction in 2011-2013, we have a ratio of more than 1.2, which indicates the existence of recessionary decoupling, i.e. when the GDP and environmental pressure decrease.

Figure 3. Dynamics of integral decoupling factors of Ukraine by components 2011-2021



Source: constructed by authors based on results of own calculations

Let's pay attention to the dynamics of the integral decoupling factor over the entire period under study. It is worth noting a clear downward trend in the indicator throughout the period, i.e. economic growth leads to a significant increase in anthropogenic pressure or depletion of natural resources.

This situation can be explained, first of all, by the existence of still old approaches to resource use, i.e., based on the principles of sustainable development, overexploitation of natural resources, which contradict the principles that are extracted from ecosystems and processed into

products that are used frequently for a very short period of time and then returned to the environment as waste. Such a system of using exhaustible resources cannot be sustainable in the long term, especially given the scale of wastefulness observed today.

The circular economy is a model based, on the contrary, on the example of the closed cycle of substances in nature and aimed at maximizing the value of goods and raw materials that are in them at the end of their use. The transition to such a system promises not only environmental but also economic benefits by creating new jobs, saving costs, and preventing environmental pollution.

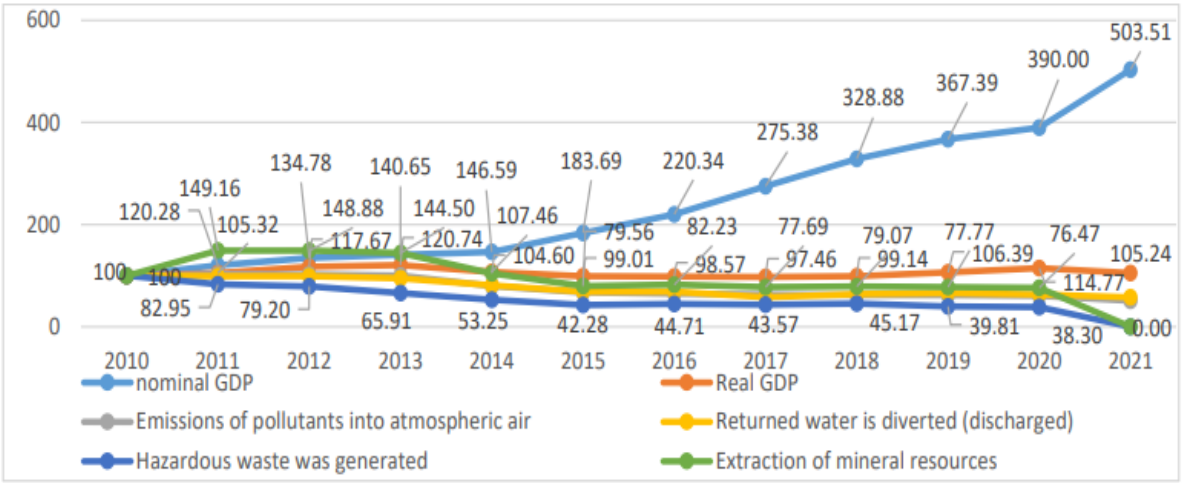
6. DISCUSSION

The article calculates the decoupling factor by the components of anthropogenic impact on the environment, namely, emissions of pollutants into the air, generation of hazardous waste of the I-III stages, discharged (discharged) waste water, fresh water use and waste disposal.

To determine the decoupling effect, the correlation between the volume of national production and environmental emissions for 2010-2021 was calculated using the correlation coefficient.

Indicators of the decoupling factor, both in terms of individual components and the integral one in the dynamics, have shown unstable behavior in Ukraine as a whole. Against the background of positive values, certain fluctuations are observed, namely a decrease in the index throughout the entire period under study. This indicates the lack of balanced development of the state. Therefore, it is reasonable to talk only about the possibility of relative decoupling. This can be seen more clearly in Fig. 2, which shows the trend lines separately for each of the analyzed factors (nominal GDP, Real GDP, Emissions of pollutants into the atmosphere, returned water is diverted (discharged), Hazardous waste was generated).

Figure 4. Trend lines according to the main indicators of decoupling factor calculation (2010 – 100%).



Source: constructed by authors based on results of own calculations.

Based on the calculations made, it is possible to draw conclusions about the general trends of decoupling in Ukraine. It is advisable to consider that, considering more indicators of anthropogenic impact on the environment, the decoupling index may have even lower values than the calculated ones. In general, the decoupling index is a tool for determining whether countries or regions are really moving towards sustainable development.

7. CONCLUSIONS

Decoupling is an important condition for the transition to a circular economy not only for developed countries, but also for emerging economies such as Ukraine. Ukraine has a significant potential to reduce resource and energy consumption, which will reduce the negative impact on the environment and increase the sustainability of the economy as a whole.

One of the main features of decoupling in Ukraine is the significant potential for the introduction of energy-efficient technologies and reduction of energy consumption. Ukraine has significant opportunities for the development of renewable energy, in particular wind and solar energy, which will reduce dependence on imported energy resources and reduce emissions.

Ukraine can also increase the efficiency of water resources use and reduce pollutant emissions into water bodies. For example, more efficient technologies for wastewater treatment and water consumption in industry could be used.

Significant potential for decoupling also exists in the area of waste recycling and material reuse.

Ukraine has significant potential for the development of waste recycling, including attracting investment in the creation of new industries that will specialize in waste recycling and material reuse.

However, there are also certain challenges and obstacles to decoupling in Ukraine. One of the main challenges is the lack of necessary investments and funding for the introduction of new energy-efficient technologies and the creation of new waste processing facilities.

In addition, there is a rather low level of awareness among the population and businesses in Ukraine about the importance of transitioning to a circular economy and decoupling. More work needs to be done on conscious consumption and responsible behavior towards the environment.

Ukraine also faces the problem of low resource and energy efficiency in industry and construction. More work needs to be done to create new energy efficiency standards and environmental regulations in construction and industry.

A decoupling analysis should be carried out when assessing the implementation of these measures, which can be generally described as the “green” modernization of Ukraine to accelerate its transition to a circular economy. Target decoupling indicators can be used in the development of strategic plans for sustainable development of the state and regions. The calculation of decoupling indicators will allow us to assess Ukraine’s success or failure on the path to sustainable development and implementation of the circular economy.

The results of the analysis can be used in the development of management decisions in the field of environmental and economic interactions, as well as in the preparation of strategic planning documents. Comparison of the rates of economic development and environmental pollution in the context of the main types of economic activity can be useful when considering investment projects planned for implementation in the country, including initiatives involving foreign investment. In order to achieve the decoupling effect for certain types of negative environmental impacts, a set of measures is needed to improve the environmental protection mechanism (increasing the rates of payments for negative impacts, restoring the targeted nature of their use, etc.

Thus, decoupling is an important condition for the transition to a circular economy in Ukraine. This requires efforts to increase energy efficiency, use renewable energy sources, recycle waste,

and reduce pollutant emissions. However, in order to achieve these goals, it is necessary to develop the investment environment, attract investments, and do more work on conscious consumption and environmental education of the population and businesses.

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