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Sustainability for Regions



## CIRCULAR ECONOMY AND SMART SPECIALISATION BUSINESS STRATEGIES: THE DNIPROPETROVSK REGION CASE

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Received 14 October 2024; accepted 14 February 2025; published 30 March 2025

**Abstract.** This article explores the integration of the circular economy in Ukraine's smart specialisation strategies, focusing on a case study of the Dnipro Region. Investigating the symbiotic relationship between these concepts delves into legal aspects and presents an overview of Dnipro's unique economic characteristics. The case study illustrates the city's potential to use the smart specialisation approach to enhance economic growth. Utilising correlation regression analysis, it assesses the region's readiness for circular economy principles. Global case studies offer insights for Dnipro, and a SWOT analysis guides policymakers. In conclusion, the article provides a roadmap for harmoniously integrating circular economy principles and smart specialisation to future-proof Ukraine's regional development trajectories.

**Keywords:** circular economy; smart specialization; circular business models; sustainable development; regional development; Ukraine

**Reference** to this paper should be made as follows: Churikanova, O., Pilova, D., Giordano, B., Piccinetti, L., & Amoruso, M. 2025. Circular economy and smart specialisation business strategies: the Dnipropetrovsk region case. *Insights Into Regional Development*, 7(1), 109-130. <https://doi.org/10.70132/y8378689786>

**JEL Classifications:** O20, O10, R10

### 1. Introduction

Ukraine is currently fighting against the aggressor. The paper is devoted to the analysis of the transition towards a circular economy and smart specialisation before the war.

The urgent task of accelerating the Ukrainian economy has consistently been a key priority. Ukraine has worked towards closing the gap with leading European nations regarding GDP per capita for many years. The goal has been to create employment opportunities, offer fair wages, and foster growth across light and heavy industries and the agricultural sector (OECD, 2022). Moreover, the country envisions creating a healthier society where people enjoy clean air and the purest drinking water. But can these goals be achieved simultaneously, ensuring both economic growth and environmental sustainability? The answer is yes, through implementing a circular economy model, which focuses on fundamental principles such as energy efficiency, eco-friendly consumption and production, and regenerative methods (see Ellen MacArthur Foundation, 2013). A circular economy aims to minimise waste and optimise resource utilisation by redefining conventional production and consumption approaches (Ellen MacArthur Foundation, 2013). This concept has gained increasing importance as the world faces challenges related to carbon emission reductions, pollution control, and the shift away from fossil fuel dependency (Khalifa et al., 2022). Unlike traditional development models, the circular economy promotes the

conservation of resources and materials, creating pathways for long-term sustainable growth (Ellen MacArthur Foundation, 2013, Bressanelli et al., 2022; Ruginè & Žilienè, 2024; Bazienè et al., 2024; Daniek et al., 2024; Webster, 2024; Sondhi et al., 2025).

While the European Union has integrated circular economy principles into its economic development policy for several years, Ukraine has only recently adopted these practices (OECD, 2022). The shift toward a more circular economy in Ukraine is expected to deliver various advantages, such as the emergence of new market niches in areas like recycling, services, and industrial design, alongside the introduction of innovative business models. Additionally, the success of this transition will rely heavily on creating a state incentive program, strong regional governance frameworks, technological innovation, and attracting investments (OECD, 2022). Implementing a circular economy could offer numerous benefits to Ukraine, including economic renewal, energy and resource savings, job creation that helps reduce unemployment, lower carbon emissions, and an overall improvement in the environmental situation. The focus of this paper on Ukraine's transition toward circularity highlights the importance of this shift at both the national and regional levels (OECD, 2022). This also emphasises the need for active collaboration between academics and policymakers to deepen research and evaluations in this field.

Developing smart specialisation in the context of the circular economy in Ukraine is an urgent and strategically important task (Koval et al., 2025). Ukraine has abundant natural resources and can benefit significantly from the balanced use and rational management of these resources through the circular economy. Smart specialisation and the circular economy would allow regions to develop specific areas with unique capabilities or advantages. In Ukraine, where many regions have distinctive economic and industrial characteristics, smart specialisation in a circular context can catalyse innovative and sustainable solutions in renewable energy, secondary processing of raw materials and the more efficient use of resources. At the same time, developing these strategies can contribute to reducing the negative impact on the environment, which is one of the main problems in Ukraine. Using circular production and resource management models can help reduce waste and pollution, contributing to a country's sustainable development. Smart specialisation, therefore, in the context of the circular economy in Ukraine, is a relevant strategy that can contribute to innovative, sustainable and effective development of regions, ensuring competitiveness and the balanced use of resources. The paper, therefore, critically evaluates existing government policies and initiatives pertinent to the adoption of circular economy principles in Ukraine, focusing on assessing their efficacy. The analysis identifies opportunities for optimising collaboration between various stakeholders to promote circular economy practices in the Dnipro region and potential strategies to improve coordination and communication among government, industry and academia. Subsequently, evidence-based recommendations for integrating circular economy principles, addressing challenges, and leveraging opportunities in the Dnipropetrovsk region are discussed.

## **2. Literature review**

### **2.1. Circular economy**

The circular economy helps to change the traditional "wasteful" consumption and production paradigm, moving to more efficient use of resources and waste processing. The application of circular economy principles allows products, components, and materials to pass through successive life cycle stages, which are stored, recycled, and reused instead of being thrown away after use. Ghisellini et al. (2016) emphasise balancing economic and ecological systems. The European Commission's "Circular Economy Package" defines strategies and policies to support the development of the circular economy. In a similar vein, initiatives such as "Towards the Circular Economy" and "Circular Economy in Cities: Evolving the Model for a Sustainable Urban Future" from the Ellen MacArthur Foundation (2013) provide strategies for sustainable development at various levels from the global to the regional and local level. The authors argue that the transition to a circular model contributes to creating sustainable and resilient urban systems, directly affecting regions' standard of living and economic dynamics. Interestingly, Tashtamirov (2023) analyse practical cases of implementing circular strategies at the regional level

and their impact on sustainability, employment, and innovation. Rezk et al. (2023) examine numerous challenges to establishing a circular economy, such as limited understanding, insufficient government backing, and inadequate infrastructure; there are also opportunities, such as increasing demand for eco-friendly goods and services and a receptive business environment.

A key point, therefore, from the literature is that the circular economy can and does have a significant impact on the development of regions, creating new opportunities for sustainable economic growth, increasing competitiveness and improving the quality of life of the population (e.g., Dielini et al., 2024). We use this as the premise for analysing the development and implementation of the circular economy at the regional level within Ukraine. Hitherto, it is relevant to discuss research on the links between the circular economy and sustainable development that have been carried out by Ukrainian researchers including (see Churikanova & Denysenko, 2022); the analysis of the conditions for the introduction of the circular economy in Ukraine (see Trushkina, 2021); the study of the development of the circular economy in the context of industrial enterprises (see Gurochkina, & Budzynska, 2020); and the development of circular economy in the Ukraine context (see Timoshenko & Dronova, 2018).

It is essential to highlight that the circular economy extends far beyond waste management. This concept entails profound transformations in the mechanisms underlying economic processes. These changes involve selecting more sustainable and recyclable raw materials, adjusting production techniques, and adopting innovative service models where waste from one process serves as valuable input for another. Economically, the circular economy's principle of converting waste into resources tackles environmental concerns and addresses pressing economic challenges, such as the ongoing depletion of natural resources, rising costs of raw materials, and reduced reliance on imported resources. These issues became particularly evident during the recent pandemic, as border closures forced many domestic industries to halt operations. Additionally, the full-scale military invasion of Ukraine has introduced new challenges for the national economy and reshaped the specialisation of its regions, making the need for regional economic development strategies even more urgent.

The relevance of the circular economy has only grown in this context, as it often relies on domestic supply chains and distribution networks, minimising external dependencies. In this model, regions are central hubs for supply, sales, and processing. Therefore, adopting circular economy principles at both national and regional levels becomes imperative. This approach is vital for economic growth and offers a strategic path forward for Ukraine's recovery and long-term development.

## **2.2. Smart specialisation and the circular economy**

The concept of "smart specialisation" was first used in the European Commission's (EC's) "Green Paper on Territorial Cohesion", published in 2008 (Green Paper on Territorial Cohesion, 2008). Subsequently, the approach was further elaborated in the "Europe 2020" strategy - the development strategy of the European Union for the ten years from 2010 to 2020. In this context, "smart" stands for the abbreviation: "S" - acceleration (Smart), "M" - modernisation (Modern), "A" - activation (Accessible), "R" - resources (Resource-efficient), "T" - creativity (Transparent). Since then, it has become a core policy embedded within the EC's Regional Policy funding to support the efficient use of resources to drive regional innovation, competitiveness and economic development across Europe (see Foray, 2014). In summary, smart specialisation means selecting and developing priority development areas in a particular region or country, focusing on respective competitive advantages, expertise and innovative potential. This strategy envisages the concentration of efforts, resources, and investments in highly innovative industries that will contribute to economic growth and increase the region's competitiveness in the international market. Arguably, it has become essential for stimulating economic development and creating jobs in areas, using their specific potentials and unique competitive advantages. The main idea is to focus on areas where a country or region already has expertise, which can be developed further, creating competitiveness in the

global market. This helps regions avoid direct competition with other areas and focus on unique opportunities to achieve more sustainable and innovative development.

In this paper, we argue that smart specialisation can contribute to the development of the circular economy, in particular regions, by encouraging interventions to develop innovation (see Figure 1). For example, suppose a country has the technological potential to produce electric vehicles. In that case, focusing efforts on the development of this industry can help reduce dependence on traditional cars with fuel engines and facilitate the transition to a more sustainable transport system with electric vehicles that can use secondary materials. Thus, the two approaches can complement and support each other. When implementing a circular economy, regions can focus their efforts on developing industries that allow efficient use of resources and materials already in the economy. These can be industries focused on recycling, secondary processing or repair of goods. Thus, regions can become specialised in the sustainable use of resources and environmentally friendly technologies.



**Figure 1.** Synergy of Circular Economy and Sustainable Development

*Source:* developed by authors

Thus, the combination of a circular economy and smart specialisation can help to contribute to economic growth and sustainable development through the allocation of resources to those areas where a country or region has an advantage and opportunities to achieve competitiveness in the global economy combined with the creation of innovative solutions to ensure sustainable development. In turn, this can contribute to reducing the environmental impact, reducing waste and exploiting natural resources, and creating new opportunities for business and the labor market. Combining these two approaches can help countries and regions become more sustainable, competitive and capable of ensuring the quality of life for their communities. For example, industries focused on recycling secondary materials or repairing and restoring products are becoming essential elements of the circular economy, accelerating the development of green industries and reducing the negative environmental impact. Moreover, applying the circular economy can increase the responsible use of resources, reduce the adverse environmental effects and ensure a more sustainable future for our planet. The focus on smart specialisation makes this process more efficient and more focused on achieving specific development goals. This combination can lead to a more prosperous, environmentally sound and economically sustainable future.

### 2.3. The legislative dimensions

This section explores the legislative dimensions of smart specialisation strategies and the circular economy. First, in 2013, EU Regulation 1303/2013 laid down the following definition: “a smart specialisation strategy is a national or regional strategy that sets priorities to build competitive advantages by innovatively developing own strengths for business needs, in a coordinated manner, without duplication and fragmentation of efforts using new opportunities and market trends”. Subsequently, the smart specialisation concept has developed from an avant-garde idea to Europe's most popular approach to regional development. Indeed, the need to build and implement smart specialisation strategies became mandatory for all EU regions in order to receive research support funding from the Horizon 2020 and Horizon Europe 2021-2027 funds respectively. Significantly, in this paper context,

with the entry into force of the Association Agreement between Ukraine and the EU in 2017, the approach to regional development through smart specialisation became embedded into domestic legislation. The Ukrainian Cabinet of Ministers made appropriate changes to the procedures for developing the State Strategy for Regional Development and Regional Development Strategies (Resolution No. 959 dated November 14, 2018). Moreover, current legislation contains the following definition: “smart specialisation is an approach that involves the reasoned determination by regional development entities within the framework of the regional strategy of individual strategic goals and objectives for the development of types of economic activity that have innovative potential taking into account the competitive advantages of the region and contribute to the transformation of sectors to make the economy more effective.”

In Ukraine, the main circular economy programme documents include the following:

- 1) State Strategy for Regional Development for 2021-2027;
- 2) Action Plan for 2021-2023 for the implementation of the State Strategy for Regional Development for 2021-2027;
- 3) National waste management strategy until 2030;
- 4) Strategy of the state environmental policy of Ukraine for the period until 2030;
- 5) Concept of implementation of state policy in the field of climate change for the period up to 2030 and its implementation plan;
- 6) Low-carbon development strategy of Ukraine until 2050, etc.;
- 7) The strategy for the development of the economy in Ukraine until 2030 is a strategic document that defines the main directions of the development of the circular economy in Ukraine and includes specific goals and measures.

Enacted in 2017, the National Waste Management Strategy, which runs until 2030, outlines the adoption of the finest European practices for managing different types of waste in Ukraine. This includes industrial waste, solid household waste, agribusiness waste, construction waste, hazardous waste, and other waste categories. The primary objectives of this strategy are to address and resolve key waste management issues in Ukraine, identify priority areas for establishing an innovative waste management model, enhance the existing waste management infrastructure through improved methods and approaches, promote sustainable development in Ukraine, enhance the quality of services provided and reduce administrative burdens.

The National Waste Management Plan, which also runs until 2030, approved by the Cabinet of Ministers in February 2019, serves as a guiding document for realising the National Waste Management Strategy. It sets out precise objectives and actions to enable Ukraine to transition towards a new waste management model, embracing a closed-loop economy similar to those adopted by leading Western European countries by 2030. Implementing these measures aims to align national waste management legislation with EU standards.

The fundamental principles (strategy) of Ukraine's state environmental policy until 2030, approved in 2019, aim to address the consequences of environmental issues and tackle their root causes. This strategy, which has been successfully implemented in EU countries, includes measures to reduce water and air pollution and necessary adjustments in public administration through adopting environmental norms and standards. The strategy aligns fully with EU ecological norms and standards and the government's medium-term priority actions.

The formulation of draft laws and other regulatory acts in the field of climate change is guided by the concept and implementation plan of the Ukrainian domestic policy on climate change for the period up to 2030. These documents also establish the key areas of focus for implementing the concept. The purpose of the concept is to enhance the state's policy on climate change and create conditions for Ukraine's transition to a low-carbon development path while ensuring the well-being of its population and economic, environmental, and energy security.

The Ukraine Low-Carbon Development Strategy until 2050 (SNVR), adopted on July 18, 2018, by the Ukraine Central Committee, outlines the transformation of the Ukrainian economy into a low-carbon development model. This involves a shift towards renewable energy sources and primarily focuses on reducing greenhouse gas emissions into the environment. The strategy was devised to fulfil Ukraine's commitments under the Paris Agreement, decisions made by the Conference of the Parties to the UN Framework Convention, and the directives of the Cabinet of Ministers of Ukraine. The strategy's goals encompass establishing a new energy system, increasing carbon absorption and retention, reducing greenhouse gas emissions, and implementing eco-friendly production concepts in Ukraine through adopting "green" (environmentally friendly) technologies.

Notably, despite numerous programme documents, Ukraine has not yet established a cohesive system of support for advancing the circular economy. The development level of sectors operating within the framework of the "closed-cycle" economy remains relatively low. Furthermore, these strategic documents lack sufficient coordination and collaboration among relevant departments. Consequently, as this paper explores, integrating smart specialisation and the circular economy in the Ukrainian context remains challenging, and much more work is required. Several significant opportunities and strengths can be developed with the right policy interventions. This is precisely the aim of the Dnipro case study that we explore in more detail in this paper.

### **3. Research questions**

The aim is to illustrate how and in what ways smart specialisation interventions can be implemented to encourage more circularity in the Ukrainian sub-national context. In so doing, the case study addresses the following key research questions:

- How can the principles of the circular economy be effectively integrated into the smart specialisation strategies of Ukraine's regions, specifically in the Dnipro region?
- How can the circular economy contribute to sustainable economic development and environmental protection in the Dnipro region?
- What are the specific industry sectors in the Dnipro region have the highest potential for circular economy practices, and what strategies can be employed to leverage these opportunities?
- What are the key challenges and opportunities associated with the transition to a circular economy in the context of Ukraine's economic and environmental landscape?
- What role can government policies and initiatives play in facilitating the adoption of circular economy practices in Ukraine?
- How can collaboration between various stakeholders (government, industry, academia) be optimised to promote the circular economy in the region?

The following section discusses the methodological approach used to collect and analyse the data for the Dnipro case study.

### **4. Research methodology**

The methodology adopted involves a comprehensive approach to examining the transition to circular economy and smart specialisation in the Dnipropetrovsk region. It begins with a thorough literature review and legal analysis, followed by data collection from various sources. A SWOT analysis identifies key development aspects, while case studies and economic modelling explore sector-specific dynamics. Environmental assessment and policy analysis inform recommendations for enhancing stakeholder collaboration and integrating circular economy principles into regional strategies.

This study will comprehensively analyse European and Ukrainian research on the circular economy and smart specialisation. The primary objective is to lay the theoretical groundwork for the research while identifying

existing gaps that require further exploration. Additionally, examining Ukraine's contemporary legal framework will focus on the normative legal base relevant to the circular economy.

As part of the research methodology, the study will offer a detailed overview of Dnipro, Ukraine, emphasising its economic and industrial characteristics. Special attention will be given to the application of Smart Specialization within the Dnipropetrovsk region to understand its potential for circular economy development.

The study aims to gather relevant data through rigorous scientific methods. Primary data sources include analytical reports on the Dnipropetrovsk region, particularly the *Strategy for the Development of the Dnipropetrovsk Region*. Additional datasets will be collected from reports published by the State Statistics Committee of Ukraine, focusing on the region's economic, social, and environmental aspects. Practical applications of circular economy principles currently in the region will also be identified and organised to provide real-world insights.

A Strengths, Weaknesses, Opportunities, and Threats (SWOT) analysis specific to the region's transition toward a circular economy will be performed. This analysis will highlight innovative development opportunities through smart specialisation and circular economy initiatives.

Select industrial sectors within the Dnipropetrovsk region will be chosen for detailed case studies. These case studies will explore ongoing circular economy initiatives, focusing on successful strategies, best practices, and challenges encountered.

The core analytical tool will be a correlation-regression analysis widely used in social and economic research. This model will examine relationships between various factors, assessing how social, industrial, and innovation climates interact. The primary goal is to determine how these factors act as prerequisites for effectively introducing circular economy principles within the region.

The research will evaluate potential environmental trade-offs and synergies associated with adopting circular economy practices. Key circular economy tools will also be examined, identifying challenges and prospects at the regional level and for end consumers.

A critical review of current government policies and initiatives related to the circular economy will be conducted. The research will assess the effectiveness of these policies, providing policy recommendations based on best practices observed in similar regions and countries.

Opportunities for optimising collaboration between stakeholders will be identified to promote circular economy practices within the Dnipro region. Strategies for improving communication and coordination among government bodies, industry, and academic institutions will be developed. The study will explore integrating circular economy principles into the Dnipropetrovsk region's smart specialisation strategies. It will also assess how circular economy practices can align with and support regional development objectives.

The findings from each section will be synthesised to address the research questions. Evidence-based recommendations will be provided to guide the integration of circular economy principles in the region, address challenges, and leverage existing opportunities for sustainable development.

## 5. Results

This section discusses the Dnipropetrovsk regional case study.

### 5.1. An overview of Dnipropetrovsk region, Ukraine, highlighting its economic and industrial characteristics

Dnipropetrovsk region is one of the most economically developed regions of Ukraine. It is located in southeastern Ukraine (see Figure 2). It is characterised by a favourable geographical location, rich natural resources, powerful industrial and scientific potential, developed agricultural production, and high transport and communication development.

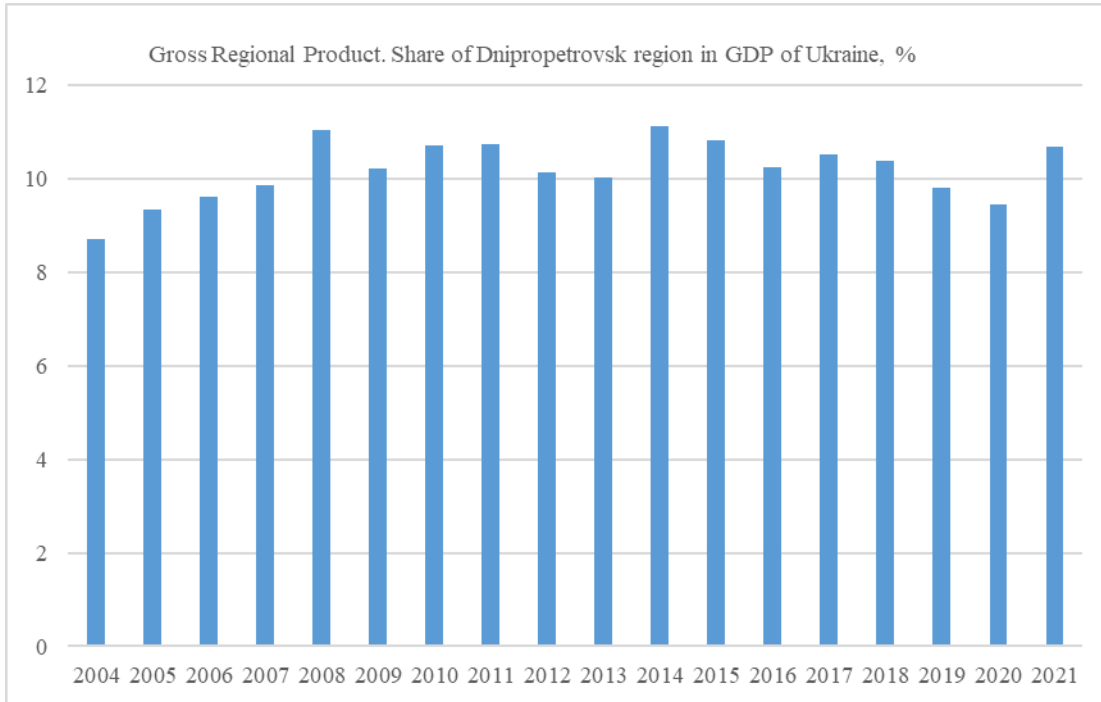


**Figure 2.** Map of the Dnipropetrovsk region

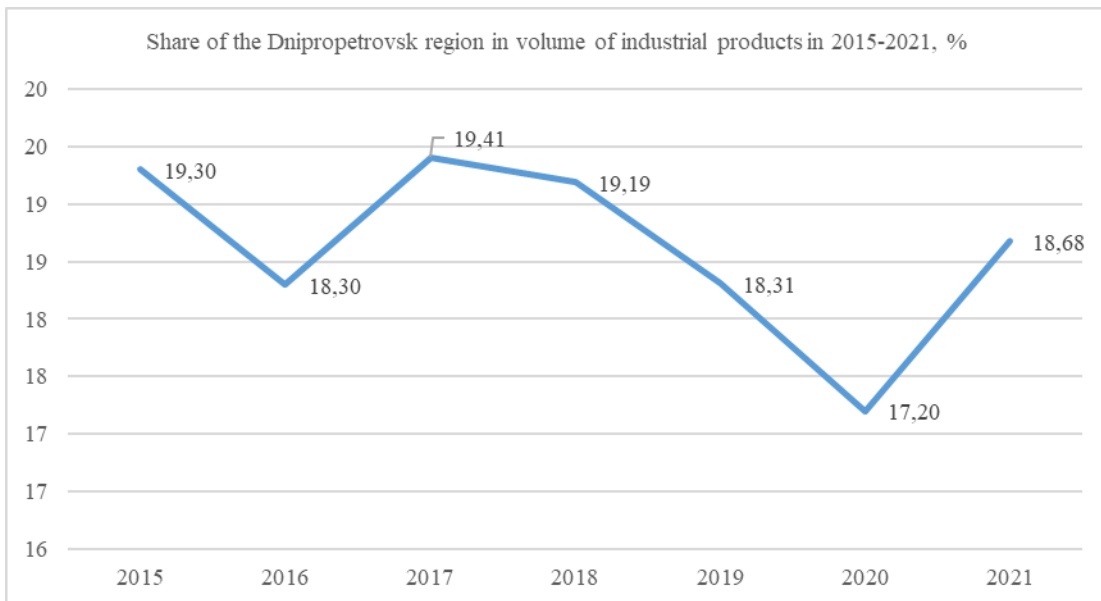
*Source:* developed by authors

The Dnipropetrovsk region is unique in its diversity and reserves of minerals. The richness of the region's subsoil is known in the country, Europe, and the world because unique mineral deposits are concentrated here. The region owns about 50% of the national mineral reserves. The supply of mineral resources is more than three times higher than the national level; 100% of manganese ore, iron ore, coal, uranium, rare earth metals, kaolin and granites, oil and gas are also mined in the region. The Kryvyi Rih iron ore basin ranks first in Ukraine in terms of the number of discovered reserves and the annual production volume. Nikopol basin of manganese ores is one of the largest in the world. Forty types of mineral raw materials are mined in the region. The primary foundation of the region's soil cover consists of ordinary chernozems of different depths of the humus layer and mechanical composition, which, together with the favourable natural and climatic conditions of the region, allow intensive agriculture, promote the cultivation of all grain crops and allow obtaining high-quality food grain.

Occupying 5.3% of the territory with a population share of 7.6%, the Dnipropetrovsk region is one of the leading regions of Ukraine. Its contribution to the Gross Regional Product of Ukraine is more than 10% (see Figure 3), and the region also has a share of more than 18,5% (in volume) of industrial products sold in Ukraine (Figure 4).



**Figure 3.** Gross Regional Product. Share of Dnipropetrovsk region in GDP of Ukraine, %  
 Source: developed by authors on statistical data



**Figure 4.** Share of the Dnipropetrovsk region in volume of industrial products in 2015-2021, %  
 Source: developed by authors on statistical data

Dnipropetrovsk region (or oblast) is a significant industrial region. The largest industrial centres of the region are the cities of Dnipro, Kryvyi Rih, and Kamianske. Powerful industrial enterprises are also located in Nikopol, Pavlograd, Marhanka and Novomoskovsk. More than 4,000 industrial enterprises of almost all main types of economic activity, with a total employment level of about 267,000 people, are engaged in economic activity in the region. The region's most significant share of industrial production is realised by enterprises in mining and

metallurgical processing (almost 65%), which provides nearly a third (or UAH 139.6 billion) of the total volume of industrial products sold in the region. More than 67,000 people are employed at metallurgical enterprises. The leading enterprises include PJSC "ArcelorMittal Kryvyi Rih", PJSC "Dniprovsky Metkombinat", LLC "Metallurgical Plant "Dniiprostal". The volume of sold products in the production of chemicals and chemical products is 3.7% (or UAH 15.7 billion) of the region's industrial production volume.

Dnipropetrovsk region is also one of the most energy-rich regions in Ukraine. Electric power is a highly developed branch of the region's economy, which includes power-generating enterprises. The main businesses include VP "DTEK Kryvorizka TPP", JSC "DTEK Dniproenergo" and VP "DTEK Pridniprovska TPP", JSC "DTEK Dniproenergo", branch "Serednyoprovvska HPP" PJSC "Ukrhydroenergo" and JSC "Dniprovska Tets".

## **5.2. Smart Specialisation in the Dnipropetrovsk region**

The Dnipropetrovsk region uses the concept of smart specialisation to try to drive innovation, competitiveness and sustainable growth within the region. Aligned with the State Strategy for Regional Development (2021-2027), the key regional priorities are listed below:

The priorities of smart specialisation are:

- Production of complex agrochemical products;
- "smart" paints and varnishes, flame retardants, household chemicals, cosmetics products, reagents for water purification, materials for modern diagnostic methods;
- production of the latest materials for technological solutions in the machine building industry, in particular high-tech, transportation, energy, defence industry, agricultural production (precision agriculture);
- development of knowledge-intensive and high-tech industries, including aerospace, precision instrumentation, etc.

The main objectives of the strategy include:

- The creation of chemical and machine-building clusters to expand chemical and pharmaceutical production, including existing value chains and the manufacturing of differentiated products for consumer markets (including complex agrochemical products, "smart" paints and varnishes, flame retardants, household chemicals, cosmetics, reagents for water purification, materials for modern diagnostic methods diagnostics). In addition, the objective production of the latest materials for the latest;
- developing technological solutions in the machine building industry, in particular high-tech, transportation, energy, and defence industries, agricultural production (precision farming);
- the development of knowledge-intensive and high-tech sectors, including aerospace, precision and precision instrumentation, etc.

In conclusion, the Smart Specialization strategy outlined for the Dnipropetrovsk region presents a promising path towards economic prosperity and technological advancement. By prioritising key sectors and fostering innovation, Dnipropetrovsk region aims to unlock new opportunities, enhance competitiveness, and secure sustainable growth for the future.

## **5.3 Correlation-regression analysis of the social, industrial and innovation climate of the Dnipropetrovsk region as a prerequisite for the introduction of circular economy principles**

Correlation-regression analysis is a powerful tool in social and economic research that allows you to study the relationships between various factors and determine how one affects another. We aim to conduct such an analysis to assess the social, industrial and innovation climate in the Dnipropetrovsk region and find out how these factors can be prerequisites for introducing circular economy principles. Let's look at the details of this idea.

Analysis of the social climate: First, it is important to study the social climate in the region, which includes factors such as education, cultural development, access to information and awareness of citizens. By analysing these data, it is possible to determine how open society is to new economic models, particularly circular economy.

Analysis of the industrial climate: The circular economy's success largely depends on the region's industrial base. Analysing the level of innovation and the degree of readiness of enterprises to switch to a circular production method, it is possible to determine which industries have the potential to develop a circular economy and where obstacles may arise.

Analysis of the innovation climate: The circular economy requires new innovative solutions in production and consumption. Analysis of the innovation climate in the Dnipropetrovsk region will allow us to determine the presence and development of innovative companies, research centres and state support for creative projects.

To build the mathematical model, the following statistical data for the region from 2007 to 2021 were taken (Table 1).

**Table 1.** Statistical data of the Dnipropetrovsk region from 2007 to 2021

Years	GRP	VIP	VInnP	N <sub>Inn</sub>	EP	N <sub>SE</sub>	N <sub>RR&amp;D</sub>	Ex	InnP	VI	N	E	UnE	In
2007	71173,0	109585,2	1622730,8	9,3	31,5	68	93	192569,00	1,80	654,46	99642,2	1582,4	39,9	39015
2008	104687,0	142612,4	1678887,5	7	47,4	72	88	182926,00	0,90	975,4	14656,0	1580,0	33,9	52352
2009	93331,0	111487,0	532400,7	6,3	167,9	69	84	39580,80	1,90	675,95	13066,0	1537,1	52,1	56014
2010	116136,0	166497,8	179667,2	7,1	85,4	71	78	64527,00	2,10	720,77	16259,0	1541,9	117,7	69394
2011	140020,0	200555,8	471514,5	7,1	56,8	76	73	18481,30	3,60	1238,5	19602,0	1531,3	112,3	80888
2012	147970,0	220458,2	302268,8	7,7	60,2	80	69	13324,50	3,60	1215,49	20715,0	1528,5	108,5	95349
2013	152905,0	107033,5	668532,8	7,8	69,2	79	62	13767,10	0,80	1021,92	106987	1531,0	106,8	98806
2014	176540,0	123578,0	108028,4	8	66,3	82	57	13233,30	0,50	1327,68	149755	1437,3	128,9	105223
2015	215206,0	150644,2	203067,0	8,9	72,1	80	58	6867,80	0,60	1703,39	158783	756,3	115,3	127830
2016	244478,0	171134,6	53785,2	9,8	73,4	79	55	11525,50	1,40	3606,42	151432	1391,3	121,7	143861
2017	313830,0	219681,0	69042,6	9,9	73,1	86	54	12708,10	2,30	3867,69	142146	1347,9	129,2	185230
2018	369468,0	258627,6	81283,0	9,8	75,1	91	55	10082,40	4,40	3162,45	140377	1402,3	121,5	240620
2019	390325	273227,5	85871,5	9,8	78	93	52	10842,36	0,40	39033,5	148502	1380,5	124,1	189903,6
2020	398732	279112,4	87721,0	9,9	78,2	94	50	11075,88	0,20	39870,2	153234	1375,1	125,35	212925
2021	582363	407654,1	128119,9	10,1	85	98	51	16176,75	1,8	59236,3	167567	1402,3	121,5	240620

Source: Developed by the authors based on data from the State Statistics Committee of Ukraine

Where: VIP – Volume of industrial products sold (million UAH); VInnP – Volume of innovative products (thousand UAH); N<sub>Inn</sub> – Number of enterprises that implemented innovations, %; EP – Economic potential of industrial enterprises (profit dynamics), %; N<sub>SE</sub> – Number of small enterprises per 10,000 of the existing population, units; N<sub>RR&D</sub> – Number of organisations, which perform scientific research and development; Ex – Expenses of organisations for the implementation of research and development by their forces, thousand UAH; InnP – Share of implemented innovative products in the volume of industrial production, %; VI – Volume of investments in industry, million UAH; N – Number of enterprises; E – Employment of the population (thousands of people); UnE – Population unemployment (thousands of people); In – Disposable income of the population (million UAH).

The statistical data analysed in this study is limited to the period from 2007 to 2021 due to significant disruptions caused by the full-scale war in Ukraine, which began in 2022. The war has drastically impacted the region's economy, altering industrial output, innovation activities, employment levels, and investment flows. Many

enterprises have ceased operations or shifted priorities toward essential wartime needs, leading to a reorientation of economic and social strategies. As a result, the pre-war data provides a more stable foundation for assessing long-term trends and prerequisites for introducing circular economy principles. However, given the evolving economic challenges, future analyses must reassess whether priorities remain unchanged and how post-war recovery efforts may redefine the region's approach to circular economy development.

Gross regional product (GRP), one of the key indicators used to assess the effectiveness of the region's activities, was adopted as the resulting indicator in the economic-mathematical model. GRP determines the total economic productivity and value of all goods and services produced in a given region over a given period. It reflects the region's economic growth, social development, the degree of efficiency in the use of resources, the introduction of innovations, etc. The results of the correlation analysis are presented in Table 2 (see below):

**Table 2.** The results of the correlation analysis

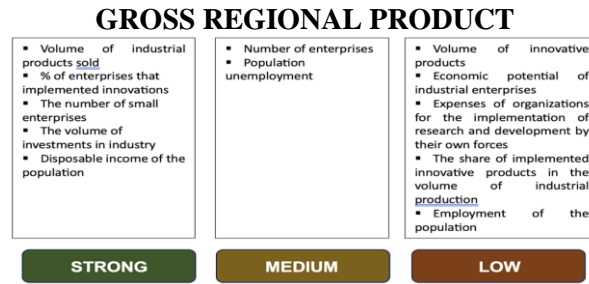
	X1	X2	X3	X4	X5	X6	X7	X8	X9	X10	X11	X12	X13	X14
X1	1,0													
X2	0,9	1,0												
X3	-0,6	-0,5	1,0											
X4	0,8	0,6	-0,4	1,0										
X5	0,1	0,0	-0,4	-0,3	1,0									
X6	1,0	0,9	-0,6	0,7	0,0	1,0								
X7	-0,8	-0,6	0,8	-0,7	0,0	-0,9	1,0							
X8	-0,5	-0,4	0,9	-0,3	-0,4	-0,6	0,8	1,0						
X9	-0,1	0,2	-0,1	-0,1	0,0	-0,1	0,2	-0,1	1,0					
X10	0,9	0,8	-0,3	0,6	0,1	0,8	-0,5	-0,3	-0,3	1,0				
X11	0,7	0,4	-0,5	0,9	-0,1	0,7	-0,8	-0,4	-0,4	0,5	1,0			
X12	-0,3	-0,1	0,4	-0,4	0,0	-0,3	0,5	0,4	0,3	-0,1	-0,6	1,0		
X13	0,6	0,5	-0,9	0,5	0,0	0,7	-0,9	-0,9	0,0	0,3	0,6	-0,4	1,0	
X14	1,0	0,8	-0,7	0,8	0,1	1,0	-0,9	-0,6	0,0	0,7	0,7	-0,4	0,7	1,0

Source: Developed by the authors

Where: X1 – GRP; X2 - Volume of industrial products sold (million UAH); X3 - Volume of innovative products (thousand UAH); X4 - % of enterprises that implemented innovations; X5 - Economic potential of industrial enterprises (profit dynamics), %; X6 - The number of small enterprises per 10,000 of the existing population, units; X7 - The number of organisations, which performs scientific research and development; X8 - Expenses of organisations for the implementation of research and development by their own forces, UAH; X9 - The share of implemented innovative products in the volume of industrial production, %; X10 - The volume of investments in industry, million UAHs; X11 - Number of enterprises; X12 - Employment of the population (thousands of people); X13 - Population unemployment (thousands of people); X14 - Disposable income of the population (million UAH).

The results of the analysis of the influence of regional development indicators are presented in Figure 5.

As the results of the correlation analysis illustrate, the level of industrial enterprise significantly influences the region's development (correlation coefficient is 0,9), which once again confirms the status of the Dnipropetrovsk region as an industrial one.



**Figure 5.** The results of the analysis of the influence of indicators of the Dnipropetrovsk region on the Gross Regional Product

Also, the indicator recorded a significant degree of influence reflecting the number of enterprises introducing innovations (correlation coefficient is 0,9). Indeed, regional policy is aimed at developing innovations in the region. The number of enterprises that introduce innovations can significantly influence the development of the circular economy in the region.

Businesses that actively engage in innovation are usually looking for more efficient and sustainable ways of producing and consuming. Innovations can help companies reduce waste, improve resource efficiency, and move towards a circular business. Enterprises that invest in innovation can develop new business models to save resources and recycle products. Regions with active, innovative enterprises usually attract more investments. Investors value companies that implement new technologies and creative approaches, as this increases their competitiveness and stability. This can contribute to the development of infrastructure for a circular economy.

Therefore, the number of enterprises that invest in innovation can be a key factor in forming a favourable ecosystem for developing a circular economy in the region. Innovations contribute to changes in consumer behaviour and efficient use of resources, creating opportunities for increased sustainability and reduced negative environmental impact.

The next indicator found to be very influential is the number of small enterprises in the region (correlation coefficient is 0,9). Small businesses often have greater flexibility and speed in decision-making, which makes them more prone to implement innovative approaches. In the context of the circular economy, this can mean creating new products, services, and business models to reduce waste and use more resources. Small businesses can more easily cooperate with local suppliers and buyers. This creates opportunities for the development of local circular supply chains, where waste from one enterprise can become resources for another.

Small businesses often have closer relationships with consumers and the local community. They may be more inclined to consider the wishes of consumers and create more sustainable products and services that meet the demand for quality and responsibility. Small businesses can act as circular economy ambassadors in local communities. They can actively contribute to spreading awareness about the importance of resource conservation and responsible consumption among the region's residents.

Small businesses, particularly those specialising in circular solutions, can create additional regional jobs. This can improve the quality of life of the local population and support economic development.

Summarising, the number of small enterprises in the region can be a key factor in implementing and developing the circular economy. They can be more flexible and innovative in implementing circular practices and contribute to creating a sustainable and responsible economy in the region.

Let's move on to the next powerful indicator - the volume of investments in the industry (the correlation coefficient is 0,9 for GRP and 0,8 for the volume of investment).

The volume of investments in the region can significantly impact the development of the circular economy. Investments can create an enabling environment for developing circular practices and promote implementation. Investments can be used to make the necessary infrastructure for a circular economy, such as sorting lines, recycling plants, processing centres, and the development of waste collection and processing systems. Investments can finance research and development of new technologies and innovative resource and waste management approaches. This can contribute to the improvement of circular processes and the creation of new circular solutions. Investments can provide financial support to startups and small businesses specialising in circular solutions. This can contribute to developing circular business models and increase their competitiveness. Investments can attract investors interested in circular practices and sustainable production. This can create additional capital for circular projects and stimulate the development of this direction. Therefore, investments in the region can strengthen and develop the circular economy, making the necessary conditions and resources for the implementation of circular practices and promoting the transition to more sustainable and responsible consumption and production.

The next indicator that has a significant impact on the region's development is the population's disposable income (the correlation coefficient is equal to 0,7-1). A higher income can positively influence the population's willingness to implement circular practices. People with higher incomes may be more inclined to buy goods and services that are built on circular economy principles, such as refurbished or recycled goods. Higher household income can stimulate investment in circular enterprises and startups. People with higher incomes may be able to invest in circular projects, which contributes to their development.

Changed demands for products: Higher income can lead to changes in demands for products and services. Consumers with higher incomes may look for higher quality and durability of goods, which can stimulate the development of circular business models, as they aim to extend the life of goods and recycle them. Usually, a higher level of income is accompanied by a higher level of education and consciousness. People with higher incomes may be more educated about waste and the environmental impact of consumption. This can contribute to the promotion of circular practices and more responsible consumption.

As for other factors, the impact of which is of a medium or low level, we see that the level of use of innovative products, the implementation of scientific developments by enterprises and the introduction of innovations, in general, is still low.

The circular economy is based on innovative technologies and methods for saving resources, waste and production. If the region does not invest in research and development of new technologies, achieving significant improvements in circular processes is difficult. Analysing the statistics of the region's innovative activity, we can conclude that investments in innovative development are available but insufficient to impact the region's growth significantly.

Thus, summing up the availability of a favourable climate in the region, Correlation analysis showed that the number of industrial enterprises and innovatively developing enterprises are key factors. The industrial foundation of the area creates a basis for the implementation of circular practices, and innovations contribute to more efficient use of resources and waste reduction. Along with that, the region should pay more attention to innovative research and the introduction of innovations. This is possible thanks to attracting investments in this direction.

In addition, the growth of small businesses supports sustainable consumption and reduced environmental impact. Investments also play an essential role in creating an enabling environment for the circular economy. In summary, the region has the potential to develop a circular economy thanks to a favourable climate and infrastructure.

#### **5.4. Case studies or examples of the enterprises from the Dnipropetrovsk region that have successfully integrated smart specialisation and the circular economy**

Building on the previous analysis, there is considerable potential for the Dnipropetrovsk region to use smart specialisation to develop a circular economy. This takes time to implement; it is a gradual process and requires an incremental approach to investment and policy coordination; The government needs to work closely with small and large companies to move the agenda forward.

There are already positive developments worth noting here. For example, Polygreen, a recycling plant part of the Biosphere Corporation, is one of the largest in Ukraine. Thanks to modern equipment, they carry out a complete cycle of processing and purification of polymers, turning plastic into polyethylene granules. Any manufacturer can use these pellets, including McDonald's, which cooperates with the Biosphere Corporation. This is just one example of the implementation of the circular economy in the Dnipropetrovsk region of Ukraine. New recycling plants, waste processing enterprises, and other initiatives are gradually appearing, contributing to a closed cycle of resource use and reducing the negative environmental impact.

Another example is PAPACKS, a company that works in the field of circular economy in Ukraine. They specialise in the production of environmentally friendly paper and cardboard packaging. The company's primary goal is to reduce the use of single-use plastic packaging and promote the reuse and recycling of materials. PAPACKS is an example of a company that implements the principles of the circular economy in its activities, ensuring the sustainable use of resources, reducing the use of plastic materials and improving the impact on the environment. Their efforts contribute to the development of a more sustainable and environmentally responsible approach to packaging and consumption.

"Nova Poshta" is one of the largest and most successful logistics companies in Ukraine, which can also be recognised as an example of the circular economy. They implement various practices and initiatives to reduce environmental impact and create a more sustainable logistics system. Some aspects that reveal their circular activity are the following: energy efficiency and emission reduction, use of secondary resources, restoration and repair, electric mobility, and electronic solutions.

Dvipa LLC, based in the Magdalynivka district of Dnipropetrovsk region, has been growing organic wheat, raspberries, strawberries, currants, corn, rye, spelt, red currants, and amaranth seeds for more than 15 years, and now annually exports 100 tons of grain and up to 60 tons of berries to the EU. This company's products, sold under Ahimsa, are entirely organic and have the Organic Standard certificate. The company is located in the National Nature Park on the banks of the Orla River and has 150 hectares of certified organic fields. Recently, the company started offering a new 'trendy' product - freeze-dried berries, freeze-dried yoghurt, berry and vegetable powders, seeds and shirts oil. With this assortment, Dvipa LLC took part in the international exhibition BIOFACH 2020 and aroused interest from international buyers.

A striking example of using the benefits that have opened up for Ukrainian agricultural producers after the signing of the Association Agreement and the introduction of European approaches to food safety and quality is the Zdravlyk farm in the village of Hreve, Hrechane. By setting up snail-like production based on HACCP principles, the farmers could sell their products to the EU. The planned production volume of Zdravlyk is 20 tons of snails per year, and 95% of them are exported to the Baltic States. From there, intermediaries distribute the snails across the European Union. The farm produces processed products, such as salted snail caviar, which also meets the ISO22000 quality standards. Half of the company's profits are used to help internally displaced people, promote the development of personal snail agribusiness and support the local community.

Sady Dnepra LLC is one of the largest apple producers in Ukraine. The company grows, stores and sells apples under the UApple brand. Founded in 2016, the company is dynamically developing and rapidly gaining

momentum, with the territory of the orchards expanding by 100 hectares every year. Today, the company sells its products to local supermarket chains and exports them to the European Union, Asia, and the Middle East. UApple's team gains knowledge and experience in growing, caring for, storing, and processing Apple products from experts from the European Union (the Netherlands). At the same time, regional companies in other industries do not lose their positions in global rankings and annually produce specialised products for domestic consumption and export and provide services.

Interpipe is a prominent Ukrainian industrial company specialising in producing and exporting seamless pipes and railway wheels. With a broad global reach, the company supplies products to more than 80 countries through an extensive network of sales offices, focusing on key markets in the CIS, the Middle East, North America, and Europe. In 2020, Interpipe achieved sales of 662 thousand tons of finished goods, including 192 thousand tons of railway products under its K LW brand. The company has demonstrated its ability to cater to diverse market needs by developing a customised wheel design for Indian Railways tailored to meet India's specific operational requirements. Additionally, Interpipe supplies railway wheels to Deutsche Bahn, Germany's national railway operator, further solidifying its position as a reliable partner in the global rail industry.

**5.5. SWOT analysis of the Dnipropetrovsk region in terms of circular economy development**

The development of the Dnipropetrovsk region strategy follows European and national legislation. The set of defined strategic and operational goals and tasks meets the requirements of smart specialisation of the city of Dnipro within the framework of the socio-economic development strategy for Ukraine. An important aspect is that the European definition of smart specialisation is based on the same terminology ("strengths", "opportunities") as the SWOT analysis methodology. Conducting a SWOT analysis of a region is essential to make evidence-based decisions and guide sustainable development efforts in line with the principles of circular economy and smart specialisation. Such analyses allow stakeholders to build on strengths, address weaknesses, capitalise on opportunities and mitigate threats, ultimately contributing to sustainable and prosperous communities (see Table 3). Subsequently, the tools, expected results and challenges to implementing circular economy principles in the Dnipropetrovsk region are presented in Table 4.

**Table 3.** SWOT analysis of the Dnipropetrovsk region regarding following the strategy of smart specialisation and circular economy

Strengths	Weaknesses
<ul style="list-style-type: none"> <li>- A strong base of educational and scientific institutions;</li> <li>- Availability of creative specialists to create innovations;</li> <li>- Availability of vocational and technical educational institutions, specialists-graduates (potential labour resources);</li> <li>- Availability of strong business and manufacturing industries to support and develop the educational sector;</li> <li>- Presence of large industrial developed business clusters (metallurgy, aerospace industry, IT, construction, chemical, financial, food processing sectors);</li> <li>- A million-population city as a primary sales market, an environment for multiplier effects from innovations (availability of a “critical mass” for the implementation of viable innovations) and a source of a large number of educated workers;</li> <li>- The city's brand is perceived as an industrial and scientific centre;</li> <li>- Proximity to natural resources (iron, manganese, nickel, aluminium, uranium, titanium, rare metals, water, black earth) and powerful sources of electricity;</li> <li>- Experience of commercialisation by industries;</li> <li>- Availability of primary small municipal support for technological innovations (INNODNIPRO startup project competition);</li> </ul>	<ul style="list-style-type: none"> <li>- Loose interaction of local businesses with scientists and developers, unfair distribution of profits;</li> <li>- Wear and tear of the material and technical base of education, lack of modern laboratories;</li> <li>- Lack of popular cases of commercialisation of technical innovations, which forms the brand of the city;</li> <li>- The small amount of commercialisation of innovations by industries does not give the effect of overflowing knowledge and practice - "copy and do";</li> <li>- Low level of operation of the municipal support infrastructure, etc.;</li> <li>- Inertness of the existing industry to changes and obsolescence of technological systems;</li> <li>- Closedness of local businesses to innovations: they do not develop themselves and distrust both innovations and partners and competitors on the market;</li> <li>- The weak material base of the innovation support ecosystem</li> <li>- Lack of understanding that innovation is the economy and GDP (the city management has an interest in supporting the innovation vector only as a brand);</li> <li>- Unsystematic approach, lack of a city strategy and vision for</li> </ul>

<ul style="list-style-type: none"> <li>- The physical presence of large anchor enterprises that can be both consumers of innovations and generators of their innovations and a source of innovation;</li> <li>- City management is interested in supporting the innovation vector as a brand.</li> </ul>	<p>industrial development;</p> <ul style="list-style-type: none"> <li>- Limited connection with world centres of economic activity.</li> </ul>
<p><b>Opportunities</b></p>	<p><b>Threats</b></p>
<ul style="list-style-type: none"> <li>- The general global trend towards the formation of cities as subjects of the ecosystem, etc.;</li> <li>- The possibility of attracting major market players to cooperate and partial financing of scientific and educational centres;</li> <li>- A large number of support programs from foreign funds for the creation and financing of innovative ecosystems;</li> <li>- Deepening of the decentralisation reform (partial budget decentralisation, creation of regional and local authorities equal to cities, territorial and administrative reform with redistribution of powers, but without expansion of economic rights of communities). Cities will be able to independently make decisions regarding the development strategy and financing of innovative sectors;</li> <li>- The possibility of creating local financing tools: funds from local budgets; own funds of specialised state and communal innovative financial and credit institutions; funds (investments) of any individuals and legal entities; donor business support programs and grant programs;</li> <li>- A new stage in the development of the world's aerospace industry involving the private sector;</li> <li>- Decreasing the cost of energy sources (due to the transition to alternative energy sources: hydrogen, sun, wind, etc.);</li> <li>- The possibility of developing industries through educational and entertainment infrastructure (scientific, economic, industrial, ecological, entertainment theme parks);</li> <li>- Increasing the mobility of scientists;</li> <li>- Establishment of scientific partnerships with leading innovation centres.</li> </ul>	<ul style="list-style-type: none"> <li>- Lack of a strategic plan for the development of innovations at the country level;</li> <li>- The imperfection of patent law for ensuring insecurity of innovators and investments;</li> <li>- Lack of interest in vocational and technical schools in the city and other stakeholders (absence of a quality system of ordering state, municipal, and private sectors for vocational technical specialists);</li> <li>- Imperfect system of tax, financial and other instruments, which increases the threat of creation of legal entities in different jurisdictions;</li> <li>- Front-line city, war: due to the high mobility of the creative class, threats of this kind influence the acceleration of the outflow of the creative class from the city;</li> <li>- Depopulation of the city. The greatest threat is the departure of the creative class as the most mobile segment of the community.</li> <li>- Lack of a legislative framework regarding the possibility of having institutions and development tools at the regional level and implementing policies and standards.</li> </ul>

**Table 4.** The systematisation of tools, expected results and challenges for following circular economy principles in the Dnipropetrovsk region

<b>Tool</b>	<b>Expected result</b>	<b>Challenges of implementation</b>
<p><b>Design.</b> This approach aligns with the core principle of the circular economy, which emphasises production processes that rely on recycled materials. By reintroducing waste into the value chain, recycling minimises the extraction of new resources, reduces environmental impact, and fosters sustainable production. This principle ensures that materials retain their value within the economy for as long as possible, supporting the transition to a more resource-efficient and eco-friendly economic model.</p>	<p>The goal is to reduce production waste and optimise the use of raw materials.</p>	<p>Currently, the Dnipropetrovsk region is only at the beginning of introducing the concept of circular economy at the regional level. Therefore, there is a problem of finding chains of transformation of waste into raw materials.</p>
<p><b>Sharing and virtualisation.</b> The development of platforms for effective interaction between users and products or services aims to maximise their utilisation. This approach is particularly valuable for manufacturers facing low product usage rates or underutilised production capacities. Additionally, it fosters opportunities for competitors to collaborate by sharing fixed</p>	<p>Ensure product or service efficiency improvement, cost reduction, profit increase, and rapid product penetration into new markets.</p>	<p>The Dnipropetrovsk region has a sufficiently highly competitive environment both within the region and outside. Along with this, major market players lack the intention to share their resources with competitors. Programs of state stimulation and encouragement in this direction are needed.</p>

<p>costs, thereby improving operational efficiency. Such platforms promote resource-sharing, extend product lifecycles, and enhance productivity, aligning with the principles of both the circular economy and cooperative business models.</p>		
<p><b>Goods as a service.</b> This approach serves as an alternative to the conventional model of selling goods or services. It moves beyond traditional direct sales, leasing, or renting by offering clients the option to enter into a subscription agreement. Customers gain continuous access to the product or service through a fixed monthly or annual payment without needing ownership. This model ensures more efficient utilisation of resources and fosters longer-term relationships between providers and users, promoting sustainable consumption patterns in line with circular economy principles.</p>	<p>Applying this approach reduces the costs for users who purchase the product. The product can be used for several cycles (which helps reduce raw materials costs and additional costs during production).</p>	<p>The trust of the end consumer in the quality of products on the one hand, and the responsibility of the manufacturer regarding the control of ensuring this quality on the other. The general problem is not only for the Dnipropetrovsk region but also for the country. Despite a quality control system, some industries may have no or insufficient control, especially in agriculture and small enterprises. In addition, in Ukraine, there is a lack of modern infrastructure and equipment to ensure adequate quality control. And finally, insufficiently strict laws on quality control and product standards can lead to a drop in the quality of products on the market.</p>
<p><b>Reuse in production.</b> This approach emphasises the secondary use of certain parts and individual components of products that can no longer function as a whole. Many products globally are discarded despite containing components that remain in good condition. By salvaging and reusing these parts, manufacturers can reduce waste and extend the lifecycle of valuable materials. This practice minimises the need for new raw materials, decreases environmental impact, and aligns with circular economy principles by promoting repair, refurbishment, and remanufacturing over disposal.</p>	<p>This approach significantly reduces production costs, minimises the use of raw materials, and substantially contributes to improving the environment around the world by reducing the use of natural resources.</p>	<p>A significant challenge lies in the insufficient investment in innovation, research, and development. This issue was already substantial before the war, but it has intensified during the conflict, further exacerbated by the migration of skilled professionals from the country. An urgent priority is the improvement of systems for collecting used parts and components for reintegration into production processes. The successful adoption of a circular economy also depends on advances in processing technologies and the secondary use of raw materials. Achieving this requires substantial investment in innovative research and development and upgrading production facilities to accommodate new technologies and processing methods. Without these investments, the transition to a circular economy remains challenging to realise effectively.</p>
<p><b>Reuse in consumption.</b> This approach focuses on reusing previously used products and can be applied at multiple levels. At the <i>client-to-client</i> level, individuals resell used goods through online marketplaces, social initiatives, or trading platforms, promoting product longevity and reducing waste. At the <i>business-to-client</i> level, enterprises complete the restoration or refurbishment of used products, returning them to the market at a lower price point. This strategy makes goods more affordable and decreases the environmental footprint by minimising the need for new production, aligning with the principles of sustainable consumption and the circular economy.</p>	<p>Applying this approach allows you to extend the product's life cycle, increasing the company's profits not through producing new products but by recovering and recycling existing ones. It also enables the population to satisfy their needs for specific products at a much lower price. This approach contributes to the reduction of raw material costs and the efficient use of natural resources, which improves the environmental situation in general. The recovery and recycling of existing products help reduce the amount of waste and pollution, which positively affects the natural environment.</p>	<p>Substandard products and customer-to-customer fraud can affect trust in the circular economy approach. This requires the development of verification mechanisms and quality standards for reused products. The lack of a developed business client interaction algorithm can delay the spread of the circular economy at the company level. It is necessary to promote the exchange of knowledge and experience between companies and stimulate a conscious change in management. The small volume of manufacturing companies implementing the product recovery procedure may limit the range of products available on the market. Here, it is necessary to promote the support of innovative enterprises and create a favourable</p>

		<p>environment for implementing circular solutions.</p> <p>The solution to these problems may include legislative support, the development of standards and certifications, increasing public and business awareness of the benefits of the circular economy, and active promotion of innovative enterprises.</p>
<p><b>Industrial symbiosis and processing of industrial waste.</b> Implementing circular economy principles plays a crucial role in enhancing business efficiency. It enables companies to reduce production costs, lowering prices for manufactured goods. These savings are achieved by optimising resource use, incorporating recycled and reused materials, and streamlining production processes. Additionally, the circular economy supports the reduction of CO<sub>2</sub> emissions and minimises environmental harm. Using recycled inputs and energy-efficient technologies, businesses can lower their greenhouse gas emissions, contributing to resource conservation and improved air quality. This approach fosters economic sustainability and aligns with global environmental goals.</p>	<p>The implementation of the circular economy significantly increases business efficiency in all directions. This includes minimising economic costs for production, which decreases the cost of manufactured products. Recovery and use of secondary resources allow for the reduction of the costs of purchasing new raw materials and production costs.</p> <p>Circular economy approaches also help reduce CO<sub>2</sub> emissions. Less need for new raw materials, less energy consumption for processing, and less waste going to landfills and incineration leads to a reduced volume of greenhouse gases released into the atmosphere.</p>	<p>There are almost no industrial symbioses in the Dnipropetrovsk region. In general, the number of enterprises that exchange resources and interact in a circular format is still limited in Ukraine.</p> <p>The need for investment at the initial stage: the initiation and development of circular practices requires some investment, especially at the first stage. However, the long-term benefits of resource efficiency may outweigh the costs.</p> <p>Modernisation and innovation: the successful implementation of the circular economy requires modernising technologies and the introduction of innovative developments. This may require additional efforts and funding from businesses and the state.</p>
<p><b>Recycling.</b> Recycling is a well-established practice, serving as a key component in the circular economy and traditional economic models. It focuses on repurposing waste materials into new products, enabling the reintegration of discarded resources into production cycles. This approach reduces the need for virgin raw materials, promoting resource efficiency and sustainability across conventional and circular economic systems.</p>	<p>Encouraging the processing industry will help create new jobs, promote the development of innovative technologies, and attract investments. Introducing a system of extended responsibility, where they take responsibility for the final stage of the life cycle of their products, will increase the motivation to use more sustainable materials and reduce waste producers.</p> <p>This approach will help reduce the negative impact on the environment, reduce pollution and increase the level of renewable resources.</p>	<p>Currently, most large state-owned companies in Ukraine and the Dnipropetrovsk region are transitioning toward using recycled materials in their production processes. However, the adoption of recycling practices among small businesses remains limited. As a result, processing raw materials is primarily the domain of larger enterprises. The significant financial investment required to modernise production processes and implement innovative technologies is a key barrier preventing smaller companies from engaging in these practices. Such upgrades are necessary to efficiently integrate secondary raw materials into production, making it challenging for small businesses to participate in the shift toward sustainable manufacturing.</p>

## Conclusions

This research underscores the benefits of seamlessly integrating circular economy principles into the Dnipropetrovsk region's smart specialisation strategy. This study's key findings and insights emphasise the substantial economic, environmental, and social advantages that can be derived from such integration. These are discussed below.

### *Circular Economy Benefits*

The research unequivocally establishes that adopting circular economy practices in the Dnipropetrovsk region can lead to enhanced resource efficiency, diminished waste generation, and considerable cost savings across various industries. These practices, particularly in manufacturing, agriculture, and energy production, offer a promising avenue for sustainable economic growth.

### *Environmental Impact*

A transition to a circular economy can significantly reduce the environmental footprint of the Dnipropetrovsk region. This includes a notable decrease in emissions and pollution and a more responsible use of natural resources. These ecological benefits align with global imperatives for climate change mitigation and improving air and water quality.

### *Economic Growth*

Circular economy initiatives emerge as catalysts for stimulating economic growth in the Dnipropetrovsk region, fostering innovation, creating job opportunities, and attracting investments. By prioritising sustainable economic development, the area can bolster its competitiveness on a global scale.

### *Challenges and Barriers*

Identified challenges such as limited awareness, inadequate infrastructure, and regulatory hurdles highlight the need for concerted efforts to overcome these barriers. Enhanced stakeholder collaboration and improved coordination mechanisms are crucial to addressing these challenges effectively.

### *Policy and Governance*

The research underscores the pivotal role of effective government policies and incentives in promoting circular economy practices. Clear regulations and supportive initiatives can motivate businesses and industries to embrace circular models, drawing valuable lessons from international experiences.

### *Collaboration Optimisation*

Optimising stakeholder collaboration through improved communication and information-sharing mechanisms is imperative. Establishing platforms for knowledge exchange and best practice sharing can contribute to the successful implementation of circular economy principles.

### *Recommendations for Further Research and Action Steps*

The outlined actions and recommendations provide a roadmap for future endeavours, encompassing awareness campaigns, infrastructure development, policy refinement, and robust monitoring and evaluation frameworks. Pilot projects in key sectors and international cooperation could offer tangible pathways to showcase the feasibility and benefits of circular practices. In conclusion, integrating the circular economy within the Dnipropetrovsk region's smart specialisation approach presents a potentially transformative opportunity for sustainable economic development, environmental protection and improved resource management. By implementing the recommended actions, the region can expedite progress towards a more circular and prosperous future while adeptly navigating and addressing the challenges that may arise along this transformative journey.

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