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Exploring the Potential of Circular Economy in Ukrainian Enterprises

Hanna Zavadskykh*[1], Nataliia Safonik[2], Elina Moroz[3], Kateryna Alekseieva[4], Iryna Honcharenko[5]

[1]Department of Economics and Business, Dmytro Motornyi Tavria State Agrotechnological University, Zaporizhzhia, Ukraine. E-mail: hanna.zavadskykh@tsatu.edu.ua
ORCID: https://orcid.org/0000-0002-3240-3870
[2]Department of Air Transport Economics, Faculty of Economics and Business Administration, State University "Kyiv Aviation Institute", Kyiv, Ukraine. E-mail: nataliia.s.2023@gmail.com
ORCID: https://orcid.org/0000-0002-9822-3696
[3]Institute of Law, Economics and Administration, University of the National Education Commission, Krakow, Poland. E-mail: elina.moroz@uken.krakow.pl
ORCID: https://orcid.org/0009-0007-7076-3870
[4]Department of Production and Investment Management, Faculty of Agrarian Management, National University of Life and Environmental Sciences of Ukraine, Kyiv, Ukraine.
E-mail: katerinaalex@ukr.net | ORCID: https://orcid.org/0000-0003-1129-0771
[5]Department of Public Management, Administration and International Economics, Mykolayiv National Agrarian University, Mykolayiv, Ukraine. E-mail: ihoncharenko305@gmail.com
ORCID: https://orcid.org/0000-0001-9670-9812
**Corresponding Author*

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Abstract

The circular economy concept promotes sustainable development and more sustainable production of products. The dissemination of relevant ideas is linked to the challenges of rational resource use, waste losses, climate change, and environmental protection. The aim of the article is to conduct an analytical study of the practice and prospects of implementing measures by manufacturing enterprises within the circular economy framework in Ukraine. Using a case study approach, the research examines how Ukrainian manufacturing enterprises are transitioning to a circular economy. The Centre for Resource Efficient and Cleaner Production (RECP) database was used to analyze the cases. The results show that the activities of the RECP Centre under the EU Environment Programme have positively impacted the implementation of resource efficiency measures at Ukrainian manufacturing enterprises. Companies' investments in the replacement, modernization, automation, and installation of new equipment vary considerably depending on their capabilities, bringing economic and environmental benefits. The paper identifies the stimulating and discouraging factors of macro- and micro-level influence on the prospects for introducing the circular economy in Ukraine. The practical significance of the work lies in the quantitative assessment of investments, savings, and environmental effects (reduction of energy, water, gas consumption, and waste reduction) from the measures taken by manufacturing enterprises to rationally use resources.

Keywords

Circular economy; Closed-loop economy; Circular production; Sustainable development; Rational use of resources; Energy efficiency

Introduction

The circular economy concept aims to promote sustainable development and more sustainable production of products (Ferreira-Gregorio, Pié and Terceño, 2018). The spread of relevant ideas is associated with the problems of rational use of natural resources, their losses due to waste, negative climate change, and environmental protection. Therefore, different countries' policies seek to stimulate more sustainable cyclic production to find a balance between profitability and the environmental impact of enterprises. In this context, the concept of circular economy has become a tool for optimizing resource use, extending the life of products, minimizing energy and water consumption, and reducing plastic, carbon and waste emissions. The awareness of resource scarcity explains the growing attention to this concept. The circular economy is a production system that involves the transformation of production processes, consumption patterns, and system redesign (Santibanez-Gonzalez *et al.*, 2019).

In connection with the processes of European integration and the significant negative consequences of the war's impact on the environment, Ukraine has seen increased activity in promoting the concepts of the circular economy and implementing certain measures at both the national and micro levels. Indicators of growing attention to the circular economy include the adoption of relevant legislation in this area of regulation, as well as measures at the micro level to reduce energy consumption and rationally use resources. The relevance of these measures and the development of strategies for their implementation have grown due to the ongoing military actions and, consequently, the reduced accessibility of enterprises to certain types of resources, including energy resources.

The article examines the practices and prospects of manufacturing enterprises in Ukraine as they adopt circular economy measures. It focuses on the following research objects:

1. Factors that facilitated the implementation of circular economy measures by manufacturing enterprises in Ukraine;
2. The role of the Resource Efficient and Cleaner Production Centre in promoting circular economy practices in Ukraine;
3. The main quantitative results of implementing resource-efficient measures by manufacturing enterprises in Ukraine.

Literature Review

UNIDO defines the circular economy as an industrial economy with multiple uses of materials, products, and parts. It involves creating more value, generating less waste, minimizing it, preserving value over the long term, and developing products for longer periods (UNIDO, 2024). According to the RECP, a closed-loop economy or circular economy is an alternative to the linear economic model based on renewal, rational consumption of resources, and production factors.

The traditional production paradigm implies the dominance of an open-ended linear business model. In contrast, a circular economy implies a closed production cycle, a circular flow of materials, raw materials, and energy in the economic system (Garza-Reyes *et al.*, 2019). In the context of production activities, circular business models are built on

preserving resources in the economy as long as possible through their recycling, environmentally friendly production, long-term use of products, and recovery processes. The latter ensures the return of products, by-products and waste to the economy through reuse, production, recycling, and the transition from non-renewable to renewable resources (including energy and labour) (Clift, Martin and Mair, 2022). Therefore, the circular economy aims to optimize the use of resources to minimize consumption and increase the reuse of products (Ionescu *et al.*, 2017). The circular economy is becoming an alternative to the classical make-use-dispose approach to production (Kumar *et al.*, 2019).

In the scientific literature, most studies focus on the principles and approaches to implementing the circular economy concept, business models associated with circular economy, strategies for transitioning to circular production, as well as the challenges and barriers enterprises face in shifting from a linear to a circular production model. Thus, according to the results of the literature review on sustainable economic development from 1960 to 2017, Ferreira-Gregorio, Pié and Terceño (2018) found that most of the studies in the field of "circular economy" relate to management styles (17%), industry clusters/programmes (125), and policy analysis (12%). Geissdoerfer *et al.* (2018) consider the circular economy in the context of sustainability, pointing to the sustainability of circular business models, supply chains and circular governance. The authors identify cyclical business models that differ regarding supply chain complexity and the value they create (tightening, slowing, amplification, narrowing, dematerialization cycles). The theoretical review of sustainable business models by Lahti, Wincent and Parida (2018) also highlights their implications for companies in sustainable development. The study by Gupta, Kumar and Wasan, (2021) focuses on developing a theoretical framework for a cyclical business model for manufacturing enterprises to modify them from traditional to more sustainable ones.

Dovhan (2022) considers the 3R and 9R principles of the circular economy, supplementing them with new ones to expand the possibilities of transition to a closed-loop economy and systematizes the classification features of types of circular business models. Ghisellini, Cialani and Ulgiati (2016) study the principles, approaches, advantages, disadvantages, modelling and implementation of the circular economy at different levels in China, the EU, the USA, and Japan. As a result, they identify the initial stages of implementation of the concept worldwide, mainly focused on recycling. Conclusions about the low level of circular production are also drawn by Gusmerotti *et al.* (2019), using the example of 821 Italian manufacturing companies. This is due to pressure from regulators, ineffective environmental initiatives, and risks of resource exploitation. A survey of 63 UK and EU manufacturing companies by Kumar *et al.* (2019) provides an overview of the obstacles, opportunities, and benefits companies receive when implementing the circular economy concept (socio-political, economic, legal, and environmental).

These studies reinforce the complexity of implementing the circular economy. Kuzma *et al*. (2021) confirm previous findings that transitioning to a circular economy remains a significant challenge. Meanwhile, Van Loon, Diener and Harris (2021) highlight the lack of concrete evidence proving the benefits of circular economy products and business models, suggesting that more empirical research is needed. In contrast, Atstaja *et al*. (2022) emphasize the rational use of existing products rather than overproduction, which

contributes to waste reduction across the entire product life cycle. Ranta, Aarikka-Stenroos and Mäkinen (2018) analyzed the business models of circular economy companies in the EU, the USA, China, and Finland. The authors determined that the success of a circularity-based business depends on the economic efficiency of circular operations. Closed-loop models require the introduction of separate management of the relevant processes. The principles of reduction or reuse are more challenging to implement than recycling.

Lewandowski (2016) presents the outline of the cyclic business model of enterprises, which includes the following components: value proposition (cyclic products), customer segments, sales channels for cyclic products, customer relations (custom production, implementation of the Recycling 2.0 concept), revenues (from circular products), key resources (resources that allow for the restoration of natural capital), activities (focus on productivity, technology change, equipment modification, product design improvement), partnerships (selection and cooperation of partners that support the circular economy), costs, return system, and acceptance factors. Brennan, Tennant, M. and Blomsma,(2015) studied cyclical strategies in industry that help reduce negative environmental impacts. The authors point out the problems of their implementation: the feasibility of using closed-loop models, the importance of their implementation, the growth of consumption, and the increase in population. Bocken *et al.* (2016) studied product design and business model strategies for companies moving to a closed-loop production cycle.

Based on a morphological analysis of 26 circular economy business models by their main parameters and specific characteristics, Lüdeke-Freund, Gold and Bocken (2019) identify a wide range of design options. As a result, they propose six main business models: repair and maintenance, reuse and redistribution, repair and recycling, secondary processing, cascading and repurposing, and organic raw materials business models. As Madau *et al.* (2020) argue, the debate in academia on the concept of the circular economy is in its infancy. Research on circular business models is also in its infancy (De Angelis, 2021). In general, research in this area is focused on the national, regional, and industrial levels (Korhonen, Honkasalo and Seppälä, 2018). Implementing circular economy principles and practices in production systems and processes remains an under-researched issue (Garza-Reyes *et al.*, 2019). Therefore, this study aims to address gaps in circular economy research by focusing on the micro-level implementation of sustainable resource consumption strategies in Ukrainian manufacturing enterprises.

Methodology

Research Design

The research methodology includes a set of general scientific methods for studying the practice of manufacturing enterprises in various sectors of the Ukrainian economy that implement measures that facilitate the transition to a closed-loop economy. The article applies the methods of monitoring the performance indicators of the implementation of circular production measures, comparative analysis, and quantitative and qualitative analysis to compare the indicators. The paper is an overview and analytical study which

aimed to examine the practices of Ukrainian manufacturing enterprises in transitioning to a circular economy.

Data Source and Collection

To analyze current practices, we utilized data from the Resource Efficient and Cleaner Production Centre (RECP), which was established in Ukraine in 2013 as part of a UNIDO project funded by the governments of Austria and Switzerland. The RECP database provides comprehensive descriptions of manufacturing enterprises, detailing the specific resource-efficiency measures they have implemented. These measures were introduced based on the Centre's monitoring activities and recommendations, which include quantitative assessments of their potential impact on resource optimization, waste reduction, and overall sustainability.

Data Analysis Methods

The article uses the method of monitoring the performance indicators of the implementation of resource-efficient and cleaner production measures at Ukrainian enterprises: the volume of investments, the volume of savings, the volume of reduction in energy and water consumption, and the volume of carbon emissions reduction. Comparative analysis is used to compare manufacturing enterprises by the system of performance indicators. The quantitative analysis was used to estimate the amount of investment required to implement all the resource efficiency measures proposed by the RECP and the actual costs of manufacturing enterprises. An analysis of potential and real savings and resource savings achieved by enterprises after the implementation of the measures is carried out. A comparison of potential and actual performance indicators is carried out to determine the difference between theoretical effects and actual results of manufacturing enterprises.

Selection Criteria for Manufacturing Enterprises

Manufacturing enterprises selected for analysis and systematization of quantitative results of implementing measures within the framework of the circular economy concept were chosen based on the following criteria: 1) the availability of quantitative assessments of the outcomes of implementing the recommended measures; 2) the enterprises are engaged in the production of goods and have significant potential for reducing resource consumption; 3) enterprises are actively involved in RECP trainings and educational programs; 4) manufacturing enterprises have implemented real resource efficiency and cleaner production measures; 5) enterprises selected for analysis had to implement at least 30% of the resource efficiency measures proposed by RECP. The RECPC database (2024) contains the results of monitoring of 12 manufacturing enterprises (8 medium, 2 large, 2 small) using the Centre's methodology in the following industries: light industry, food, chemical industry, machine building, and construction.

Limitation of the Study

The study is limited by potential biases in the RECP data, although it highlights specific resource efficiency measures implemented by manufacturing enterprises. These

measures were recommended for implementation after the RECP assessment. Therefore, they cannot be considered as recommendatory for enterprises in other sectors of the economy.

Results and Discussion

The circular economy for manufacturing companies involves setting up production that ensures the rational use of resources, recycling of waste, and transition to renewable energy sources. By implementing the principles of the circular economy, the goals of reducing waste, reducing environmental pollution, and improving biodiversity are achieved. Since Ukrainian legislation explicitly provides for the expansion of producers' responsibility for waste prevention (Verkhovna Rada of Ukraine, 2024a), the implementation of circular economy principles and related measures is extremely relevant. Favourable factors supporting the circular economy concept in Ukraine include integration into the EU, which facilitates the adaptation of legislation to European regulatory norms and requirements in this area. Businesses in the EU mainly use the principle of recycling as a component of waste management (Ghisellini,Cialani and Ulgiati, 2016; Ranta, Aarikka-Stenroos and Mäkinen, 2018) and one of the principles of the circular economy. This is related to EU policy, which provides for the implementation of the Circular Economy Action Plan adopted by the European Commission in March 2020 (European Commission, 2020).

The state policy in the field of waste management in Ukraine is only beginning to be formed and implemented as a result of the acceleration of European integration processes and Ukraine's commitment to implement the provisions of Directive 2008/98/EC of the European Parliament and of the Council of November 19, 2008. In late December 2024, the government approved the National Waste Management Plan until 2033 (Verkhovna Rada of Ukraine, 2024b). The document envisages the development of waste management plans by regional and local authorities, and measures for their implementation at the expense of the state and local budgets (Table 1). Despite the existence of legislation in the field of waste management and national, regional, and local plans, the main political problems of transition to a circular economy in Ukraine are related to the lack of a comprehensive transition strategy, the absence/limited goals for regulation in specific sectors of the economy (for example, construction), fragmentation of departmental and municipal cooperation in this area, and the lack of approaches to monitoring the indicators of the circular economy. In addition, the developed legislative acts are recommendatory, and no mechanisms for monitoring compliance with the circular economy principles have been defined.

Creating the Resource Efficient and Cleaner Production Centre helps accelerate the implementation of circular economy practices in Ukraine. The Centre plays an important function, primarily in disseminating knowledge about the concept and potential of circular production and rational resource consumption. It also assists companies in integrating sustainable practices into their business models. According to a UNIDO survey in 2023, the outlook of Ukrainian enterprises has changed due to the Centre's activities: 41 per cent of companies have adopted strategies for more efficient resource use as a response to the war (UNIDO, 2024). At the same time, the challenges of

implementing circular production methods primarily include limited availability of financing, high interest rates, documentation procedures, and collateral requirements.

Table 1: Factors contributing to the implementation of circular economy practices and measures in Ukraine

Factors	*Characteristics*
Political	Adoption in June 2022 of the Law of Ukraine «On Waste Management» dated November 15, 2024 № 2320-IX to regulate the management of waste generated in Ukraine, its transportation, export outside the country for disposal, recycling. Adoption of the National Waste Management Plan dated December 27, 2024 № 1353-p by 2033 in 2024 to define tasks and practical measures to ensure Ukraine's transition to a new waste management model. Development of regional waste management plans by 2025 and local waste management plans by regional administrations.
Infrastructure	Lack of monitoring system, data and statistics on waste management (recycling, reuse, disposal; Outdated waste management infrastructure and practices (household waste disposal to landfills, dumps, industrial waste disposal, low recycling rates).
Other issues	Low material efficiency, above-average carbon emissions and raw material consumption, inefficient industrial production processes and, consequently, increased resource consumption; Insufficient investment in research and development of enterprises and renewable energy infrastructure; Outdated farming methods and a lack of modernization lead to low yields and inefficient land use.

Source: RECP Centre (2024d)

The RECP Centre's activities are carried out within the framework of the European Union for Environment (EU4Environment) programme for the Eastern Partnership countries from 2019 to 2024. Enterprises that collaborated with the RECP Centre demonstrated initiative in implementing resource efficiency measures. This was supported by the Centre’s education and training programs, which aimed, among other objectives, to establish RECP teams within enterprises. In this way, measures were implemented to improve working conditions, conduct responsible business, and reduce the consumption of material and energy resources. Consequently, the RECP monitoring of Ukrainian food industry enterprises has become an incentive for them to intensify energy-saving activities and restructure the work of the entire enterprise to reduce energy consumption. The RECP monitoring results revealed that 12 manufacturing enterprises are implementing measures to rationalize the use of resources. In general, among all 12 enterprises, at least 30% of the measures proposed by the RECP Centre for more efficient use of resources were implemented in the first months after monitoring the companies' operations.

Out of the 12 companies, 9 have successfully implemented resource-saving and cleaner production measures. Out of 75 proposed measures, 24 have been implemented, and six are in the implementation process. According to the monitoring results, it was found that the implementation of 75 RECP measures requires EUR 2,220.9 billion of investments for all companies. Companies have invested €321.4 billion in the measures. The potential savings from the measures were estimated at €770.5 billion/year, while actual savings amounted to €213.3 billion/year. The companies had the opportunity to save 8,529,895 kWh/year of energy, 21,037 m^3/year of water, and reduce CO_2 emissions by 2,319 tons/year. The actual figures achieved were 2,891,904 kWh/year, 300 m^3/year, and 852 tons/year (Table 2).

Table 2: Results of monitoring the implementation of resource-efficient and cleaner production measures for Ukrainian manufacturing enterprises

Indicator	*Potential for implementation of measures*	*Actual measures implemented*
Investments, EUR million	2 220 865	321 396
Savings, euros/year	770 479	213 333
Energy kWh/year	8 529 895	2 891 904
Water m^3/year	21 037	300
CO_2, tons per year	2319	852

Source: RECP Centre (2024d)

The results of RECP implementation by production enterprises confirm the economic and environmental efficiency of activities related to the rational use of resources. Uzhhorod Garment Factory PrJSC saved €1,040 per year by optimizing the operation of its production sites, saving resources and reducing carbon emissions by 25.3 tonnes per year. Other companies' measures included optimizing systems and equipment, replacing or adding additional equipment, modernizing and automating equipment and production processes, reducing waste, reducing energy and gas consumption, and installing solar power plants. The investment amount varied considerably depending on the RECP measures chosen: from EUR 3 thousand to EUR 1,233 thousand. The economic effects of the measures differed accordingly: the companies' savings ranged from EUR 5 thousand/year to EUR 201 thousand/year (Table 3).

The practice of Ukrainian manufacturing enterprises in implementing resource efficiency measures shows that the principles of the circular economy (Dovhan, 2022) are followed: reducing the use of resources, maximizing the efficient use of resources. The study also identifies the benefits of implementing these circular economy principles: savings in the short (up to 1 year) and medium term (1-5 years) for most manufacturing enterprises; automation of production processes to maximize resource use, and increase productivity. Replacement, renewal, and modernization of equipment at manufacturing enterprises contribute to increasing resource efficiency, ensuring the transition from business models to circular business models by slowing down the processes of resource depletion (Geissdoerfer *et al*., 2018).

Table 3: Results of RECP measures implementation by manufacturing enterprises

Enterprise	*Direction of implementation of RECP measures*	*Economic indicators by implemented measures*	*Saving resources*	*Total pollutant reductions*
PrJSC "Uzhhorod garment factory"	Optimizing the operation of production sites by improving equipment performance	Investments: 2981 euros Savings: 10040 euros/year	Electricity: 18,792 kWh / 4.8% per year Natural gas: 26,702.4 m^3/year	Reduction of CO_2 emissions to 25.3 tons per year
Yaroslav PE	Energy efficiency measures at production sites are aimed at optimizing the operation of systems and equipment.	Investments: €23770 Savings: 19002 euros/year	Electricity: 48,491 kWh per year	Reduction of CO_2 emissions to 40.84 tons per year
Spetstekhosnastka LLC	Energy efficiency measures at production sites	Investments: 13619 euros Savings: 5055 euros/year	Electricity: 30,956 kWh/year Water: 2880 m^3/year	Reduced CO_2 emissions by up to 13 tons per year
JSC "SMNVO-Engineering"	Measures to improve equipment performance, reorganize the warehouse and modernize production processes.	Investments: 111124 euros Savings: 201025 euros/year	Electricity: 475,156 kWh per year Water: 9,808 m^3/year	Reduced CO_2 emissions by up to 600 tons per year
Oberbeton-Invest	Measures to reduce waste generation, energy and gas consumption	Investments: 129175 euros Savings: 65512 euros/year	Electricity: 85157 kWh per year Natural gas: 59 thousand m^3/year	Reduction of CO_2 emissions to 165.47 tons per year
Premier Sox PE	Improving the efficiency of equipment. Creation of a heating system, installation of a solar power plant	Investments: 121824 euros Savings: 42220 euros/year	Electricity: 281470 kWh per year	Reduction of CO_2 emissions to 118.22 tons per year
Kievguma LLC	Automation of production processes, improvement of production processes and staff performance	Investments: 37814 euros Savings: 57472 euros/year	Natural gas: 54.4 thousand m^3/year	Reduction of CO_2 emissions to 152.64 tons per year
Ligos LLC	Installation of additional equipment, replacement of equipment components	Investments: 67500 euros Savings: €23401/year	Electricity: 290173 kWh per year Water: 780 m^3/year	Reduction of CO_2 emissions to 121.86 tons per year

Enterprise	*Direction of implementation of RECP measures*	*Economic indicators by implemented measures*	*Saving resources*	*Total pollutant reductions*
"JP Agro" Ltd.	Installation of a solar power plant, application of energy-saving technologies, and implementation of a recycled water supply system	Investments: 152016 euros Savings: €43359/year	Electricity: 299,284 kWh per year	Reduction of CO_2 emissions to 126.5 tons per year
Kyivska Makaronna Fabryka, Ltd	Replacement, optimization of equipment, installation of new equipment, modernization of automation	Investments: 233863 euros Savings: 90146 euros/year	Electricity: 282 thousand kWh per year	Reduction of CO_2 emissions to 364 tons per year
Goodwelly Ukraine LLC	Measures to optimize production technologies, automation of steam generation control	Investments: 3950 euros Savings: 151484 euros/year	Natural gas: 453 thousand m^3/year	Reduction of CO_2 emissions to 99.9 tons per year
AGROLIFE TRANSSERVICE LTD	Improving production processes by automating them and installing energy-efficient equipment	Investments: 1233001 euros Savings: 145713 euros/year	Electricity: 899.6 thousand kWh per year	Reduction of CO_2 emissions to 483.3 tons per year

Source: RECP Centre (2024a)

Certain components of the circular business model are created as a result of the implementation of resource-efficient measures (Lewandowski, 2016): activities (changing production technologies, individual production processes, purchasing new production equipment); costs (reducing production costs). For example, the installation of a solar power plant, the use of energy-saving technologies and the integration of a recycled water supply system are examples of the implementation of a closed-loop business model that completely changes the production process of JP Agro Ltd. The circular business model is partially implemented in the production process of Premier Sox PE, which managed to improve the efficiency of equipment use by creating a heating system and installing a solar power plant. For the Ukrainian context, the barriers to the transition from traditional to circular business models are relevant, including barriers to the implementation of circular economy principles: high initial investments, insufficient knowledge of manufacturing enterprises, and outdated technological infrastructure (Kumar *et al*. 2019; Kuzma *et al*. 2021; Van Loon, Diener and Harris *(* 2021). Therefore, Ukrainian firms have been able to implement fewer resource-efficient measures than originally identified by the RECP Center. The RECP Center's expertise and training helped overcome the barriers of lack of knowledge and experience in the transition to closed-loop business models.

Compared to the EU, the US, Japan, and China, where the initial stages of the transition of enterprises to a closed-loop economy and the focus of measures on processing

processes have been identified, Ukraine's measures include the replacement, renewal, and modernization of equipment and production technologies. Therefore, the transition to a circular economy in Ukraine is different from other countries due to the different measures that are implemented in production activities. The principles of resource reduction or reuse are more difficult to implement than the principles of recycling (Ranta, Aarikka-Stenroos and Mäkinen, 2018). Therefore, the EU has a low level of closed-loop production (Gusmerotti *et al*. 2019). According to research conducted by the RECP Centre in Ukraine, the manufacturing sector (including electronics, machine building, metalworking, and food processing), agriculture, and construction are among the most promising sectors for implementing the circular economy concept. This is due to the significant production volumes of these sectors and the significant impact of their activities on the consumption of material resources and the environment. In agriculture, the principles of the circular economy can help solve the problems of the raw material component of this industry and the dependence of enterprises in this sector on fossil fuels. In construction, there are low carbon emission reduction rates and dependence on material resources. In addition, these findings of the RECP Centre of Ukraine align with European strategies and the sectoral action plan for implementing the circular economy. The action plan focuses on key value chains in the food, light industry, ICT and electronics, EU automotive, and construction sectors (RECP Centre, 2024b).

Ukraine's transition to a circular economy depends on several factors, including policy initiatives, technology availability, and business practices. The implementation of a circular economy in Ukraine may become part of the state’s policy for supporting businesses during wartime (Alekseieva *et al.*, 2023), focusing on the acquisition of environmentally friendly equipment by firms. It is also advisable to introduce the circular economy model in priority sectors such as agriculture, where there is potential to increase production efficiency through innovative and clean technologies (Zbarsky *et al.*, 2025). According to the RECP Centre, managers of manufacturing enterprises have selected the most important factors that they consider promising for Ukraine in the short, medium, and long term. Figure 1 shows this list of factors, ordered by priority according to the enterprises.

Therefore, businesses have noted the greatest short-term importance of the zero-waste concept in Ukraine. Zero-waste construction materials and sewage disposal systems are the main factors favouring a circular economy. Other important factors include common standards, circular economy regulations, reverse logistics centres for recycling and reuse, and circularity awareness. In the medium term, ensuring zero waste is the most important factor in implementing a closed production cycle. In addition, expanding producers' responsibility, integrating digital supply chains, and social eco-innovations are becoming important. In the long term, expanding producer responsibility is the most important factor in developing a circular economy. Industrial symbiosis and innovation for long-life products are seen as critical.

The RECP Centre's survey of manufacturing enterprises indicates that Ukraine's potential in the selected areas of successful circular economy transformation remains low or medium (Figure 2).

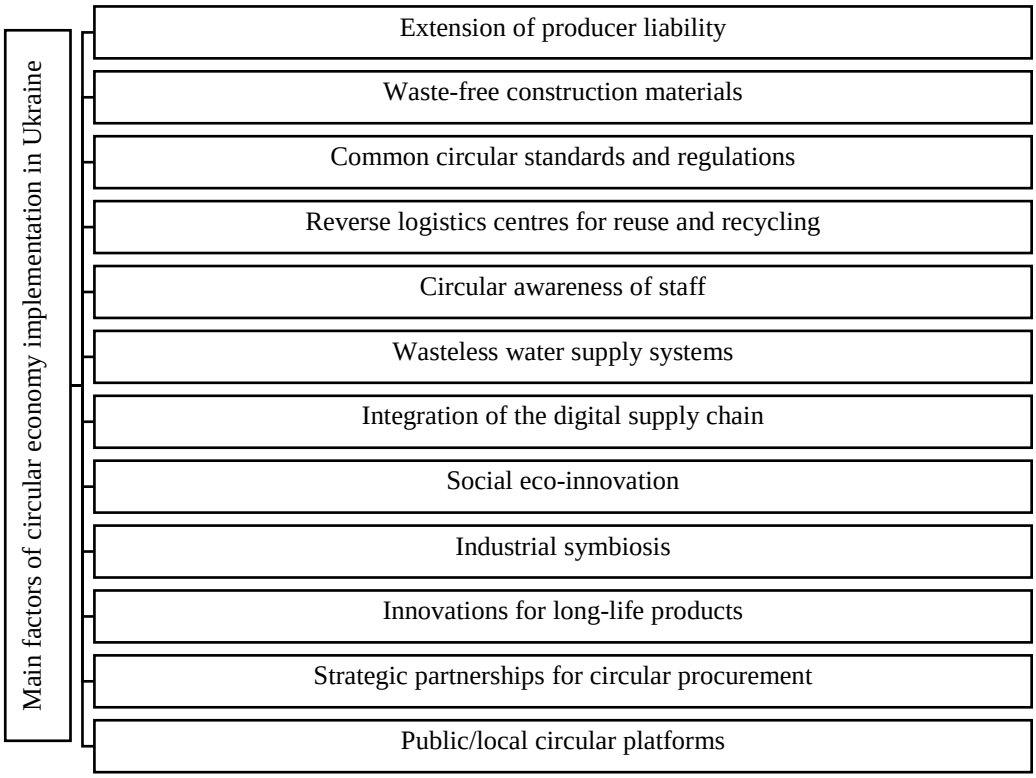

Figure 1: Factors that will determine the prospects for the implementation of the circular economy in Ukrainian business in the short, medium and long term
Source: compiled by the author based on RECP Centre (2024c)

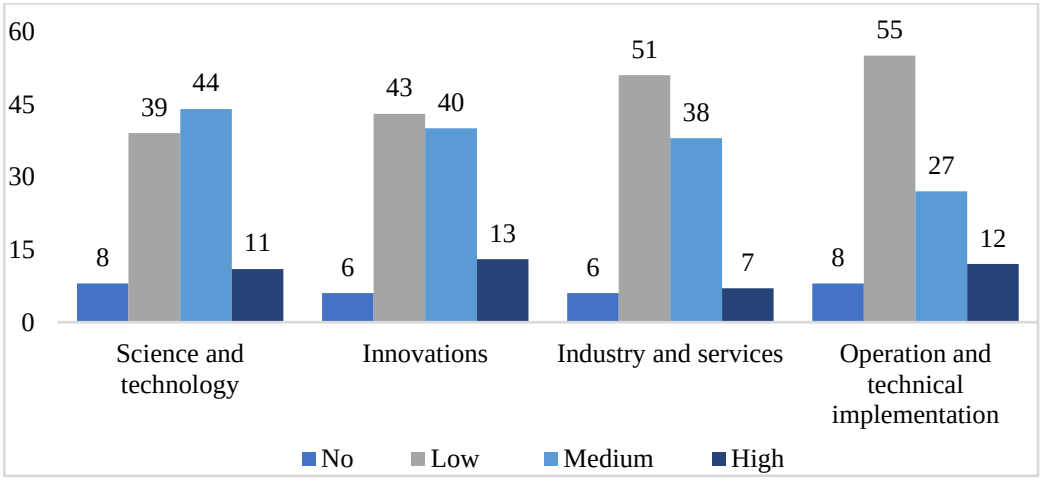

Figure 2: Ukraine's potential in various areas of transition to a circular economy
Source: RECP Centre (2024c)

Respondents in science and technology assess the transformation potential as medium or promising (44%). This is due to Ukraine's traditionally developed science and technology sector. Respondents assessed the potential of innovation for implementing the circular economy as relatively low (43%). In the industrial and service sectors, the

potential is assessed as low (51%) and, to a lesser extent, medium (38%). More than half of the respondents (55%) consider Ukraine's potential in operation and technical implementation low, and only 27% consider it medium. Taking into account the priority of various measures identified by enterprises that will facilitate the transition to a circular economy, the state policy of business support in this area should include stimulating the acquisition of resource-efficient and clean production technologies; introducing standards and principles of the circular economy that are most easily implemented in practice (reducing resource use, maximizing resource efficiency, recycling); expanding the network within the RECP to share knowledge and experience, and opportunities to implement resource-efficient measures.

Conclusion

The study demonstrates that implementing incentives actively promotes the circular economy in Ukraine. The RECP Centre's activities under the EU for the Environment programme have positively impacted the implementation of resource efficiency measures at Ukrainian manufacturing enterprises. Companies' investments in the replacement, modernization, automation, and installation of new equipment vary considerably depending on their capabilities, and such investments bring economic and environmental benefits. Quantitative estimates of the financial resources saved by energy efficiency measures taken by manufacturing companies range from EUR 5 to 200 thousand. Quantitative estimates of energy consumption reductions range from 30 to 899.6 thousand kWh per year and carbon emissions reductions from 13 to 600 thousand tons yearly.

At the macro level, adopting relevant legislation and national, regional, and local waste management action plans are the stimulating factors influencing the rational use of resources in the context of the circular economy concept. At the same time, in Ukraine, the lack of a comprehensive strategy for developing the circular economy, the fragmentation of departmental and municipal cooperation in this area, and the lack of approaches to monitoring circular economy indicators constrain factors for introducing a circular economy. In addition, the developed legislative acts are recommendatory, and there are no mechanisms for monitoring compliance with the circular economy principles. At the micro level, Ukrainian enterprises are limited in implementing closed-loop production by the lack of financing, high interest rates, and low awareness of circular economy principles. Given the above, the prospects for implementing resource efficiency measures and practices in Ukraine remain low to medium. This is due to a sufficiently developed scientific and technical potential and, at the same time, a low degree of innovation potential. Manufacturing, agriculture, and construction are the most promising sectors for implementing circular economy principles.

Further research should focus on identifying the relationship and impact of government and local government policies in Ukraine on implementing circular economy practices by domestic enterprises. Today, such studies are limited by the lack of a comprehensive system for monitoring the indicators of circular economy development.

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Authors' Declarations and Essential Ethical Compliances

Authors' Contributions (in accordance with ICMJE criteria for authorship)

Contribution	*Author 1*	*Author 2*	*Author 3*	*Author 4*	*Author 5*
Conceived and designed the research or analysis	Yes	No	Yes	Yes	Yes
Collected the data	Yes	No	Yes	No	No
Contributed to data analysis & interpretation	Yes	Yes	No	Yes	Yes
Wrote the article/paper	Yes	Yes	No	No	No
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