# Measuring indicators of a circular economy and sustainable development in European Union countries

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**Abstract.** The study analyses the principles and conditions of the functioning of the circular economy and identifies factors contributing to its successful implementation. Specialized general indicators, such as the Sustainable Development Index and the Innovation Index, are used in the study to assess the adoption of innovative and eco-friendly technologies. The data on circular economy development, innovation, and sustainable development in EU countries are analysed. It enables a comparison of their development levels and circular economy implementation. The research findings demonstrate that countries actively implementing environmental requirements and standards in social production, such as Sweden and Finland, or economically advanced countries like France, Germany, and the Netherlands, have the highest adoption of the circular economy. This information can be valuable for identifying leaders in circular practice implementation and potentially developing countries in this direction. The research can also serve as a basis for further enhancing the methodology of monitoring indicators of sustainable development, circular economy, and innovation in European Union countries.

## 1 Introduction

Sustainability and sustainable development are becoming increasingly essential priorities for the modern world. There is a growing awareness that economic progress should go hand in hand with environmental sustainability and social justice. European Union countries, which have long been paying attention to these issues, are actively developing and implementing strategies to achieve sustainable development. One of the key monitoring tools for measuring progress toward sustainable development, circular economy, and innovation is the system of indicators. European Union countries have established mechanisms for collecting and analysing data, allowing them to assess and compare their achievements in these areas.

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Monitoring indicators of sustainable development in the European Union encompass a wide range of metrics that reflect the state of the economy, social well-being, and environmental sustainability. Economic development indicators are assessed using GDP per capita, competitiveness index, and investment activity. Social indicators include poverty level, unemployment, access to education, and healthcare. Environmental indicators aim to evaluate resource efficiency, impact on environmental pollution, and the use of renewable energy sources. Additionally, an essential aspect of monitoring sustainable development is assessing the level of venture capital involvement in circular economy production technologies. The performance of this economy is evaluated based on economic indicators such as its share in GDP and the national debt.

This study aims to assess the level of circular economy in the national economies of EU countries. Accordingly, the following hypotheses are proposed:

1. The circular economy is one of the instruments for achieving sustainable development goals.
2. Sustainable development indicators reflect the implementation level of circular economy in national output.

## 2 Literature review

Western European scientists of the late XIX to mid-XX centuries made a significant contribution to the establishment of sustainable development as a separate scientific concept, namely Keating and Hooghe [1]. It was influenced by socio-historical circumstances and industrial progress, which provided the basis for activating urbanization processes. The modern approach to the development of the sustainable development concept is based on the improvement of mechanisms of public-private partnership associated with the increasing influence of major international corporations and transnational structures on economic, social, political, and cultural processes globally [2, 3]. Among the researchers, notable works include those by Darnton [4], Robinson [5], Agyeman [6] and Wirzba [7]. It is worth noting the significant contribution to the theory of sustainable development by international organizations, particularly the Organization for Economic Cooperation and Development (OECD). A comprehensive scientific and analytical review titled "Regulatory Policy and the Road to Sustainable Growth" (2010) was conducted by a group of experts on sustainable development from many developed countries, including the EU. The results of this review were combined with the findings from various OECD reviews on sustainable development in other countries. The report also considers recent conceptual analysis by the OECD on critical issues, including assessing the impact of information and cognitive technologies, which have been rapidly developing in recent years, on ensuring the "sustainability" of the analyzed countries' national economies [8].

The Russian-Ukrainian war has posed significant challenges to sustainable development in the affected regions. The conflict has resulted in the destruction of critical infrastructure, including energy facilities, transportation networks, and agricultural resources, hindering long-term development prospects [9]. Environmental degradation has also been a concern due to military activities and the neglect of environmental regulations during the conflict. Efforts to achieve sustainable development goals have been impeded as resources are diverted towards immediate humanitarian needs and the restoration of basic services. Rebuilding and promoting sustainable development in the aftermath of the war will require extensive international cooperation, investment, and the implementation of effective environmental and social policies to mitigate the long-term consequences of the conflict.

Implementing the sustainable development concept requires the transformation of national economies to meet the requirements of environmental friendliness, stability, and social security.

The circular economy is one of the instruments for achieving sustainable development [10]. That is due to the diverse group of researchers and experts who apply this concept and emphasize various aspects based on their professional specifications and research goals. This diversity of definitions complicates the possibility of a precise measurement of the level of circularity in the economy. Scholars often highlight three main elements: closed loops, renewable energy, and systemic thinking of the circular economy [11]. Thus, the concept of integrating linear production lines into a closed loop, known as the circular economy, has become relevant today. This model is based on implementing closed production cycles, using renewable energy sources and resources, and systemic thinking. Furthermore, the circular economy serves as a means to achieve the Sustainable Development Goals defined by the United Nations. It contributes to achieving these goals through direct and indirect actions.

## 3 Methods

The research methodology is based on conducting a systematic literature review and analysing existing studies, concepts, and theoretical approaches regarding sustainable development, circular economy, and innovation indicators. Firstly, relevant scientific works, including dissertations, monographs, articles, informative-analytical reviews, and instructional manuals, were collected and analysed. The authors utilized Eurostat statistical data, specifically information on taxes, gross domestic product (GDP), and gross fixed capital formation. These data were used for quantitative analysis of indicators, which enabled the estimation of assessments, rankings, and indicators related to circular economy development. The macroeconomic indicators were calculated within the research framework (the investment ratio coefficient and circular economy return on debt coefficient). The investment ratio coefficient reflects the ratio of total investments to GDP, while the circular economy returns on debt coefficient reflects the percentage of GDP and total government debt to the potential investments of the national economy. The potential investments include the amount of tax revenue, venture capital, and gross fixed capital formation. Based on the calculated coefficients and indices of sustainable development and innovation, the level of circular economy application in the national production of European Union countries was determined. A rating system was employed for this purpose, allowing for comparing countries based on this indicator. The calculation methodology included analysing and comparing quantitative indicators for each EU country, such as the investment ratio coefficient and circular economy return on debt coefficient. The results were utilized to create a ranking where countries were ranked according to the level of circular economy application, with higher positions indicating a higher level of circular economy development.

## 4 Results and discussion

In recent decades, Europe has undergone a transformation towards a new era of global governance for development and the environment, emphasizing trust, shared values, and common goals instead of relying solely on legally binding frameworks. Extensive research validates that when governments make commitments, they have the potential to drive changes at both individual and national levels. However, at such a scale, questions remain about how it can be successful, especially considering the influence of transnational corporations and global financial markets [12]. Therefore, implementing the EU's sustainable development policy requires independent implementation by individual states.

Each mean specifies aspects of integration, but the entire set must be implemented through coordination (Figure 1) so that, for example, a reduced set of essential variables can be determined through implementation data means and then pass through defining a set of standards within partnership means, and they determine the priorities of incentives in the means. The agenda should include implementing the main goals (SDGs 1-16) through integrated pathways and ensuring that the means of achieving these and other goals become standalone tasks [12].

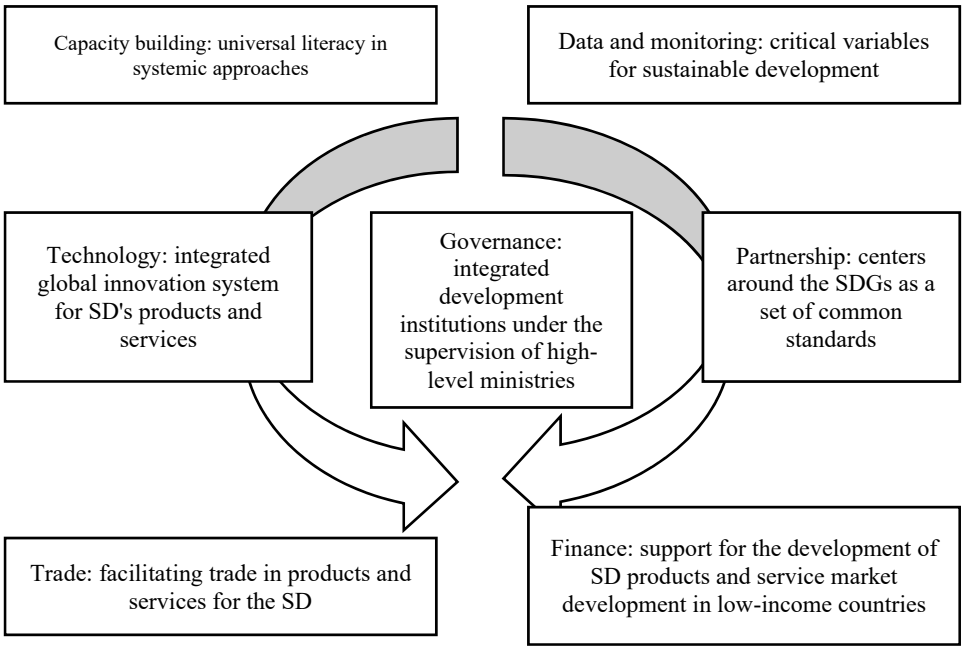


**Fig. 1.** Means of Sustainable Development Goals Implementation within the EU Sustainable Development Policy [12].

Each country is responsible for developing and implementing Sustainable Development Goals (SDGs) within a favourable international economic environment and governance. All member states actively encourage the development of "ambitious national responses," but there are no guidelines on how countries could monitor the integration process. Without this, there is a risk that countries may "select" goals that align with their priorities or data collection systems and, at the same time, ignore goals that are inconvenient in terms of implementation or monitoring. Consequently, environmental goals may continue to be ignored or be included in overly rigid frameworks. Instead, countries must recognize that short-term benefits for their national well-being can easily be undermined in the long term if this compromise is not achieved at the national and global levels [12].

Considering the provisions of the "2030 Agenda for Sustainable Development," the engagement of civil society and consultations with governmental and private institutions form the basis of the SDG process, starting from the contextual analysis that determines the distance to achieving SDGs ('positioning') to identifying strengths and weaknesses. These contribute to defining national goals. Thus, over 200 sustainable development tasks have been involved, significantly contributing to contextual analysis and providing useful insights that reflect the vision of the "2030 Agenda for Sustainable Development" in national strategies [13].

European state authorities cooperated throughout the process to establish common national strategies and goals and determine viable and available means of implementation. Universities and research agencies also reviewed and consolidated the scientific and technical base and contextual analysis content. Regional authorities actively participated in collecting data on territorial issues and priorities. Stakeholders involved in defining the national sustainable development strategy directly carry out initiatives related to the implementation of SDGs and the SDG process. In particular, the Italian Alliance for Sustainable Development (L'Alleanza Italiana per lo Sviluppo Sostenibile - ASviS), which brings together over 150 organizations in the economic and social spheres, launched the first Sustainable Development Festival in May 2017, a large-scale information and awareness campaign to promote cultural and political reflections on this issue throughout the country. ASviS and the Ministry of the Environment, Land, and Sea are working to make it an annual event and a reference point for all SDG initiatives [13].

Since the early 1990s, several European countries have established advisory councils dedicated to sustainable development. Some countries (e.g., the United Kingdom) created new and independent bodies, while others (such as Ireland and the Netherlands) utilized existing institutions, expanding their advisory services to include specific tasks related to sustainable development. In addition to national councils, several subnational and regional advisory bodies were also established (e.g., Catalonia, Flanders, and Wales). However, Germany only joined this process in 2001.

Since 2003, the European Environmental Advisory Councils network (EEAC), initially created in 1993 solely for academic environmental consultations, expanded its scope to include councils for sustainable development. Consequently, the network was renamed the European Environmental and Sustainable Development Advisory Councils network. Currently, over 13 councils operate in European countries. The network and its members aim to support and learn from each other, respect and disseminate ideas that go beyond national perspectives and are crucial for achieving sustainable development and fostering a healthy and sustainable environment within and beyond the European region [14].

Modern society faces various global challenges related to population growth, depletion of natural resources, and environmental pollution. In this context, the "circular economy" concept becomes increasingly relevant as a strategy for achieving sustainable development and preserving natural resources for future generations. A circular economy, or a closed-loop economy, is based on efficient resource utilization, waste minimization, and transforming waste into valuable resources. Overall, scientific literature and professional journals utilize over 100 different definitions of the circular economy. However, the critical aspect of these definitions is the reuse of resources. Therefore, this economy is characterized by the "3R" approach [15]:

- "Reduce" – minimizing resource usage;
- "Reuse" – maximizing the reuse of products and components;
- "Recycle" – high-quality recycling of resources.

Unlike the traditional "linear economy," where resources are consumed and discarded after use, the circular economy proposes closing this cycle by implementing three fundamental principles: reduction, recycling, and the use of secondary resources.

The first principle, reduction, involves minimizing resource consumption and producing less waste. It can be achieved by increasing the lifespan of products, developing environmentally friendly technologies, employing energy-efficient processes, and adopting the "design for reuse" principle.

The second principle, recycling, entails transforming waste into new materials or products. It can involve secondary recycling, where waste undergoes recycling and is used to manufacture new goods.

The third principle, the use of secondary resources, involves viewing waste as valuable resources that can be utilized in other industries. For example, waste from one production process can serve as raw materials for another. It creates a system of exchange and collaboration between different sectors, maximizing resource utilization and reducing the need for new production.

The circular economy has the potential to bring numerous benefits to both the economy and the environment. It contributes to conserving natural resources, reduces energy consumption and greenhouse gas emissions, and creates new opportunities for businesses and innovation. The circular economy requires collaboration between government, companies, and the public. It necessitates appropriate policy regulations, support for innovative projects, and public education about the advantages and possibilities of the circular approach.

The circular economy requires closed material cycles and renewable energy sources, and the implementation of innovative ecological technologies based on venture capital. The circular economy serves as a tool for achieving the Sustainable Development Goals. The circular economy model is built upon the following fundamental factors:

1. Resources. This idea challenges the concept of waste. The products are designed to have a long service life, utilizing quality materials and optimizing them for reuse. Narrow production cycles differentiate the circular economy model from mere disposal and processing, where a significant amount of embedded energy and labor is lost. The ultimate goal is to preserve and increase natural capital by controlling end stocks and balancing flows of renewable resources.
2. Following natural cycles and design. It involves dividing production technology into technical and biological cycles. Consumption occurs solely within biological cycles, where bio-based materials (food products, natural textiles, etc.) are designed to return to the system through anaerobic digestion and composting processes. These cycles regenerate living systems such as soils and oceans, which provide renewable resources for the economy. In turn, technical cycles regenerate products (e.g., washing machines), components (e.g., motherboards), and materials (e.g., limestone) through strategies such as reuse, repair, or recycling. Ultimately, one of the goals of the circular economy is to optimize resource usage by circulating products, components, and materials, utilizing them with the highest utility at any given time in both technical and biological cycles.
3. Full utilization of renewable energy. Powering all systems and cycles with green energy reduces reliance on carbon-based energy resources and increases system resilience [16].

At present, the critical elements identified for implementing a circular economy are [17]:

1. Future-proof design: envisioning future systems during the design phase, using appropriate materials, developing long-term operational strategies, and creating products for future reuse.
2. Comprehensive application of digital technologies: tracking and optimizing resource utilization, strengthening connections within logistic chains from extraction to final product.
3. Support and prolongation of the product life: supporting repair, maintenance, and upgrading of products to maximize their lifespan and enabling strategies for return and reuse whenever possible.
4. Priority on regenerative resources: ensuring efficient utilization of renewable, reusable, and non-toxic resources as raw materials and fuel.
5. Waste as a resource concept: utilizing waste streams as sources of secondary resources and promoting waste recovery and recycling.

6. Business model transformation: exploring opportunities to create more excellent product value and adopting business models emphasizing the interaction between goods and services.

7. Creating shared value: collaboration throughout the supply chain, within companies, and with the public sector to enhance transparency and generate mutual value.

This model is being implemented in practice. Recycling and upcycling are becoming more accessible, and cities are adopting new systems to reduce environmental impact through waste reduction, resource recycling, and cleaner energy production. The amount of food waste is decreasing as efforts are made to address losses of approximately 30% occurring during collection, production, transportation, and retail [18].

The processed material has allowed the identification of the contemporary concept of implementing a circular economy (Figure 2).

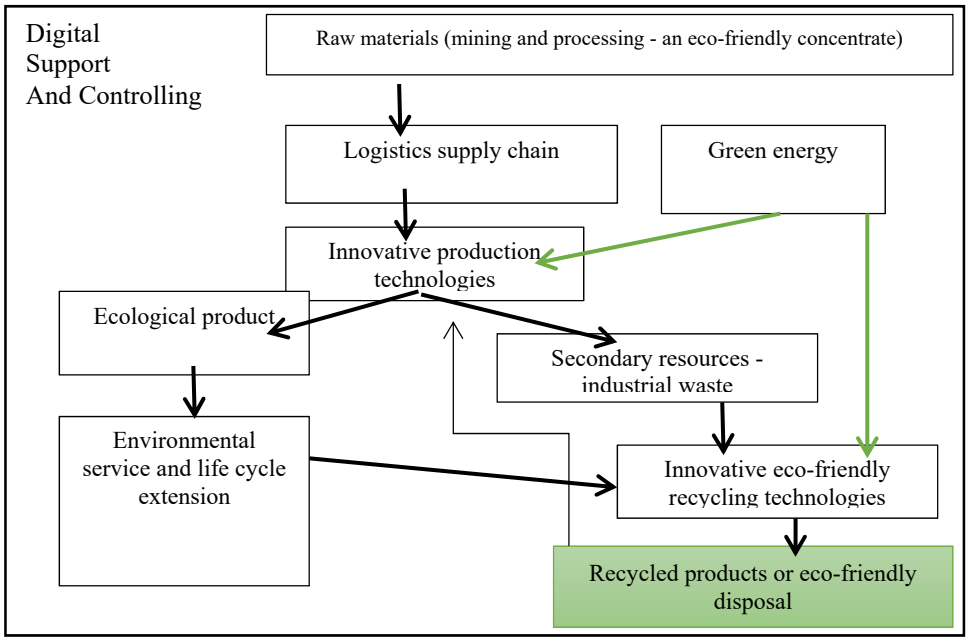


**Fig. 2.** The concept of implementing a circular economy [19].

Although sustainable development goals should guide sectoral policies for sustainable development, the monitoring of SDIs should play a direct role for governments. In the context of sustainable development strategies, the link between the two functions should be close, as stated by Perga [20]:

– The goals that are not clearly linked to SDIs are not subject to monitoring, which complicates the assessment and advancement of relevant policies.

– The SDIs without a policy reference can be politically insignificant, as they monitor what seems to have low political relevance.

Monitoring the progress of sustainable development strategy implementation, achieving sustainable development goals, and studying the results for information adaptation is a vital feedback stage that completes the strategic management cycle for sustainable development strategies. According to the OECD Development Assistance Committee's recommendations on sustainable development strategies, monitoring, and evaluation "should be based on clear indicators and integrated into strategies to guide processes, track progress, identify and internalize valuable lessons, and warn of the need for change in direction".

In addition, the United Nations Department of Economic and Social Affairs recommend using "integrated mechanisms for evaluation, follow-up, analysis, and feedback." Table 1 summarizes the challenges, approaches, and innovations identified in studying states' experience in monitoring, learning from results, and adaptation. The Table 1 also separates process and outcome monitoring [21].

**Table 1.** Sustainable development monitoring: challenges, approaches, and innovations.

| Challenges | Approaches and tools | Examples and innovations |
|---|---|---|
| Process monitoring | Process (intermediate results) monitoring and reporting (9 states)<br>Audit institutions<br>Expense analyses<br>Ministers' reports | Canada, United Kingdom<br>Canada<br>United Kingdom, Poverty Reduction Strategies for Cameroon and Madagascar<br>United Kingdom |
| Results Monitoring | National sustainable development indicators and reporting (9 countries)<br>National accounts system<br>Audit institutions<br>Audit committees<br>Independent advisory and consulting institutions | EU, Morocco<br>Sweden, South Korea<br>Canada<br>United Kingdom |
| Analysis of results and adaptation | Independent bodies and committees<br>Working group on strategy review<br>Advisory boards<br>Reporting on results<br>Research networks<br>Public discussions | Canada, United Kingdom, Philippines<br>United Kingdom, Philippines<br>Mexico<br>Sweden, Germany, EU<br>United Kingdom<br>India, Cameroon |

Monitoring the process involves assessing the progress in implementing initiatives within the state policy framework. This type of monitoring helps answer the question: "Have we achieved what we intended?" Monitoring the outcomes involves evaluating the progress in achieving tangible results targeted by policy initiatives (e.g., child mortality rates, air quality in cities, greenhouse gas emissions, household income levels, etc.). It is worth noting that organizations often use the progress made in implementing the process as a basis for improvement in achieving results [21]. It is related to the fact that the results of policy initiative implementation may only become noticeable over a considerable period. However, this often occurs due to difficulties in establishing a cause-and-effect relationship between the policy initiative and a specific sustainable development outcome, as such challenges arise from the cumulative impact of a range of government-level policy initiatives as well as actions taken by members of the public and the private sector [21].

The current stage of circular economy development is based on various indices that help measure and assess the effectiveness and progress in implementing circular practices. Below are several key indices used in contemporary practice:

1. Circular Economy Index. This index measures the level of circular economy development in a country or region. It considers indicators such as waste processing volume, use of secondary raw materials, efficient resource utilization, energy consumption, and ecological footprint.
2. Resource Productivity Index. This index evaluates resource usage in the economy and measures the efficiency of its utilization. It considers indicators such as production volume per unit of resource, energy efficiency indicators, and the use of secondary materials.

3. Secondary Raw Material Index. This index reflects the extent of secondary raw material usage in production. It assesses the proportion of materials used that are secondary (recycled) and determines the degree of their utilization.

4. Resource Smart Index. This index considers resource usage in the context of economic growth and innovative development.

However, these indices involve complex calculation formulas and require obtaining a significant amount of diverse statistical data.

The circular economy is based on innovative implementations. Therefore, its assessment should be based on venture capital involvement and investments linked to national income and national economic debt. Thus, let us calculate and evaluate the level of circular economy development in EU countries using official statistical data from Eurostat (Table 2).

**Table 2.** Calculation of the circular national economy effect of the EU countries in 2022 [22].

| Countries | GDP, EUR million | Gross fixed capital formation (investments), EUR million | Taxes on production and imports fewer subsidies, EUR million | Total public debt, EUR million | Total venture capital, EUR million | Total potential investments in the national economy, EUR million | Investment ratio coefficient | Debt return ratio of the circular economy |
|---|---|---|---|---|---|---|---|---|
| **Belgium** | 549456.2 | 132589.9 | 51490.2 | 548703.3 | 459465 | 643545.10 | 1.171 | 1.173 |
| **Bulgaria** | 84560.6 | 12 992.9 | 8068.9 | 17814.3 | 31567 | 52 628.80 | 0.622 | 2.954 |
| **Czech Republic** | 276605.9 | 74808.8 | 24035.5 | 103249.9 | 124314 | 223158.30 | 0.807 | 2.161 |
| **Germany** | 3869900.0 | 872436.0 | 353798.0 | 2475775.7 | 4691641 | 5917875.00 | 0.362 | 1.105 |
| **Estonia** | 36181.4 | 9160.9 | 4128.9 | 5534.9 | 139462 | 152751.80 | 1.529 | 2.390 |
| **Ireland** | 502583.5 | 133813.7 | 27714.3 | 235850.7 | 291996 | 453524.00 | 4.222 | 27.598 |
| **Greece** | 208030.2 | 28507.1 | 27140.6 | 353389.0 | 79367 | 135014.70 | 0.902 | 1.923 |
| **Spain** | 1327108.0 | 266351.0 | 131565.0 | 1427235.4 | 1576393 | 1 974 309.00 | 0.649 | 0.382 |
| **France** | 2639092.0 | 655507.0 | 358597.0 | 2813087.0 | 3577843 | 4 591 947.00 | 1.488 | 1.383 |
| **Italy** | 1909153.6 | 415702.5 | 224298.0 | 2677910.4 | 426715 | 1066715.50 | 1.740 | 1.632 |
| **Latvia** | 39062.5 | 8507.6 | 4338.6 | 14739.7 | 11318 | 24164.20 | 0.365 | 0.535 |
| **Lithuania** | 66791.1 | 14006.4 | 6026.8 | 24535.5 | 56656 | 76 689.20 | 0.559 | 0.398 |
| **Luxembourg** | 78130.1 | 13205.8 | 8101.3 | 17855.8 | 38896 | 60 203.10 | 0.343 | 0.381 |
| **Hungary** | 170246.8 | 48324.5 | 26094.2 | 114884.6 | 141574.. | 215 992.70 | 0.619 | 1.639 |
| **Netherlands** | 941186.0 | 201470.0 | 93028.0 | 448110 | 2180357 | 2 474 855.00 | 1.148 | 3.126 |
| **Austria** | 446933.3 | 117108.3 | 50 640.9 | 334083.8 | 459465 | 627 214.20 | 0.771 | 3.372 |
| **Poland** | 656905.5 | 109514.1 | 81824.1 | 306835.9 | 136681 | 328 019.20 | 1.269 | 1.880 |
| **Portugal** | 239241.7 | 48592.0 | 32019.9 | 269231.8 | 52607 | 133218.90 | 0.305 | 0.624 |
| **Romania** | 285884.8 | 71296.5 | 24818.1 | 116618 | 37296 | 13341.60 | 2.630 | 5.523 |
| **Slovenia** | 58988.5 | 12961.0 | 6616.1 | 38857.8 | 1005 | 20582.10 | 1.403 | 1.877 |
| **Slovakia** | 109651.9 | 22331.9 | 11328.3 | 61259.4 | 35538 | 69198.20 | 0.499 | 1.069 |
| **Finland** | 266679.0 | 65746.0 | 32997.0 | 166411 | 948451 | 1047194.00 | 0.557 | 0.495 |
| **Sweden** | 560958.6 | 152547 | 110832.7 | 192566.6 | 735159 | 998539.20 | 0.467 | 1.144 |

Based on our calculations and key sustainable development indices, let us estimate the implementation level of the circular economy in the EU countries (Table 3).

**Table 3.** Assessment of the EU circular national economy, including the Global Innovative Index and the Sustainable Development Index [23-24].

| Countries | Circular economy development potential coefficient | Global Innovative Index | Sustainable Development Index | Circular economy level in national production | Countries' groups by circular economy implementation |
|---|---|---|---|---|---|
| Sweden | 3.483 | 61.60 | 85.19 | 50.09 | Leaders |
| Finland | 5.110 | 56.90 | 86.51 | 49.51 | |
| Estonia | 15.910 | 50.20 | 80.62 | 48.91 | |
| France | 1.686 | 56.90 | 86.51 | 48.37 | |
| Denmark | 0.734 | 55.90 | 85.63 | 47.42 | |
| Netherlands | 4.076 | 58,00 | 79.85 | 47.31 | |
| Germany | 1.960 | 57.20 | 82.18 | 47.11 | |
| Austria | 1.640 | 50.20 | 82.32 | 44.72 | Countries with potential growth |
| Ireland | 1.413 | 48.50 | 80.66 | 43.52 | |
| Belgium | 1.172 | 46.90 | 79.69 | 42.59 | |
| Luxembourg | 2.071 | 49.80 | 75.74 | 42.54 | |
| Czech Republic | 1.484 | 44.60 | 80.47 | 42.18 | |
| Malta | 0.465 | 49.20 | 76.77 | 42.14 | |
| Spain | 1.435 | 44.60 | 79.90 | 41.98 | |
| Italy | 0.479 | 46.10 | 78.34 | 41.64 | |
| Portugal | 0.526 | 42.10 | 79.23 | 40.62 | |
| Slovenia | 0.439 | 40.60 | 79.95 | 40.33 | |
| Cyprus | 0.362 | 46.20 | 74.23 | 40.26 | |
| Hungary | 1.574 | 39.80 | 79.01 | 40.13 | |
| Poland | 0.784 | 37.50 | 80.54 | 39.61 | |
| Latvia | 1.129 | 37.30 | 80.28 | 39.57 | |
| Bulgaria | 1.788 | 39.50 | 74.29 | 38.53 | Countries with a sufficient development level |
| Greece | 0.516 | 37.50 | 76.81 | 38.28 | |
| Croatia | 0.450 | 35.60 | 78.79 | 38.28 | |
| Lithuania | 2.137 | 36.50 | 75.42 | 38.02 | |
| Slovakia | 0.880 | 34.30 | 78.66 | 37.95 | |
| Romania | 0.805 | 34.0 | 77.72 | 37.54 | |

The circular economy is being implemented rapidly in countries with the highest environmental sustainability and social welfare standards. Specifically, Sweden, Finland, Estonia, France, Denmark, and Germany are leading the way. Countries with economic development potential, such as Austria, Ireland, the Czech Republic, Spain, and Poland, are lagging behind the leaders, but their circular economy index ranges from 40 to 45. Other EU countries have achieved a satisfactory level of this indicator with an average value of 37.

Thus, the circular economy is confidently integrated into modern production, primarily in countries that embrace and adhere to environmental standards. The EU countries in active development widely apply this approach, although it only dominates some societal production. Other EU countries only utilize a circular economy to a third of its potential.

## 5 Conclusions

The modern economic paradigm dictates new requirements for the organization and control of social production. Such control is implemented through digital information and communication technologies. In this regard, the evaluation of implementing innovative and ecological technologies is monitored through specialized key indicators: the Sustainable Development Index and the Innovation Index. These indicators collectively characterize the implementation of the concept of sustainable development. However, this is an insufficient condition for assessing the effectiveness of circular economy implementation, as it does not allow for a clear criterion to define the efficacy of such an economic model. Therefore, the study analyzes the principles and conditions of circular economy functioning, which has led to identifying a range of essential factors in implementing the circular economic model. These factors include the level of potential investments, including venture capital (as an implementation of an innovative approach), taxes, and gross accumulation of fixed capital.

Based on these indicators and considering the indexes, EU countries were analyzed regarding circular economy development, innovation, and sustainable development indicators. The research has allowed for a comparison of the levels of development and implementation of circular economy practices in different countries. It has revealed a clear tendency for the circular economic model to be most effectively implemented in countries actively adopting environmental requirements and standards for social production (such as Sweden and Finland) and economically developed countries (such as France, Germany, and the Netherlands). This information can help analyze and identify countries that lead in implementing circular practices and determine potentially developing countries in this direction.

Furthermore, this research can be utilized for further improvement of the methodology for monitoring indicators of sustainable development, circular economy, and innovation in European Union countries.

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