CIRCULAR ECONOMY AS A DRIVER OF LABOUR MARKET CHANGE: EVIDENCE FROM ROMANIA (2014–2024)

Anca CRISTEA[3]
İnstitute for World Economy, Romanian Academy, Bucharest, Romania,
Faculty of Economic Studies from the "Hyperion" University of Bucharest

ABSTRACT: *The paper investigates the relationship between circular-economy development and labour-market change in Romania during 2014–2024. Using indicators of circular material use, municipal waste recycling, resource productivity, circular-sector employment and repair and reuse employment, the study combines benchmark-year trend analysis, descriptive statistics and comparison with the EU-27. The results indicate gradual improvement across all indicators but persistent convergence gaps, particularly in material circularity and resource productivity. In 2024, Romania reached only 13.6% of the EU benchmark for circular material use and 15.2% for resource productivity, while circular-sector employment reached 66.7%. This asymmetry suggests that employment has expanded faster than material and productivity performance and may remain concentrated in relatively labour-intensive circular activities. The findings highlight the need to shift towards higher-value circular models, including remanufacturing, eco-design, industrial symbiosis and advanced secondary-material processing, supported by investment, skills development, digitalisation and innovation.*

Keywords: *Circular Economy; Employment; Romania; Resource Productivity; Recycling; Skills; Circular Business Models*

JEL classification: *J21, J24, O33, Q53, Q56*

1. INTRODUCTION

The transition from a linear to a circular economic model has become a central component of the European Union's strategy for climate neutrality, resource efficiency, resilience and long-term competitiveness. Rather than focusing only on waste management, the circular economy seeks to preserve the value of products, components and materials through reduction, reuse, repair, refurbishment, remanufacturing, recycling and product–service systems (European Commission, 2020; European Environment Agency [EEA], 2024). As a result, circularity represents not only an environmental objective but also a process of economic and organisational transformation with direct implications for labour demand.

Circular activities can create employment because repair, maintenance, reuse, sorting, recycling and remanufacturing are often labour-intensive. At the same time, more advanced circular models require engineering, digital, managerial and environmental competencies, changing both the quantity and quality of labour demand. Employment effects therefore depend on the position of activities within the circular value hierarchy: basic waste processing may

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[3] PhD, Scientific Researcher III, lcancacristea@yahoo.com

create jobs with limited productivity gains, whereas eco-design, remanufacturing, industrial symbiosis and digitally enabled services can support more knowledge-intensive and higher-value employment (Beducci et al., 2024).

These issues are particularly relevant for Central and Eastern European economies, where circular transition occurs under different conditions of industrial structure, technological intensity, investment capacity and human capital. Romania combines relatively weak circularity and resource-efficiency performance with demographic decline, outward migration, regional disparities and persistent skill mismatches. At the same time, the National Strategy on Circular Economy (2022) and its Action Plan (2023) have broadened the policy focus from waste management towards circular production, innovation, digitalisation and skills (Government of Romania, 2022, 2023).

Despite growing research on the environmental and economic implications of the circular economy, comparatively limited attention has been devoted to the relationship between circularity performance and labour-market outcomes in Romania. Existing assessments tend to focus primarily on waste management, recycling or material flows, while the interaction between material circularity, resource productivity and circular employment remains insufficiently explored. This gap is important because employment growth does not necessarily imply a transition towards higher-value and more resource-efficient circular activities.

Against this background, the study examines the evolution of circular-economy performance and circular employment in Romania during 2014–2024 and assesses the extent to which national developments indicate convergence towards EU-27 patterns. Particular attention is given to the relationship between material circularity, resource productivity and employment dynamics. The analysis addresses four questions: (RQ1) How have Romania's principal circular-economy indicators evolved relative to EU-27 benchmarks? (RQ2) Has circular-sector employment increased at a pace consistent with improvements in material circularity, recycling and resource productivity? (RQ3) What does the available evidence suggest about the balance between labour-intensive and higher-value circular activities? (RQ4) Which structural, institutional and skills-related factors are relevant to the qualitative upgrading of circular employment?

The paper contributes to the literature by integrating environmental and labour-market indicators within a common analytical framework, extending the analysis beyond waste and material flows. It compares Romania with the EU-27 over 2014–2024 to identify progress and persistent convergence gaps, while interpreting these trends in relation to skills, job quality, circular business models and national policy.

2. LITERATURE REVIEW AND CONCEPTUAL FRAMEWORK

The circular economy (CE) has evolved from an environmental concept centred primarily on waste reduction and recycling into a broader framework for economic, technological and organisational transformation. Contemporary approaches emphasise preserving the value embedded in products, components and materials through reduction, reuse, repair, refurbishment, remanufacturing and recycling. Circularity therefore involves a systemic reconfiguration of production and consumption rather than isolated improvements in waste management (European Commission, 2020; European Environment Agency [EEA], 2024).

This transformation has significant implications for labour markets because changes in material flows influence production technologies, supply chains, business models and the composition of labour demand. The employment effects of circularity should therefore be understood primarily as a process of labour reallocation rather than simply net job creation. Economic activity shifts from extraction, primary production and disposal towards activities that retain the value of products and materials. Repair, maintenance, reuse, refurbishment and sorting tend to have a strong local labour component, while remanufacturing, eco-design and advanced material recovery require more specialised technical and engineering competencies.

Employment outcomes also depend on the position of activities within the value-retention hierarchy. Recycling recovers materials after much of the value embodied in a product has been lost, whereas repair, refurbishment and remanufacturing preserve products, components, knowledge and economic value. Circular activities are often labour-intensive because collection, inspection, sorting, maintenance, disassembly, repair and redistribution cannot always be fully automated. However, the quality and productivity of the resulting employment vary substantially. Waste collection and basic sorting may create relatively accessible jobs but generally generate lower value added, whereas remanufacturing and advanced recovery combine manufacturing expertise, engineering, quality control, logistics and digital technologies.

Recent research illustrates the importance of this distinction. Remanufacturing aims to restore products or components to a functional condition comparable to new products, thereby preserving a larger proportion of their embedded value. Andersen et al. (2024) highlight its potential to combine environmental benefits with resource conservation, cost reduction and extended product lifecycles, while Yang and Sun (2024) emphasise the strategic relationship between eco-design and remanufacturing in closed-loop supply chains. Consequently, an economy dominated by waste collection and basic recycling may experience growing circular employment while maintaining relatively low resource productivity and technological sophistication. In contrast, remanufacturing, industrial symbiosis, eco-design and advanced secondary-material industries can strengthen the relationship between circularity, innovation and productive employment.

A second major channel linking circularity and employment concerns skills. Circular production requires combinations of technical, environmental, digital and organisational competencies. Beducci et al. (2024) show that circular manufacturing has both quantitative and qualitative workforce implications, creating new occupational profiles and transforming existing ones. Digitalisation reinforces this process. Industry 4.0 technologies, including the Internet of Things, artificial intelligence, data analytics, automation, digital twins and product-tracking systems, can support product traceability, predictive maintenance, reverse logistics and secondary-material management. Sahoo and Jakhar (2024) demonstrate that Industry 4.0 deployment can support circular-economy performance and complement activities such as green procurement and remanufacturing.

The circular and digital transitions are therefore increasingly interconnected. Workers must often combine traditional production knowledge with digital competencies, while engineers and managers require greater understanding of lifecycle considerations, resource efficiency and circular procurement. Human capital consequently acts as an enabling factor: insufficient technical and digital skills can constrain investment, reduce productivity gains and limit the adoption of advanced circular business models.

This creates a need for both upskilling and reskilling. Existing workers may require additional competencies in resource-efficient production, disassembly, digital monitoring or lifecycle management, while workers displaced from declining linear activities may need more extensive retraining. The required competencies extend beyond technical expertise to systems thinking, problem solving, collaboration and lifecycle thinking (Beducci et al., 2024). Education, vocational training and lifelong learning therefore play an important role in translating circular investment into productive employment.

Circularity also affects employment through new business models. Product–service systems, leasing, sharing, repair services and resale platforms seek to extend product utilisation and reduce resource consumption. Product–service systems can increase incentives for durability, maintenance and repair while creating employment in technical support, logistics, refurbishment and digital services. Reverse logistics is similarly important because circular supply chains require products and components to return from consumers to firms for repair, remanufacturing or recycling. Evidence from automotive remanufacturing identifies reverse logistics as a critical organisational condition for circular production (van Dam & Bakker, 2024).

Nevertheless, employment growth alone does not provide a sufficient measure of the social benefits of circularity. Job creation should also be considered in relation to productivity, wages, occupational safety, contractual stability, social protection and opportunities for professional development. Waste collection, sorting and materials recovery may contribute significantly to environmental objectives while involving relatively low productivity or insecure working conditions. By contrast, eco-design, advanced remanufacturing, engineering and digital circular services can generate more knowledge-intensive and productive employment.

A distinction can therefore be made between lower-value and higher-value circular employment. Lower-value activities recover relatively limited economic value, whereas higher-value activities preserve or recreate embedded value through specialised knowledge, innovation and more sophisticated production processes. Lower-skilled activities remain important for both local employment and environmental objectives, but a transition dominated by these activities is unlikely to maximise productivity, wages and technological competitiveness. Job quality should consequently be regarded as an integral component of the social dimension of circularity.

Circular transformation may also reduce labour demand in conventional resource-intensive industries, creating uneven effects across occupations, sectors and regions. This highlights the relevance of a just transition, in which environmental transformation is accompanied by realistic opportunities for workers and communities to adapt. Regions dependent on resource-intensive industries may experience adjustment pressures even when aggregate employment effects are positive. Reskilling, vocational training, career-transition support and regional development policies are therefore necessary complements to environmental and industrial policies.

The employment effects of circularity are also conditioned by national economic structures and institutional capacity. Differences in industrial specialisation, innovation, human capital, infrastructure and regulatory effectiveness mean that similar circular policies may produce different outcomes across EU Member States. Economies with stronger innovation systems may develop advanced remanufacturing, circular design and digital services, whereas countries with weaker technological capabilities may remain concentrated in waste management and basic recycling. SMEs are particularly relevant because many repair, maintenance, reuse and recycling activities are performed by smaller firms, whose transition may be constrained by limited access to finance, technology and specialised personnel.

These considerations are particularly relevant to Romania, which combines comparatively weak circularity and resource-productivity indicators with demographic pressures, outward migration, regional disparities and skill mismatches. The central issue is whether Romania is moving from a predominantly waste-oriented model towards a value-retention model based increasingly on repair, reuse, remanufacturing, eco-design, industrial symbiosis and advanced secondary-material processing.

This distinction has direct labour-market implications. A waste-oriented transition may increase employment in collection, sorting and basic recycling without producing substantial productivity improvements. A value-retention transition should generate stronger demand for technicians, engineers, designers, digital specialists, logistics professionals and sustainability managers. Consequently, if Romania's circular-sector employment converges towards the EU benchmark more rapidly than circular material use or resource productivity, this may indicate that employment remains concentrated in comparatively labour-intensive and lower-value activities.

Based on the literature, the conceptual framework adopted in this study identifies four interrelated mechanisms through which circular-economy development affects labour-market outcomes:

Circular activity → labour demand. Expansion of reuse, repair, recycling, remanufacturing and related services increases labour demand, although its magnitude and characteristics depend on sectoral and technological conditions.

Circular upgrading → skill transformation. Movement from basic recycling towards remanufacturing, eco-design and advanced circular manufacturing increases demand for technical, engineering, digital and transversal competencies.

Circular business models → organisational transformation. Product–service systems, reverse logistics and digitally mediated circular services reshape organisational structures, occupational tasks and potentially employment relationships.

Structural and institutional conditions → employment quality and transition capacity. Human capital, innovation, education and training systems, regional characteristics and labour-market institutions determine whether circular transformation generates productive and inclusive employment.

On this basis, three research expectations are formulated:

H1. Improvements in circular-economy performance are positively associated with the expansion of employment in circular-economy activities.

H2. Improvements in resource productivity are expected to be more closely associated with higher-value circular employment than increases in basic recycling activity.

H3. The employment benefits associated with circular transition are conditioned by human-capital availability, technological capability and the capacity of firms and workers to adapt to changing skill requirements.

These propositions are conceptual research expectations rather than causal hypotheses tested econometrically. Given the limited number of benchmark observations, the empirical analysis assesses whether the descriptive patterns observed for Romania during 2014–2024 are consistent with the relationships identified in the literature.

The analytical logic can therefore be summarised as:

Circular-economy development → reuse, repair, recycling, remanufacturing and resource efficiency → changes in labour demand → occupational and skill transformation → employment quantity and quality, while skills, innovation, digitalisation, institutions and regional conditions act as enabling or constraining factors.

This framework allows Romania's circular transition to be assessed not only in terms of employment growth, but also according to whether it supports a shift towards higher-value activities capable of improving resource efficiency, productivity, technological upgrading and sustainable employment.

3. DATA AND METHODOLOGY

3.1. Research design

The empirical analysis adopts a quantitative, descriptive and comparative design to examine selected circular-economy and labour-market indicators in Romania during 2014–2024. Romania is benchmarked against the EU-27 to distinguish domestic improvement from relative convergence. Because the dataset contains four benchmark observations—2014, 2018, 2021 and 2024—for each indicator, the study identifies temporal patterns, structural differences and associations rather than causal effects.

The period captures major changes in the European and Romanian circular-economy policy framework, including the 2020 Circular Economy Action Plan and Romania's national strategy and action plan (European Commission, 2020; Government of Romania, 2022, 2023). The analysis proceeds in three stages: indicator trends are compared for Romania and the EU-27; descriptive statistics are calculated; and absolute gaps and relative performance measures are used to assess convergence or divergence.

3.2. Data sources

The empirical analysis uses secondary statistical data compiled from European and international sources. Eurostat is the principal statistical reference because it provides harmonised indicators for EU Member States and the EU aggregate, while European Commission and EEA publications provide policy and institutional context. OECD and World Bank materials are used primarily to support the discussion of green employment, skills, productivity and labour-market adjustment (Eurostat, 2024a, 2024b; European Commission, 2024; EEA, 2024; OECD, 2023a, 2023b, 2024; World Bank, 2023a, 2023b).

The use of harmonised secondary data improves comparability and reproducibility, although circularity remains multidimensional and cannot be represented by a single measure. Five complementary indicators are therefore used to capture material circularity, resource efficiency and labour-market participation.

3.3. Selection and operationalisation of indicators

The circular material use rate (CMUR) measures the share of recycled materials in overall material use and is expressed as CMUR = Circular use of materials / Overall material use × 100. The municipal waste recycling rate (MWRR) represents the proportion of municipal waste recycled: MWRR = Recycled municipal waste / Total municipal waste × 100. These indicators capture complementary dimensions of material recovery and reintegration, although recycling alone should not be treated as synonymous with circularity.

Resource productivity (RP) measures economic value generated relative to domestic material consumption and is expressed as RP = Gross domestic product / Domestic material consumption (EUR/kg). Higher values indicate greater efficiency in transforming material inputs into economic output and can be associated with more advanced forms of circular upgrading.

The labour-market dimension is captured by circular-sector employment (CES), expressed as CES = Employment in circular sectors / Total employment × 100, and by the employment share associated with repair and reuse. The latter provides a more specific indication of value-retention activities that extend product lifetimes and support locally embedded technical and service employment. These aggregate measures do not directly capture wages, occupational status, job quality or technological sophistication and are therefore interpreted together with the material and productivity indicators.

3.4. Analytical methods

The empirical analysis relies on benchmark-year trend analysis, descriptive statistics and EU benchmarking. For each indicator, the arithmetic mean is calculated as $\bar{x} = \Sigma x_i/n$ ($n = 4$), while variability is assessed using the sample standard deviation, $s = \sqrt{[\Sigma(x_i - \bar{x})^2/(n - 1)]}$. Long-term progress is measured as $\Delta\% = [(X_{2024} - X_{2014})/X_{2014}] \times 100$.

Convergence is assessed through the 2024 absolute gap, $Gap_{2024} = XEU_{,2024} - XRO_{,2024}$, and relative performance, $(XRO_{,2024}/XEU_{,2024}) \times 100$. A value approaching 100% indicates greater proximity to the EU benchmark. Percentage changes from low initial values are interpreted cautiously.

The indicators are interpreted within an integrated sequence linking material circularity, resource efficiency and employment. The analysis does not assume that circularity mechanically causes employment change; rather, it evaluates whether the observed trajectories are consistent with the relationships identified in the literature. A stronger employment trajectory than material circularity or resource productivity may be consistent with concentration in labour-intensive, lower-productivity activities, whereas simultaneous improvements in employment and productivity would be more consistent with qualitative upgrading.

3.5. Romania–EU comparative approach

The EU-27 is used as the principal benchmark because Romania's transition takes place within the common European regulatory and economic framework. Three outcomes are distinguished: convergence, when Romania improves and the gap narrows; parallel improvement without convergence, when both improve while the gap remains broadly unchanged; and divergence, when Romania's relative position deteriorates. This distinction prevents positive national growth rates from being interpreted automatically as successful convergence.

3.6. Methodological limitations and reproducibility

The principal limitation is the small number of benchmark observations. Four observations per indicator are appropriate for descriptive comparison but insufficient for robust multivariate time-series econometrics. Consequently, the findings are interpreted as descriptive evidence of patterns, gaps and associations rather than estimates of causal effects. A stronger econometric design would require annual data and preferably a larger country, regional or sectoral panel with controls for investment, innovation, skills, industrial structure and digitalisation.

A second limitation concerns measurement of circular employment. Aggregate indicators do not fully capture informal activity, occupational differences, wages, job security, working conditions or the distinction between lower- and higher-value circular occupations. In addition, the EU-27 is a policy and statistical benchmark rather than a structurally identical comparator. Nevertheless, the use of harmonised sources and transparent calculations allows the reported descriptive measures to be reproduced from the underlying data.

4. RESULTS

The results show gradual but uneven progress in Romania between 2014 and 2024. All five indicators improved, but convergence with the EU-27 remained limited, especially for material circularity and resource productivity. Employment-related indicators display a substantially stronger relative position than material-efficiency indicators, pointing to an asymmetric transition.

Table 1 indicates that Romania improved across all five circular-economy and employment indicators between 2014 and 2024, although substantial gaps relative to the EU-27 persisted. The weakest performance is observed in **circular material use and resource productivity**. Romania's circular material use rate increased only marginally, from 1.3% to

1.6%, compared with 11.4% to 11.8% in the EU-27, while resource productivity rose from EUR 0.32/kg to EUR 0.38/kg, remaining far below the EU level of EUR 2.50/kg in 2024. Municipal waste recycling followed a more consistent upward trajectory, increasing from 13% to 17%, although the gap with the EU-27 remained substantial as the European rate increased from 43% to 52%.

Table 1. Circular economy and employment indicators: Romania vs EU-27, selected years

Indicator	2014 RO	2014 EU	2018 RO	2018 EU	2021 RO	2021 EU	2024 RO	2024 EU
Circular material use rate (%)	1.30	11.4	1.50	11.7	1.30	11.5	1.60	11.8
Municipal waste recycling rate (%)	13	43	14	47	15	49	17	52
Resource productivity (EUR/kg)	0.32	2.00	0.34	2.20	0.36	2.40	0.38	2.50
Employment in circular sectors (% total employment)	1.10	1.70	1.20	1.80	1.30	1.90	1.40	2.10
Repair & reuse employment share (%)	0.30	0.60	0.40	0.70	0.40	0.80	0.50	0.90

Source: Author's compilation based on Eurostat (2024a, 2024b) and European Commission (2024).

Employment indicators show a comparatively more favourable evolution. Circular-sector employment increased steadily from 1.1% to 1.4% of total employment in Romania, while repair and reuse employment rose from 0.3% to 0.5%. Although both indicators remained below EU-27 levels, the relative employment gap was considerably smaller than the gaps observed for material circularity and resource productivity.

Overall, the table reveals a **structurally uneven transition**: Romania has made gradual progress, but employment-related indicators are closer to EU-27 levels than material-efficiency indicators. This asymmetry suggests that circular employment is developing faster than improvements in material circularity and resource productivity. However, given the aggregate nature of the data, this pattern should be interpreted as an indication of the structure of Romania's circular transition rather than direct evidence that employment is concentrated in lower-productivity activities.

Table 2 confirms the persistent and uneven nature of Romania's convergence towards EU-27 circular-economy performance. The largest disparities are observed in circular material use and resource productivity. Over the analysed period, Romania recorded an average circular material use rate of only 1.43%, compared with 11.60% in the EU-27, while average resource productivity was EUR 0.35/kg, substantially below the EU average of EUR 2.27/kg. Despite positive changes between 2014 and 2024, Romania reached only 13.6% of the EU benchmark for circular material use and 15.2% for resource productivity in 2024.

Municipal waste recycling shows stronger progress, increasing by 30.8% over the period. Nevertheless, Romania reached only 32.7% of the EU-27 level in 2024, with a gap of 35 percentage points. This indicates that domestic improvement has not been sufficient to achieve substantial convergence in waste-management performance.

Table 2. Descriptive statistics and Romania–EU convergence indicators

Indicator	RO mean	EU mean	RO SD	2014–2024 RO change (%)	2024 gap (EU–RO)	RO/EU in 2024 (%)
Circular material use rate (%)	1.43	11.60	0.15	23.1	10.20	13.6
Municipal waste recycling rate (%)	14.75	47.75	1.71	30.8	35.00	32.7
Resource productivity (EUR/kg)	0.35	2.27	0.03	18.8	2.12	15.2
Employment in circular sectors (% total employment)	1.25	1.88	0.13	27.3	0.70	66.7
Repair & reuse employment share (%)	0.40	0.75	0.08	66.7	0.40	55.6

Note: Means and sample standard deviations are calculated from the four benchmark years. Percentage change compares 2024 with 2014. The 2024 gap is expressed in the original unit of each indicator.

Source: Author's calculations based on Table 1.

A different pattern emerges for the employment indicators. Circular-sector employment increased by 27.3% and reached 66.7% of the EU benchmark in 2024, while repair and reuse employment recorded the largest relative increase (66.7%) and reached 55.6% of the EU level. These results indicate that Romania is considerably closer to EU performance in labour-market participation than in material circularity and resource efficiency.

Overall, the relative performance in 2024 follows a clear hierarchy: **circular-sector employment (66.7%) > repair and reuse employment (55.6%) > municipal waste recycling (32.7%) > resource productivity (15.2%) > circular material use (13.6%)**. This pattern reinforces the main empirical finding of the study: Romania's circular transition is progressing more rapidly in employment terms than in material efficiency and value creation. However, this divergence should be interpreted cautiously, as the aggregate indicators do not directly identify the productivity, occupational structure or quality of circular employment.

4.1. Circularity and resource efficiency

Romania's circular material use rate remained persistently low, increasing from 1.3% in 2014 to 1.6% in 2024. The average was 1.43%, compared with 11.60% for the EU-27, and Romania reached only 13.6% of the EU benchmark in 2024. The limited variation across benchmark years suggests stability around a structurally weak level rather than sustained acceleration, pointing to limited reintegration of secondary materials into production.

Municipal waste recycling improved more consistently, from 13% in 2014 to 17% in 2024, a 30.8% increase. However, the EU-27 rose from 43% to 52%, widening the absolute gap from 30 to 35 percentage points. Romania therefore achieved domestic progress without substantial convergence and reached only 32.7% of the EU benchmark in 2024.

Resource productivity increased steadily from EUR 0.32/kg to EUR 0.38/kg, but the EU-27 rose from EUR 2.00/kg to EUR 2.50/kg. Romania reached only 15.2% of the EU benchmark in 2024, while the absolute gap widened to EUR 2.12/kg. This persistent difference indicates that the economy continues to generate considerably less value per unit of material consumed and that the circular transition has not yet produced substantial material-efficiency gains.

4.2. Employment dynamics

Circular-sector employment increased from 1.1% of total employment in 2014 to 1.4% in 2024, representing cumulative growth of 27.3%. Although the absolute gap with the EU-27 increased slightly from 0.6 to 0.7 percentage points, Romania reached 66.7% of the EU benchmark in 2024. This relative position is substantially stronger than for circular material use, resource productivity or municipal recycling.

Repair and reuse employment increased from 0.3% to 0.5% of total employment, the strongest proportional growth among the Romanian indicators (66.7%), although the absolute change was only 0.2 percentage points. Romania reached 55.6% of the EU benchmark in 2024. The expansion of these activities is relevant because they extend product lifetimes and support locally embedded technical and service employment, but the indicator does not by itself demonstrate improvements in wages, productivity or job quality.

4.3. Structural interpretation and research expectations

The 2024 relative-performance ranking is clear: circular-sector employment (66.7%) > repair and reuse employment (55.6%) > municipal waste recycling (32.7%) > resource productivity (15.2%) > circular material use (13.6%). Romania is therefore considerably closer to EU performance in employment than in the underlying material and productivity dimensions of circularity.

This asymmetry is consistent with a transition in which employment expands partly through labour-intensive activities such as collection, sorting, basic recycling, repair and maintenance. However, the indicators do not directly identify occupational composition, and this interpretation should not be treated as a demonstrated causal result. More detailed sectoral and occupational data would be required to determine the extent to which employment is concentrated in lower- or higher-value circular activities.

The findings are broadly consistent with H1 because circular-performance and employment indicators improved in the same direction, although the relationship is neither proportional nor causal. H2 receives indirect support from the large divergence between resource productivity and circular employment, which is consistent with the possibility that employment growth has not yet been matched by qualitative upgrading. H3 cannot be tested statistically because human capital, innovation and technological capability are not directly measured, but these factors remain relevant to interpreting Romania’s structural gaps.

5. DISCUSSION

The central empirical finding is not simply that circular employment increased, but that it developed more rapidly relative to the EU benchmark than material circularity and resource productivity. This distinction matters because employment-intensive circularisation and productivity-enhancing circularisation are not equivalent. Romania’s pattern is consistent with an early-stage transition in which essential activities such as collection, sorting, recycling, maintenance and repair expand before more technologically sophisticated value-retention activities reach comparable scale.

The literature suggests that a more mature circular economy relies increasingly on repair, refurbishment, remanufacturing, eco-design, industrial symbiosis and advanced secondary-material processing, which preserve more embedded value and require more specialised competencies (Andersen et al., 2024; Yang & Sun, 2024). Romania’s weak resource-productivity performance therefore strengthens the case for policies that connect circularity with industrial upgrading rather than treating waste management as the principal measure of transition.

Digitalisation can support this shift by improving traceability, predictive maintenance, reverse logistics and secondary-material management. Industry 4.0 technologies may therefore complement remanufacturing and other advanced circular activities while increasing demand for engineering, diagnostics, data-management and advanced-maintenance skills (Sahoo & Jakhar, 2024). The circular and digital transitions should consequently be treated as mutually reinforcing components of industrial policy.

Human capital is equally important. Circular manufacturing requires technical, digital and transversal competencies, implying a need for both upskilling and reskilling (Beducci et al., 2024). Vocational education and training can incorporate repair technologies, refurbishment, resource-efficient production, reverse logistics and digital diagnostics, while universities can strengthen circular design, lifecycle analysis and sustainable business-model competencies. Lifelong learning is particularly important for workers already employed in material-intensive or technologically changing sectors.

The social dimension also requires attention to job quality. Growth in circular employment should not automatically be interpreted as growth in high-quality green employment, because activities differ in wages, productivity, occupational risks, contractual stability and career opportunities. A just transition therefore requires policies that combine job creation with training, occupational safety, social protection and mobility towards more productive activities.

SMEs and regional ecosystems are important channels for implementation. Repair, reuse, maintenance and refurbishment are often performed by smaller firms, which may face constraints in finance, technology and specialised labour. Targeted financial support, technical assistance and innovation networks could strengthen their participation in circular value chains. Regional policy should also reflect local specialisation: industrial regions may support remanufacturing and industrial symbiosis, urban areas repair and circular logistics, and agricultural regions circular bioeconomy activities.

Overall, the results point to a two-speed transition in which employment has advanced more rapidly than material circularity and resource productivity. The policy challenge is therefore to use the existing circular employment base as a platform for higher-value development by linking environmental objectives with innovation, digitalisation, skills and job quality.

6. CONCLUSIONS

This study examined the relationship between circular-economy development and labour-market change in Romania during 2014–2024, using the EU-27 as a benchmark. All five indicators improved, confirming gradual progress, but convergence remained limited and uneven. The largest gaps were recorded for circular material use and resource productivity, while employment indicators displayed a substantially stronger relative position.

In 2024, Romania reached 66.7% of the EU benchmark for circular-sector employment and 55.6% for repair and reuse employment, compared with 32.7% for municipal recycling, 15.2% for resource productivity and 13.6% for circular material use. This asymmetry suggests that employment expansion has preceded the deeper transformation of material flows and productive efficiency. It is consistent with, but does not directly prove, a concentration of employment in relatively labour-intensive circular activities.

The main policy implication is that Romania should move beyond a predominantly waste-oriented model towards value-retention activities such as advanced repair, refurbishment, remanufacturing, eco-design, industrial symbiosis and secondary-material innovation. Such a shift requires stronger integration of circular-economy policy with industrial development, digitalisation, innovation and human-capital policies.

The study is limited by the small number of benchmark observations and by aggregate employment measures that do not capture occupational composition, wages or job quality. Future research should use annual, sectoral, regional or cross-country panel data and incorporate variables related to skills, innovation, investment and digitalisation. This would allow the relationships identified descriptively here to be tested more rigorously and would provide a stronger basis for evaluating the quality as well as the quantity of circular employment.

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