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The impact of circular economy measures on labour productivity in EU industry

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Abstract

The transition toward a circular economy has become a strategic priority for the European Union, particularly within the industrial sector, which is characterized by intensive resource consumption and high environmental impact. This study examines the impact of circular economy measures on labour productivity in EU industry using panel data for EU Member States covering the period 2016-2024. Labour productivity is measured as the ratio of industrial production to labour input, while circular economy performance is assessed using four indicators: circular material use rate, resource productivity, municipal waste recycling rate, and the eco-innovation index. A logarithmic panel regression model is applied to evaluate the relationship between circular economy indicators and industrial productivity. The results indicate that while municipal waste recycling positively affects labour productivity, resource productivity demonstrates a statistically non-significant relationship with industrial efficiency. In contrast, the eco-innovation index demonstrates a negative relationship with labour productivity, implying that the implementation of eco-innovative practices may generate short-term adjustment costs for firms. The findings highlight the complex economic effects of the circular economy transition and suggest that while certain circular economy measures enhance industrial productivity, others may require longer adaptation periods before generating measurable economic benefits. The study contributes to the growing literature on the relationship between sustainability and industrial performance in the European Union.

Keywords: circular economy, labour productivity, eco-innovation, resource productivity, recycling rate, EU industry, sustainable development.

1. Introduction

The transition from a linear take–make–dispose industrial model to a circular economy (CE) has become a strategic priority for the European Union, aiming to ensure long-term sustainability and competitiveness. A central principle of the circular economy is the retention of material value within closed-loop systems, seeking to decouple economic growth from resource consumption while reducing environmental pressures (Winans et al., 2017). As global resource constraints intensify and climate objectives become more ambitious, the ability of the industrial sector to maintain high productivity while adopting circular practices has become a

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critical area of both scientific and policy interest (Heshmati, 2017; Merli et al., 2018; Blackburn et al., 2026).

The Circular Economy Action Plan, a key component of the European Green Deal, provides a comprehensive framework for promoting sustainable production and consumption within the EU (European Commission, 2020). By targeting resource-intensive sectors such as electronics, plastics, and textiles, the policy aims to enhance resource efficiency and foster more sustainable industrial development. However, the transition towards circularity requires significant adjustments in production processes, which may influence traditional indicators of industrial performance, particularly labour productivity.

Although the environmental benefits of circular economy practices are well established, their economic implications, especially in terms of productivity, remain less clear. Innovation plays a crucial role in this transition, as highlighted in the European Innovation Scoreboard, where innovation performance is identified as a key factor enabling economies to adapt to circular models (European Commission, 2023). The integration of eco-innovations is essential for improving resource efficiency and developing new value creation processes without compromising economic output.

Therefore, understanding the relationship between circular economy indicators, such as circular material use and resource productivity, and labour productivity is essential for evaluating the effectiveness of EU industrial policies. This study aims to assess the impact of circular economy measures on labour productivity in the EU industrial sector using data from 2016 up to 2024. The analysis focuses on key circularity indicators and examines their influence on industrial efficiency across EU Member States.

2. Literature review

The CE has been increasingly analysed as a pathway towards sustainable economic development, with a particular focus on improving resource efficiency and reducing environmental impact. Ghisellini, Cialani, and Ulgiati (2016) define the circular economy as a system aimed at minimizing resource inputs and waste generation by closing material loops. Similarly, Winans, Kendall, and Deng (2017) emphasize that circular economy models seek to decouple economic growth from resource consumption.

In this study, labour productivity is measured using production in industry relative to labour input, reflecting the amount of industrial output generated per unit of labour. According to Eurostat (2026), production-based indicators are widely used to evaluate industrial performance and efficiency across EU Member States.

In industrial economics, production-based indicators are frequently used to assess sectoral productivity and performance, particularly in manufacturing and resource-intensive industries. According to Eurostat (2026), industrial production indices provide a reliable measure of changes in industrial output and are commonly applied in comparative analyses across EU Member States. Similarly, Syverson

(2011) highlights that production-oriented measures are useful for evaluating efficiency differences between industries and economies, especially when examining technological progress and resource allocation.

The focus on the industrial sector is particularly relevant in the context of the circular economy. Industry is one of the largest consumers of raw materials and energy within the European Union, making it highly sensitive to changes in resource availability and efficiency. As a result, the implementation of circular economy practices is expected to have a more pronounced impact on productivity in industry compared to less resource-intensive sectors, such as services. Improvements in material efficiency and waste reduction can directly influence production processes, costs, and output levels in industrial activities.

Empirical research suggests that resource productivity plays an important role in enhancing economic performance. Meyer (2011) finds that higher resource productivity is associated with increased economic efficiency in European economies. This indicates that more efficient use of materials can contribute to higher output per worker, thereby improving labour productivity.

In addition, circular economy practices such as recycling and material reuse have been linked to improvements in economic efficiency. Wijkman and Skånberg (2015) demonstrate that higher recycling rates can reduce production costs and support the development of secondary raw material markets. These effects are particularly relevant in industry, where material inputs represent a significant share of total production costs.

The role of circular material use (CMU) has also been emphasized in literature. Increasing the share of secondary raw materials reduces dependence on primary resources and improves resource efficiency (Ghisellini et al., 2016). This, in turn, may positively influence labour productivity by enabling more efficient and cost-effective production processes.

Furthermore, eco-innovation is recognized as a key driver of both circular economy adoption and productivity growth. Cainelli, De Marchi, and Grandinetti (2015) find that firms engaging in eco-innovation tend to achieve higher productivity levels. In addition to improving efficiency, eco-innovations help firms comply with increasingly stringent environmental regulations within the European Union, reducing the risk of penalties and enhancing overall competitiveness. As highlighted by the European Commission (2023), eco-innovation supports the development of sustainable technologies and production processes, which are essential for maintaining industrial performance in a regulatory-intensive environment.

Despite these insights, the relationship between circular economy indicators and labour productivity in the industrial sector remains insufficiently explored at the macroeconomic level. Therefore, this study contributes to the literature by examining how circular economy measures-such as circular material use, resource productivity, recycling rates, and eco-innovation-affect labour productivity across EU Member States.

3. Methods

This study applies a quantitative research approach to examine the impact of circular economy measures on labour productivity in the European Union industrial sector. The analysis is based on panel data covering EU Member States and the period 2016-2024, depending on data availability. The panel structure enables the assessment of both cross-country differences and time dynamics, allowing for a more comprehensive evaluation of the relationship between circular economy indicators and productivity.

Labour productivity (LP) is used as the dependent variable and is measured as the production in industry relative to labour input. This indicator reflects the efficiency of labour utilization and is widely used to assess industrial performance. In line with the literature, productivity is assumed to be influenced not only by traditional production factors but also by resource efficiency and innovation.

Labour productivity (LP) is used as the dependent variable and is operationalized as a volume index, measured as the ratio of the industrial production index (2021=100) to the labour input index (total hours worked, 2021=100) within the manufacturing and industrial sectors:

$$LP_{it} = \frac{Industrial\ Poduction\ Index_{it}}{Hours\ Worked\ Index_{it}} \times 100. \quad (1)$$

This volume-index approach reflects the real efficiency of labour utilization and is the standard metric used by Eurostat for short-term industrial performance evaluation, as it filters out price fluctuations and country-size distortions. In line with the literature, productivity is assumed to be influenced not only by traditional production factors but also by resource efficiency and innovation.

To capture the multidimensional nature of the circular economy, four key explanatory variables are included in the analysis: circular material use rate (CMU), resource productivity (RP), municipal waste recycling rate (WR), and the eco-innovation index (EI). These indicators reflect different aspects of circular economy implementation, including material reuse, resource efficiency, waste management, and innovation capacity.

Based on the theoretical and empirical literature, the following hypotheses are proposed:

H1: A higher circular material use rate contributes to more efficient production processes and positively affects labour productivity.

H2: Higher resource productivity is expected to increase output per unit of input, leading to improved labour productivity.

H3: The municipal waste recycling rate is expected to have a positive effect on productivity in the long run by improving resource stability, although it may increase operational costs in the short term.

H4: Eco-innovation is expected to enhance technological progress and production efficiency, thereby positively influencing labour productivity.

To test these hypotheses, the following panel regression model is applied:

$$\ln LP_{it} = \beta_0 + \beta_1 \ln CMU_{it} + \beta_2 \ln RP_{it} + \beta_3 \ln WR_{it} + \beta_4 \ln EI_{it} + \varepsilon_{it}, \quad (2)$$

where LP_{it} represents labour productivity index for country i at time t; CMU_{it} is the circular material use rate; RP_{it} is resource productivity; WR_{it} is the municipal waste recycling rate; EI_{it} is the eco-innovation index; ε_{it} is the idiosyncratic error term.

The logarithmic transformation is applied to reduce heteroskedasticity, improve normality, and allow the estimated coefficients to be interpreted as elasticities. The coefficients (β) indicate the percentage change in labour productivity associated with a one percent change in the explanatory variables.

The empirical analysis is conducted using a pooled panel data regression model (Pooled OLS). To ensure the statistical validity and consistency of the estimated coefficients, comprehensive post-estimation diagnostics are performed. Multicollinearity across the circular economy indicators is evaluated using Variance Inflation Factors (VIF), while the independence of the error terms is verified through autocorrelation testing.

Despite the strengths of the methodology, several limitations should be acknowledged. The analysis is constrained by data availability across EU Member States and potential endogeneity between variables. In addition, due to the specific focus on circularity indicators, the model does not include certain macroeconomic control variables-such as gross fixed capital investment or industrial energy prices-which may also influence labour productivity. Finally, the use of aggregated macroeconomic and sector-level indicators may not fully capture firm-level dynamics within the industrial sector.

4. Results

To examine the impact of circular economy indicators on labour productivity in the EU industrial sector, a pooled OLS regression model was estimated (Table 1) using panel data from EU Member States. The dependent variable was the logarithm of the labour productivity index (ln_lpindex), while the explanatory variables included the circular material use rate (CMU), resource productivity (RP), municipal waste recycling rate (WR), and the eco-innovation index (EI).

The overall regression model was statistically significant ($F = 7.609$, $p < 0.001$), indicating that the selected circular economy indicators jointly explain changes in labour productivity. The coefficient of determination ($R^2 = 0.116$) shows that approximately 11.6% of the variation in labour productivity is explained by the variables included in the model. Although the explanatory power is relatively moderate, such results are common in macroeconomic and panel-data studies, where labour productivity is influenced by a broad range of structural, institutional, and economic factors not fully captured within a single model. The adjusted R^2value of 0.101 confirms that the explanatory variables retain their relevance even after adjusting for the number of predictors included in the regression.

Table 1
Regression results

Variable	Coefficient	t-value	p-value
ln_indexEI	-0.067	-3.171	0.002
ln_CMU	0.001	0.076	0.939
ln_RP	-0.024	-1.925	0.055
ln_WR	0.058	3.819	0.000

Source: designed by the author

The Durbin–Watson statistic was 1.785, suggesting that there is no serious autocorrelation problem in the residuals and that the estimated coefficients can be considered reliable. Furthermore, multicollinearity diagnostics demonstrated acceptable Variance Inflation Factor (VIF) values ranging from 1.544 to 2.186, which are well below the critical threshold of 5. Therefore, no serious multicollinearity issues were identified among the explanatory variables.

The regression results revealed that the eco-innovation index (EI) had a statistically significant negative effect on labour productivity (B=−0.067, p=0.002). This finding indicates that a 1% increase in the eco-innovation index is associated with an approximately 0.067% decrease in labour productivity, holding other variables constant. Consequently, hypothesis H4, which proposed that eco-innovation positively affects labour productivity, was not supported. Although previous literature often associates eco-innovation with efficiency improvements and technological advancement, the negative relationship identified in this study may reflect the short-term adjustment costs related to the implementation of sustainable technologies and production processes. Firms adopting eco-innovations may initially experience higher investment costs, organizational restructuring, employee training requirements, or temporary production inefficiencies before long-term productivity benefits emerge.

The circular material use rate (CMU) showed a positive but statistically insignificant relationship with labour productivity ($B = 0.001$, $p = 0.939$). Therefore, hypothesis H1 was not supported. This result suggests that increasing the share of recycled and reused materials in industrial production does not necessarily generate immediate productivity improvements at the macroeconomic level. One possible explanation is that the benefits of circular material use may emerge gradually over time and may depend on the technological readiness and industrial structure of individual EU Member States.

Resource productivity (RP) demonstrated a negative and marginally insignificant effect on labour productivity ($B = -0.024$, $p = 0.055$). Although the result was close to the conventional 5% significance threshold, hypothesis H2 was not supported. The negative coefficient may indicate that improvements in resource productivity are accompanied by short-term restructuring costs or efficiency trade-offs during the transition toward more sustainable production systems. In some industries, increasing resource efficiency may require substantial technological adaptation and process optimization, which can temporarily reduce labour productivity.

In contrast, the municipal waste recycling rate (WR) had a positive and statistically significant effect on labour productivity ($B = 0.058$, $p < 0.001$). This result implies that a 1% increase in the recycling rate is associated with an approximately 0.058% increase in labour productivity. Therefore, hypothesis H3 was supported. The findings suggest that more effective waste management and recycling systems contribute positively to industrial efficiency by improving resource availability, reducing material waste, and supporting more stable production processes. This result is consistent with previous studies emphasizing the economic benefits of recycling and secondary raw material utilization within circular economy systems.

Overall, the results indicate that not all circular economy indicators affect labour productivity in the same way. Among the analysed variables, the recycling rate emerged as the strongest positive determinant of labour productivity, while eco-innovation displayed a significant but negative short-term relationship with productivity. These findings highlight the complexity of the transition toward a circular economy and suggest that some circular practices may require longer periods before their economic benefits become fully visible.

5. Discussion

The results of this study indicate that circular economy measures affect labour productivity differently across the EU industrial sector. The positive and statistically significant effect of the municipal waste recycling rate suggests that improved recycling systems may enhance industrial efficiency by reducing material dependency and supporting more stable production processes. This finding is consistent with the research of Wijkman and Skånberg (2015), who argue that recycling and secondary raw material markets can contribute to economic efficiency and lower production costs.

In contrast, the eco-innovation index showed a statistically significant negative relationship with labour productivity. Although previous studies often emphasize the positive role of eco-innovation in improving competitiveness and efficiency (Cainelli et al., 2015), the results of this study suggest that eco-innovation may initially create additional adjustment and investment costs for firms. Therefore, the productivity benefits of sustainable technologies may become visible only in the longer term.

The effects of circular material use and resource productivity were statistically insignificant. This may indicate that the economic benefits of material circularity are not immediate and depend on factors such as technological readiness, industrial structure, and the level of circular economy implementation within individual EU Member States. Similar arguments are highlighted by Ghisellini et al. (2016), who note that the transition toward circular production systems is a gradual and complex process.

Overall, the findings suggest that while certain circular economy practices, particularly recycling activities, can positively contribute to industrial productivity, other measures may require longer adaptation periods before generating measurable economic benefits.

6. Conclusions

This study examined the impact of circular economy measures on labour productivity in the industrial sector of European Union Member States during the period 2016-2024. The analysis focused on four key circular economy indicators: circular material use rate, resource productivity, municipal waste recycling rate, and the eco-innovation index. Using a logarithmic panel regression model, the study evaluated how these indicators influence industrial productivity.

The empirical results revealed that among the analysed indicators, municipal waste recycling has a statistically significant positive effect on labour productivity, indicating that effective waste management and robust secondary material structures directly improve industrial performance. Similarly, the circular material use rate showed a positive but statistically insignificant effect, indicating that increasing the share of secondary raw materials does not yield immediate macroeconomic productivity shifts. Conversely, resource productivity demonstrated a negative and marginally insignificant relationship with labour productivity, suggesting that macro-level material efficiency improvements do not automatically translate into immediate hourly output gains and may involve short-term restructuring trade-offs.

In contrast, the eco-innovation index showed a negative relationship with labour productivity. This result may reflect the short-term costs associated with implementing eco-innovative technologies, adapting production systems, and complying with environmental regulations. Although eco-innovation is expected to generate long-term benefits, the findings indicate that the transition process may temporarily reduce productivity growth in some industries.

Overall, the study confirms that the relationship between circular economy measures and industrial productivity is complex and multidimensional. The findings suggest that policy measures promoting resource efficiency and recycling may strengthen industrial competitiveness in the European Union. However, additional support mechanisms may be necessary to help firms manage the transition costs associated with eco-innovation and sustainable production practices.

Despite the contribution of the study, several limitations should be acknowledged. The analysis was constrained by data availability across EU Member States and the use of aggregated macroeconomic indicators. Future research could expand the analysis by including firm-level data, additional control variables, or sector-specific comparisons to provide a more detailed understanding of the relationship between circular economy implementation and productivity performance.

References

Blackburn, O., Ritala, P., Keränen, J., & Bocken, N. (2026). Circular economy platforms: A systematic review. *Business Strategy and the Environment*, *35*(2), 2810-2841.

Cainelli G, De Marchi V, Grandinetti R. (2015) Does the development of environmental innovation require different resources? Evidence from Spanish manufacturing firms. *Journal of Cleaner Production*. https://doi.org/10.1016/j.jclepro.2015.02.008.

European Commission. (2020). A new Circular Economy Action Plan: For a cleaner and more competitive Europe. https://rcbc.ca/wp-content/uploads/2022/08/EU-European-Union-Circular-Economy-Action-Plan-2020.pdf

European Commission. (2020). Changing how we produce and consume: New Circular Economy Action Plan. https://www.statistiques.developpement-durable.gouv.fr/media/4636/download?inline

European Commission. (2023). European innovation scoreboard 2023 – Main report. https://research-and-innovation.ec.europa.eu/knowledge-publications-tools-and-data/publications/all-publications/european-innovation-scoreboard-2023_en

European Commission. (2024). European Innovation Scoreboard 2024: Eco-innovation index. https://projects.research-and-innovation.ec.europa.eu/en/statistics/performance-indicators/european-innovation-scoreboard/eis-2024#/

European Environment Agency. (2024). Key figures on European business. Retrieved from https://www.efta.int/sites/default/files/uploads/2025-03/key%20figures%20on%20european%20business-KSET24001ENN.pdf

Eurostat. (2026). Database. https://ec.europa.eu/eurostat/data/database

Ghisellini, P., Cialani, C., & Ulgiati, S. (2016). A review on circular economy: The expected transition to a balanced interplay of environmental and economic systems. *Journal of Cleaner Production, 114*, 11–32. https://doi.org/10.1016/j.jclepro.2015.09.007

Heshmati, A. (2017). A review of the circular economy and its implementation. *International Journal of Green Economics*, *11*(3-4), 251-288.

Merli, R., Preziosi, M., & Acampora, A. (2018). How do scholars approach the circular economy? A systematic literature review. *Journal of cleaner production*, *178*, 703-722.

Meyer, B. (2011). Macroeconomic modelling of sustainable development and the links between the economy and the environment. GWS Research Report. https://papers.gws-os.com/gws-researchreport12-1.pdf

Syverson, C. (2011). What determines productivity? *Journal of Economic Literature, 49*(2), 326–365.

Wijkman, A., & Skånberg, K. (2015). The circular economy and benefits for society. Retrieved from https://wijkman.se/wp-content/uploads/2015/05/The-Circular-Economy-and-Benefits-for-Society.pdf

Winans, K., Kendall, A., & Deng, H. (2017). The history and current applications of the circular economy concept. *Renewable and Sustainable Energy Reviews, 68*, 825–833. https://doi.org/10.1016/j.rser.2016.09.123

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