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Circular economy practices and their effect on corporate financial performance

Abstract. In this study, we investigate the relationship between circular economy (CE) practices and financial performance in European manufacturing firms. A longitudinal analysis of 200 companies from 2018 to 2022 was conducted using a custom Circular Economy Index (CEI) and various financial metrics. Panel data regression analysis revealed a positive, statistically significant relationship between CEI and financial performance. A one-point increase in CEI was associated with increases of 0.152 percentage points in ROI, 0.087 in Gross Profit Margin, 0.063 in Net Profit Margin, and 0.203 in Total Shareholder Return. Lag analysis showed this relationship strengthened over time, with the effect on ROI increasing from 0.152 (no lag) to 0.225 (3-year lag). Slight diminishing returns were observed at very high levels of circular economy implementation. Subgroup analysis indicated stronger effects for larger firms, high-tech manufacturers, and companies in Northern Europe. Brand value and operational efficiency were identified as partial mediators. These findings provide robust evidence supporting the business case for circular economy transitions in manufacturing, with implications for managerial decision-making and policy development in sustainable manufacturing.

Keywords: Circular Economy; Financial Performance; Manufacturing Sustainability; Panel Data Analysis; Corporate Strategy; Company; ROI; CEI; Northern Europe; Total Shareholder Return; TSR
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1. Introduction and Brief Literature Review

The concept of a circular economy has gained significant traction in recent years as a promising approach to address pressing environmental challenges. As global resource consumption continues to escalate and the negative impacts of linear economic models become increasingly apparent, businesses and policymakers are turning to circular economy principles as a means of reconciling economic growth with environmental sustainability (Macarthur & Heading, 2019). The circular economy model contrasts sharply with the traditional linear economy's «take-make-dispose» pattern. Instead, it promotes a restorative strategy that maximizes resource value and minimizes waste through various strategies such as design for longevity, reuse, remanufacturing, and recycling. The urgency of this transition is underscored by alarming statistics: the World Bank projects a 70% increase in global waste generation by 2050 under current trends, while the United Nations Environment Programme attributes roughly half of global greenhouse gas emissions and over 90% of global water stress and biodiversity decline to resource extraction and processing (Wysokińska, 2020; Ortiz & Marín, 2022).

While the environmental benefits of circular economy practices are well-documented, their impact on corporate financial performance remains a subject of debate. This intersection of environmental sustainability and financial viability is crucial, as it directly influences businesses' willingness to adopt circular economy principles. Proponents argue that circular practices can lead to increased competitiveness and profitability through reduced material costs, enhanced brand value, new revenue streams, and improved customer loyalty (Haar, 2024). The Ellen MacArthur Foundation estimated that adopting circular economy principles could add USD 1 trillion to the global economy by 2025 and create 100,000 new jobs within five years (Schulze, 2016). However, skeptics point to the substantial upfront investments required and potential disruption to existing business processes (Korhonen et al., 2018).

This research gap is significant, given the unique challenges and opportunities that CE implementation presents for manufacturers. Unlike some CSR initiatives that may be peripheral to core business operations, circular economy practices often require critical overhauls to business models, supply chain management, and product design (Awan & Sroufe, 2022). These changes can involve substantial initial costs and risks, making it crucial to understand their long-term financial implications.

This study aims to address this gap by conducting a longitudinal examination of the relationship between circular economy practices and financial performance in the European manufacturing sector. By focusing on a diverse sample of 200 firms over a five-year period, in this research we seek to provide a nuanced understanding of how different aspects of circular economy implementation affect various financial metrics, including return on investment, profit margins, and stock performance.

2. Methodology

This study employed a longitudinal design to investigate the relationship between circular economy practices and corporate financial performance in the European manufacturing sector from 2018 to 2022. The sample comprised 200 manufacturing firms, selected using stratified random sampling to ensure representation across geographic locations, firm sizes, and manufacturing subsectors.

To quantify circular economy practices, we developed a comprehensive CEI based on existing literature (Kristensen & Mosgaard, 2020; Macarthur & Heading, 2019). The CEI encompassed five main categories: design for circularity, resource efficiency and waste reduction, reuse and remanufacturing, recycling and material recovery, and circular business models. Data for these indicators were collected from sustainability reports, structured questionnaires, and third-party assessments. The CEI was calculated as a weighted average of the five categories, with weights determined through an Analytic Hierarchy Process involving 15 experts.

Financial performance was assessed using three key metrics: Return on Investment (ROI), profit margins (both gross and net), and Total Shareholder Return (TSR). Financial data were obtained from audited annual reports and financial databases, adjusted for inflation using the Harmonised Index of Consumer Prices for the Euro area. Control variables included firm size, industry subsector, R&D intensity, leverage ratio, market-to-book ratio, and country-specific factors. Data for these variables were sourced from company reports, financial databases, and international organizations. The analytical approach involved several stages. First, descriptive statistics and trend analysis were conducted for all variables. Panel data regression analysis was then employed to examine the relationship between financial performance and circular economy practices. The base model took the following form:

$$FP_{it} = \beta_0 + \beta_1 CEI_{it} + \beta_2 X_{it} + \alpha_i + \lambda_t + \varepsilon_{it}, \quad (1)$$

where:
FP_{it} is the financial performance metric;
CEI_{it} is the Circular Economy Index score;
X_{it} is a vector of control variables;
α_i is a firm-specific fixed effects;
λ_t captures time fixed effects;
ε_{it} is the error term.

Both fixed effects and random effects specifications were estimated, with the Hausman test (Agarwal & Ojha, 2024) used to determine the most appropriate approach.

Lag analysis was conducted to account for potential future impacts of circular economy practices on financial performance, testing lags of 1, 2, and 3 years. Nonlinear relationships were explored by including quadratic terms in the regression models. Subsample analyses were performed based on firm size, industry subsector, and geographic region to examine if circular economy practices have varying impacts depending on organizational attributes. Several robustness checks were conducted, including alternative specifications of the CEI, use of alternative financial performance metrics, addressing potential endogeneity through instrumental variable approaches and the Generalized Method of Moments (GMM) estimator, and sensitivity analyses excluding potential outliers. Finally, mediation analyses were performed to explore the mechanisms through which circular economy practices affect financial performance, considering factors such as brand value and operational efficiency as potential mediators. Potential moderating effects of firm and industry characteristics were also examined. Data management and statistical analyses were performed using Stata 17.0 and R 4.1.0. The AHP package in R was utilized for the Analytic Hierarchy Process.

3. Results

The sample demonstrated considerable variation in both circular economy implementation (as measured by CEI) and financial performance metrics. The mean CEI score of 62.7 (SD = 18.3) indicates that, on average, firms in our sample have implemented a moderate level of circular economy practices, with substantial room for improvement. Financial performance metrics also showed significant variability, reflecting the diverse nature of our sample in terms of firm size, industry subsector, and market conditions. Table 1 presents the descriptive statistics of main variables.

Analysis of trends in circular economy practices revealed a consistent increase in CEI scores over the study period. The average CEI score rose from 54.3 in 2018 to 71.2 in 2022, representing a compound annual growth rate (CAGR) of 7.0%. This trend suggests a growing adoption of circular economy practices among European manufacturers over the study period. Figure 1 illustrates this trend graphically.

Examination of financial performance trends revealed varied patterns over the study period. Notably, there was a general decline in 2019-2020, likely due to the global economic disruptions caused by the COVID-19 pandemic. However, a strong recovery is evident in the subsequent years, with all metrics showing positive growth in 2021-2022. Table 2 presents the year-on-year changes in key financial performance metrics.

The panel data regression analysis revealed a statistically significant and positive association between the CEI and all four financial performance metrics. Specifically, a one-point increase in

Table 1:
Descriptive Statistics of Key Variables (N = 1000, 200 firms over 5 years)

Variable	Mean	Std. Dev.	Min	Max
Circular Economy Index (CEI)	62.7	18.3	15.2	94.8
Return on Investment (ROI%)	11.5	7.2	-8.6	32.4
Gross Profit Margin (%)	38.2	12.6	10.5	68.7
Net Profit Margin (%)	8.7	5.4	-6.2	24.3
Total Shareholder Return (%)	13.2	22.6	-45.8	87.6
Firm Size (Total Assets, EUR M)	4.527	12.356	52	98.745
R&D Intensity (%)	4.3	3.1	0.2	18.6
Leverage Ratio	0.54	0.23	0.08	1.32

Source: Authors' own research

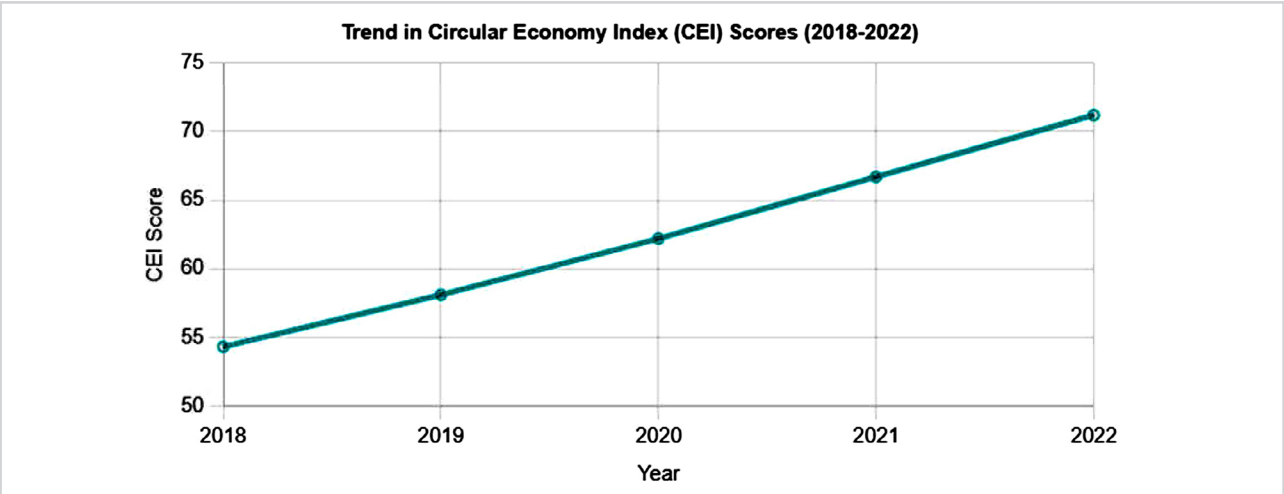

Figure 1:
Trend in CEI scores for European manufacturing firms, 2018-2022
Source: Authors' own research

Table 2:
Year-on-Year Changes in Financial Performance Metrics (%)

Metric	2018-2019	2019-2020	2020-2021	2021-2022
Return on Investment (ROI)	+2.1	-3.5	+4.8	+5.2
Gross Profit Margin	+0.8	-1.2	+1.5	+2.3
Net Profit Margin	+0.3	-2.1	+1.9	+2.7
Total Shareholder Return	+7.5	-12.3	+18.6	+15.2

Source: Authors' own research

the CEI was associated with a 0.152 percentage point increase in ROI ($p < 0.001$), a 0.087 percentage point increase in Gross Profit Margin ($p < 0.01$), a 0.063 percentage point increase in Net Profit Margin ($p < 0.01$), and a 0.203 percentage point increase in Total Shareholder Return ($p < 0.001$). These relationships remained significant even when controlling for factors such as firm size, R&D intensity, and leverage. Table 3 presents the detailed results of our main panel data regression analysis.

The lag analysis indicated that the positive relationship between CEI and financial performance strengthens over time. For ROI, the coefficient for CEI increased from 0.152 with no lag to 0.225 with a 3-year lag, all significant at the 0.1% level. This suggests that the financial benefits of circular economy practices may accumulate and become more pronounced over time. Table 4 presents the results of these analyses for ROI, using lags of 1, 2, and 3 years.

Exploration of nonlinear relationships revealed a slight diminishing returns effect. While the relationship between CEI and financial performance metrics remained positive, it began to level off at very high levels of circular economy implementation. For ROI, we found a significant positive linear term and a small but significant negative quadratic term, as shown in Table 5.

Table 3:
Panel Data Regression Results (Fixed Effects Model)

Variable	ROI	Gross Profit Margin	Net Profit Margin	Total Shareholder Return
CEI	0.152***	0.087**	0.063**	0.203***
	(0.028)	(0.034)	(0.022)	(0.057)
Firm Size (log)	1.243***	0.756**	0.532**	1.876***
	(0.312)	(0.289)	(0.201)	(0.458)
R&D Intensity	0.328**	0.412***	0.276**	0.587**
	(0.124)	(0.118)	(0.097)	(0.223)
Leverage Ratio	-0.843**	-0.567*	-0.721**	-1.132**
	(0.276)	(0.254)	(0.238)	(0.412)
Constant	-5.876**	24.312***	2.987*	-12.543**
	(1.687)	(5.432)	(1.345)	(4.678)
Observations	1000	1000	1000	1000
R-squared	0.342	0.287	0.265	0.318

Notes: Standard errors in parentheses. * - $p < 0.05$, ** - $p < 0.01$, *** - $p < 0.001$.

Source: Authors' own research

Table 4:
Lag Analysis Results for Return on Investment (ROI)

Variable	No Lag	1-Year Lag	2-Year Lag	3-Year Lag
CEI	0.152***	0.178***	0.203***	0.225***
CE	(0.028)	(0.031)	(0.035)	(0.039)
Control Variables	Included	Included	Included	Included
Observations	1000	800	600	400
R-squared	0.342	0.356	0.371	0.385

Notes: Standard errors in parentheses. *** - $p < 0.001$.

Source: Authors' own research

Table 5:
Nonlinear Relationship between CEI and ROI

Variable	Coefficient	Std. Error
CEI	0.287***	(0.062)
CEI^2	-0.002*	(0.001)
Control Variables	Included	
Observations	1000	
R-squared	0.358	

Note: * - $p < 0.05$, *** - $p < 0.001$.

Source: Authors' own research

Subsample analyses revealed that while the relationship between CEI and financial performance remained positive and significant across all subsamples, the magnitude of the effect varied. The effect appeared stronger for larger firms compared to smaller firms, for high-tech manufacturing firms compared to low-tech firms, and was strongest in Northern European countries. These variations may reflect differences in resource availability, technological capabilities, and regulatory environments. Table 6 presents the results of these analyses for ROI.

The mediation analysis suggested that both brand value and operational efficiency partially mediate the relationship between CEI and financial performance. For ROI, the direct effect of CEI remained significant, but a substantial portion of the total effect was explained by these mediating factors. This indicates that circular economy practices may enhance financial performance partly through improving a firm's brand value and operational efficiency (see Table 7).

Several robustness checks supported the validity of our findings. Using an equal-weighted version of the CEI yielded similar results ($\beta = 0.147$, $p < 0.001$ for ROI). The positive relationship held when using Economic Value Added as an alternative financial metric ($\beta = 0.138$, $p < 0.001$). Instrumental variable approaches and GMM estimators produced consistent results, suggesting our findings are robust to potential endogeneity concerns. Excluding potential outliers did

Table 6:
Subsample Analysis Results for ROI

Subsample	CEI Coefficient	Std. Error	Observations
Small Firms	0.138	(0.037)	320
Medium Firms	0.163*	(0.032)	450
Large Firms	0.172	(0.034)	230
High-Tech Manufacturing	0.198*	(0.041)	380
Low-Tech Manufacturing	0.127	(0.029)	620
Northern Europe	0.181	(0.038)	340
Southern Europe	0.135	(0.033)	320
Western Europe	0.159	(0.035)	340

Source: Authors' own research

Table 7:
Mediation Analysis Results for ROI

Path	Coefficient	Std. Error
CEI → ROI (Direct Effect)	0.093***	(0.025)
CEI → Brand Value	0.215***	(0.038)
Brand Value → ROI	0.176***	(0.029)
CEI → Operational Efficiency	0.183***	(0.031)
Operational Efficiency → ROI	0.152***	(0.027)
CEI → ROI (Total Effect)	0.152***	(0.028)

Source: Authors' own research

not significantly alter our main findings. These findings align with theoretical arguments proposing that circular economy practices can lead to increased competitiveness and profitability (Macarthur & Heading, 2019). Several mechanisms may explain this positive link, including cost reduction through efficient resource use and waste reduction, revenue enhancement from new streams in secondary markets, risk mitigation in supply chain and regulatory compliance, and enhanced brand value and loyalty (Awan & Sroufe, 2022).

The slight nonlinear relationship and variations across firm characteristics provide nuanced insights for managerial decision-making. The stronger effect observed in larger firms, high-tech manufacturers, and companies in Northern European countries may be attributed to greater resource availability, easier integration of circular principles in high-tech processes, and more supportive policy environments (Patwa et al., 2021), respectively.

4. Conclusion

This study provides compelling empirical evidence supporting a positive link between circular economy practices and financial performance in European manufacturing. Our findings demonstrate that firms with higher levels of circular economy implementation, as measured by the CEI, exhibit superior financial outcomes across multiple metrics. Importantly, these benefits strengthen over time, suggesting that circular economy transitions can drive long-term value creation. The variation in effects across firm characteristics and the identification of brand value and operational efficiency as mediating factors underscore the complex nature of this relationship. These insights offer valuable guidance for managers in tailoring circular economy strategies to their specific organizational contexts and for policymakers in designing effective support mechanisms. While acknowledging the study's limitations, our results significantly contribute to the growing body of evidence supporting the business case for sustainability. As environmental concerns continue to shape market dynamics and regulatory landscapes, embracing circular economy principles can be a source of competitive advantage and financial resilience for manufacturing firms.

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