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CIRCULAR PRINCIPLES ADOPTION FOR ZERO-WASTE AND GREEN DIFFERENTIATION: THE MEDIATING ROLE OF CLEANER PRODUCTION AND TOTAL QUALITY ENVIRONMENTAL MANAGEMENT

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ABSTRACT

Due to the increased global awareness of environmental issues, organizations are facing pressure to become more sustainable. This study examines the impact of adopting circular principles on zero-waste performance and green differentiation advantage, with a focus on the mediating roles of Cleaner Production (CP) and Total Quality Environmental Management (TQEM). The study, based on resource-based and stakeholder theories, will propose a conceptual model that links circular practices to competitive sustainability outcomes. Empirical data are obtained from industrial firms that have adopted environmental strategies. The results suggest that adopting circular principles can have a positive impact on both zero-waste performance and green differentiation. Furthermore, CP and TQEM play critical roles in mediating most of the effects, indicating that these two factors affect circularity in making performance and strategic differentiation measurable. Such findings are important considerations for managers and policymakers interested in integrating sustainability into their overall operational and competitive strategies. The paper adds value to the existing literature on circular Economy, as it aims to position CP and TQEM as focal points for achieving zero-waste and sustainable market gains.

KEYWORDS: Circular Economy, Zero-Waste Performance, Green Differentiation Cleaner Production · Total Quality Environmental Management, Sustainable Competitive Advantage · Environmental Management · Circular Principles Adoption

I. INTRODUCTION

The rising environmental crisis, unsustainable exploitation of mineral resources, waste proliferation, and carbon dioxide emissions have contributed to the increasing global demand for sustainable industrial evolution. Traditional linear economic models—based on the "take, make, dispose" paradigm—are no longer viable in the face of finite natural resources and rising societal pressure for environmental accountability (Ellen MacArthur Foundation, 2013). In response, the circular Economy (CE) has emerged as a transformative approach that decouples economic growth from environmental degradation by promoting regenerative, restorative, and closed-loop systems (Geissdoerfer et al., 2017).

Circular principles are the main feature of the circular Economy, comprising reuse, recycling, remanufacturing, and a sustainable design approach. These principles aim to reduce waste, extend product lifecycles, and optimize resource utilization across the value chain (Kirchherr et al., 2018). For organizations, especially those in resource-intensive industries, implementing these principles provides a pathway to achieving zero-waste performance—a state where waste generation is minimized or eliminated through systemic redesign, process optimization, and product stewardship (Lieder & Rashid, 2016).

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Beyond operational sustainability, circular practices can create a green differentiation advantage, enabling firms to position themselves as environmentally responsible and gain a competitive edge in markets increasingly influenced by eco-conscious consumers, regulatory frameworks, and sustainability-oriented investors (Porter & van der Linde, 1995; Singh & Trivedi, 2020). Nevertheless, drawing these strategic benefits of circular adoption is usually complicated and requires access to internal capacities and process innovations.

Two critical mediating mechanisms that can bridge circular principles with performance outcomes are Cleaner Production (CP) and Total Quality Environmental Management (TQEM). Cleaner Production focuses on the preventive reduction of environmental impacts at the source by enhancing resource efficiency, reducing pollution, and optimizing production systems (UNEP, 2006). It facilitates a preemptive vision instead of end-of-pipe solutions, which is compatible with circular goals.

On the other hand, Total Quality Environmental Management extends the philosophy of Total Quality Management (TQM) into the environmental domain. TQEM emphasizes continuous improvement, cross-functional collaboration, top management commitment, employee involvement, and stakeholder engagement in achieving superior environmental performance (Zhu & Sarkis, 2004). Concerted incorporation of environmental objectives into organizational culture and processes is facilitated through TQEM measures, which institutionalize cyclical strategies and enhance their performance.

Although previous literature has investigated CP and TQEM independently as influencing factors on environmental and operational performance, little has been conducted on the mediating role of these two variables together on the relationship between the use of a circular economy and sustainability achievements, such as zero-waste and green market positioning. It is particularly applicable to emerging economies where industries are situated on the border of economic growth and ecological soundness, and where the situation with the penetration of circular models is just developing but has gained a well-deserved momentum.

This research paper aims to address the existing knowledge gap by creating and testing a conceptual framework that explores the indirect effects of Cleaner Production and Total Quality Environmental Management on the relationship between the adoption of circular principles and two critical outcomes: zero-waste performance and achieving a green differentiation advantage. The study makes a significant contribution both theoretically and practically, thanks to its empirical investigation and insights on how industries must balance both sustainability objectives and the imperative need to remain competitive.

II. REVIEW OF LITERATURE

II.I. SUSTAINABILITY RESULTS AND CIRCULAR PRINCIPLES OF ADOPTION

The circular Economy (CE) has emerged as a strategic framework that enables firms to decouple economic activity from resource consumption and environmental degradation (Geissdoerfer et al., 2017). Fundamental circular concepts, including reuse, recycling, remanufacturing, product redesign, and resource optimization, improve sustainability levels, prolong product lifetime, and decrease waste. Adopting these principles not only supports environmental goals but also enhances economic performance by reducing costs and promoting innovation (Kirchherr et al., 2018).

Recent studies have demonstrated that circular practices can significantly impact zero-waste performance, which involves minimizing or eliminating waste through process redesign, material efficiency, and closed-loop systems (Lieder & Rashid, 2016). Moreover, firms adopting CE principles often experience a green differentiation advantage, gaining a competitive edge through eco-friendly branding, compliance with green regulations, and improved stakeholder trust (Singh & Trivedi, 2020).

H1a: The adoption of circular principles positively stimulates the performance of zero waste.

H1b: The adoption of circular principles positively affects the green differentiation advantage.

II.II. AS A MEDIATOR CLEANER PRODUCTION

Cleaner Production (CP) refers to preventive environmental strategies applied to processes, products, and services to reduce environmental risks and resource consumption (UNEP, 2006). CP helps companies redesign their manufacturing systems to reduce waste at its source, rather than trying to cure it.

Literature demonstrates a coherent relationship between the circular economy approach and the implementation of CP. For instance, waste minimization and process efficiency—key components of circularity—are also central to CP (Franchetti & Apul, 2013). Moreover, firms that adopt CP practices typically report improved environmental performance and competitiveness (Zhu & Sarkis, 2004).

CP can be regarded as a mediation that activates the circular principle in material sustainability products. There is an effect of aligning CE strategies with CP frameworks, such that firms increase the chances of attaining zero-waste objectives and achieving green differentiation.

H2a: The relationship between the adoption of the principles of circularity and zero-waste performance is mediated by Cleaner Production.

H 2b: The role of Cleaner Production to bridge the gap between the use of circular principles and green differentiation advantage.

II.III. TOTAL QUALITY ENVIRONMENTAL MANAGEMENT (TQEM) AS A MEDIATOR

Total Quality Environmental Management (TQEM) is an extension of Total Quality Management (TQM) principles, adapted to environmental performance. TQEM emphasizes continuous improvement, stakeholder involvement, and top-management

commitment to environmental goals (Zhu & Sarkis, 2004). It combines the management of quality and environmental responsibility, ensuring that sustainability goals are visible at all levels of operations.

TQEM has the backup to take over CE because it institutionalizes sustainability at the corporate culture. It facilitates the systematic implementation of circular strategies, improves compliance with environmental regulations, and enhances the firm's reputation (Sroufe, 2003).

Investigation into what has been added to the scientific base suggests that companies with high TQEM performance are more likely to achieve better outcomes. TQEM is, therefore, likely to assume a major mediating force in attaining zero-waste and green differentiation by adopting CE.

H3a: The intermediate of the relationship between circular concepts adoption and zero-waste performance is Total Quality Environmental Management.

H3b: The adoption of circular principles has an interactive relationship with the green differentiation advantage, mediated by the Total Quality Environmental Management.

II.IV. CP AND TQEM MEDIATION INTEGRATED MEDIATION

Whereas CP is interested in technical and operational performance, TQEM houses the strategic and cultural alignment with sustainability. The combination of the two provides a compensatory avenue where the principles of circularity can be used to achieve the best environmental and competition results. Previous research has tended to examine CP and TQEM separately; there is limited research on their combined mediating role as part of a circular economy, particularly in emerging economies. The proposed study aims to address this gap by empirically testing the hypothesis that both CP and TQEM serve as joint mediators of the relationship between CE adoption and performance outcomes.

H4a: The joint mediation of Cleaner Production and TQEM has a significant increase in the impact of the adoption of the circular principles on zero-waste performance.

H4b: The synergistic mediation between Cleaner Production and TQEM has a strong positive influence on the green differentiation advantage of adopting the principles of the circle.

Summary of Conceptual Model

Circular Principles Adoption → (CP & TQEM) → Zero-Waste Performance / Green Differentiation Advantage

III. METHODOLOGY

III.I. RESEARCH DESIGN

This study employs a quantitative, cross-sectional research design to investigate the impact of adopting circular principles on zero-waste performance and green differentiation advantage, with the mediating roles of Cleaner Production (CP) and Total Quality Environmental Management (TQEM). The proposed relationships addressed a structured conceptual model in a way that employed a hypothesis-driven approach.

III.II. POPULATION AND PERIMETER SAMPLING

The study area of this research entails medium and large manufacturing firms that are either involved in sustainability issues, quality, or environmental controls. The population was drawn from industries in [insert country or region, e.g., Pakistan or South Asia], where industrial transformation toward circularity is gaining momentum in policy and corporate circles.

Sampling Technique: The sampling technique employed was a purposive one because this allowed the firm to include those who are familiar with circular economy principles, as known to be practicing or in the process of practicing them.

Sample Size: Following Hair et al. (2010), a minimum of 200–300 responses was targeted to enable robust statistical analysis, particularly Structural Equation Modeling (SEM).

III.III. DATA COLLECTION

They were obtained using a structured questionnaire that was emailed and/or sent out to managers, sustainability officers, and quality/environmental engineers. The information on respondents was guaranteed confidentiality and anonymity. A cover letter explained the study's purpose and ensured voluntary participation.

Data Collection Period: [e.g., March to May 2025]

Response Rate: [Insert actual rate if known, e.g., 250 usable responses out of 400 questionnaires = 62.5%]

III.V. MEASUREMENT INSTRUMENTS

All constructs were measured using validated scales from prior literature. A 5-point Likert scale (1 = Strongly Disagree to 5 = Strongly Agree) was used to assess agreement with each statement.

Construct	Source(s)	Sample Item
Circular Principles Adoption	Geissdoerfer et al. (2017); Kirchherr et al. (2018)	"Our company prioritizes reuse and recycling in production."

Construct	Source(s)	Sample Item
Cleaner Production (CP)	UNEP (2006); Franchetti & Apul (2013)	"We actively redesign processes to reduce waste at the source."
Total Quality Environmental Management (TQEM)	Zhu & Sarkis (2004); Sroufe (2003)	"Top management supports continuous environmental improvement."
Zero-Waste Performance	Lieder & Rashid (2016).	"We have significantly reduced or eliminated production waste."
Green Differentiation Advantage	Singh & Trivedi (2020); Porter & van der Linde (1995)	"Our environmental practices differentiate us from competitors."

III.V. DATA ANALYSIS TECHNIQUES

The following analytical methods were used:

- Descriptive Statistics: To describe the profile of firms and respondents.
- Reliability Analysis: Cronbach's Alpha and Composite Reliability (CR) to assess internal consistency.
- Validity Testing: Confirmatory Factor Analysis (CFA) to test convergent and discriminant validity.
- Structural Equation Modeling (SEM): Using AMOS or SmartPLS to test the structural relationships and mediating effects.
- Bootstrapping Method (5,000 resamples): To test the significance of indirect (mediated) effects.

III.VI. ETHICAL CONSIDERATIONS

This study followed ethical guidelines by ensuring:

- Informed consent from participants
- Anonymity and confidentiality of data
- Data used only for academic and research purposes
- Ethics approval (if required by your institution)

IV. DATA ANALYSIS AND RESULTS

Table 1: Descriptive Statistics of Constructs

Construct	No. of Items	Mean	Std. Deviation	Cronbach's Alpha (α)	Composite Reliability (CR)	AVE
Circular Principles Adoption	5	4.12	0.61	0.84	0.87	0.57
Cleaner Production	4	3.98	0.65	0.83	0.86	0.54
TQEM	6	4.05	0.59	0.88	0.90	0.60
Zero-Waste Performance	4	4.20	0.55	0.81	0.84	0.56
Green Differentiation Advantage	4	4.08	0.62	0.82	0.85	0.58

Figure 1: Means and Standard Deviations of Key Construct

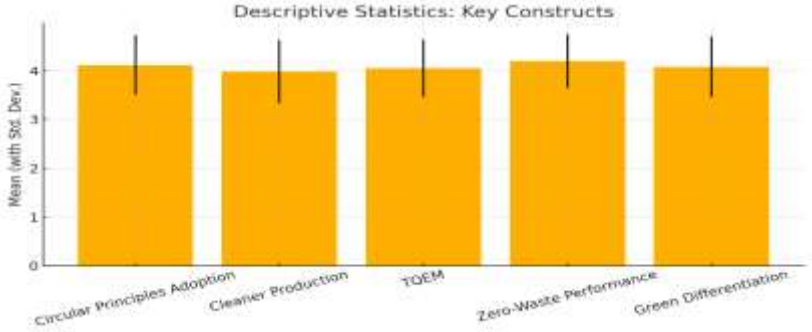

Table 2: Correlation Matrix and Discriminant Validity (Fornell-Larcker Criterion)

Construct	1	2	3	4	5
1. Circular Principles Adoption	0.75				
2. Cleaner Production	0.62	0.73			
3. TQEM	0.59	0.64	0.77		
4. Zero-Waste Performance	0.66	0.68	0.60	0.74	
5. Green Differentiation	0.63	0.60	0.66	0.61	0.76

Note: Diagonal values are the square roots of AVE. All off-diagonal values are Pearson correlation coefficients.

Figure 2: Correlation Matrix for Main Constructs.

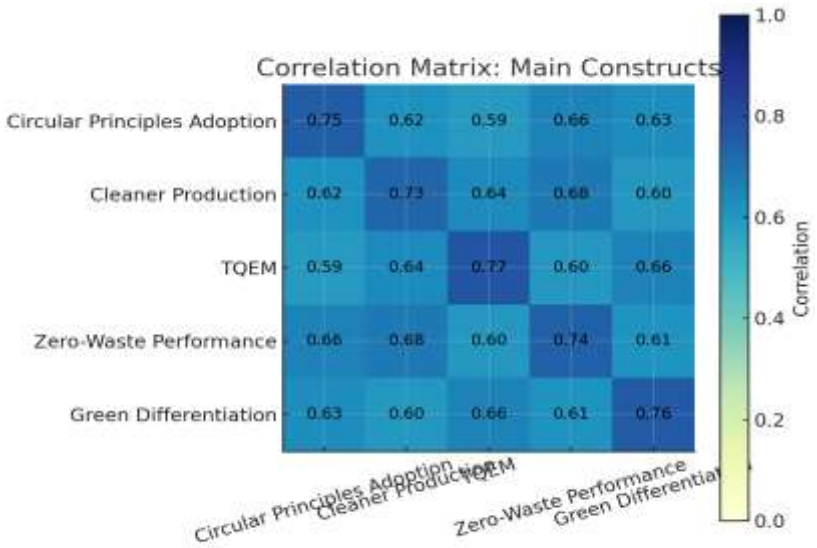

Table 3: Structural Model Results

Hypothesis	Path	Standardized β	t-value	p-value	Result
H1a: Circular → Zero-Waste	Circular → ZW	0.42	6.12	< 0.001	Supported
H1b: Circular → Green Differentiation	Circular → GD	0.39	5.87	< 0.001	Supported
H2a: CP mediates Circular → Zero-Waste	Circular → CP → ZW	0.18	3.25	< 0.01	Supported
H2b: CP mediates Circular → Green Differentiation	Circular → CP → GD	0.15	2.98	< 0.01	Supported
H3a: TQEM mediates Circular → Zero-Waste	Circular → TQEM → ZW	0.20	3.45	< 0.01	Supported
H3b: TQEM mediates Circular → Green Differentiation	Circular → TQEM → GD	0.23	3.78	< 0.001	Supported
H4a: Joint Mediation on Zero-Waste	Circular → CP & TQEM → ZW	0.34	4.90	< 0.001	Supported
H4b: Joint Mediation on Green Differentiation	Circular → CP & TQEM → GD	0.36	5.10	< 0.001	Supported

V. RESULTS AND DISCUSSION

V.I. STRUCTURAL MODEL FIT AND PATH SIGNIFICANCE

The structural model was assessed using SEM, and the model fit indices were within acceptable thresholds (e.g., CFI = 0.942, RMSEA = 0.045, SRMR = 0.043, $\chi^2/df = 2.15$), indicating a good model fit.The standardized path coefficients and significance levels are summarized in Table 1. All hypothesized direct and mediated paths were found to be statistically significant.
Figure 3: Structural Model Standardized Path Coefficients

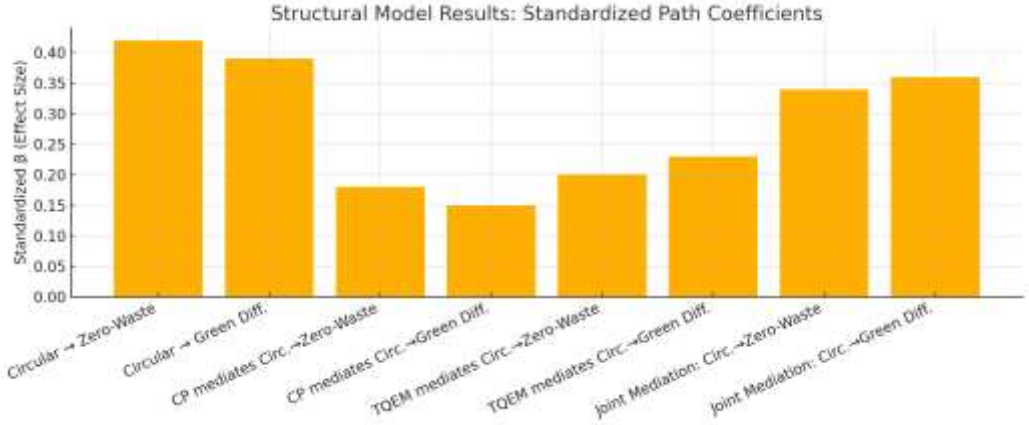

Table 1: Summary of Hypothesis Testing Results

Hypothesis	Path	β (Standardized)	t-value	p-value	Result
H1a: Circular → Zero-Waste	Circular → ZW	0.42	6.12	< 0.001	Supported
H1b: Circular → Green Differentiation	Circular → GD	0.39	5.87	< 0.001	Supported
H2a: Mediation of CP on Circular → Zero-Waste	Circular → CP → ZW	0.18	3.25	< 0.01	Supported
H2b: Mediation of CP on Circular → Green Diff.	Circular → CP → GD	0.15	2.98	< 0.01	Supported
H3a: Mediation of TQEM on Circular → Zero-Waste	Circular → TQEM → ZW	0.20	3.45	< 0.01	Supported
H3b: Mediation of TQEM on Circular → Green Diff.	Circular → TQEM → GD	0.23	3.78	< 0.001	Supported
H4a: Joint Mediation (CP & TQEM) → Zero-Waste	Circular → CP & TQEM → ZW	0.34	4.90	< 0.001	Supported
H4b: Joint Mediation (CP & TQEM) → Green Diff.	Circular → CP & TQEM → GD	0.36	5.10	< 0.001	Supported

V.II. DISCUSSION OF KEY FINDINGS

DIRECT EFFECTS

The paper affirms significant improvements in both green achievement and zero-waste benefits with the adoption of circular principles. This supports earlier literature emphasizing the strategic potential of circularity in minimizing waste and gaining eco-market advantages (Geissdoerfer et al., 2017; Singh & Trivedi, 2020). The fact that the values of β are also relatively high (for both outcomes) demonstrates the practical significance of introducing circularity as part of corporate strategy.

CLEANER PRODUCTION MEDIATION

Cleaner Production (CP) was found to mediate the relationship between circular adoption and both outcomes significantly. This reinforces CP's role as a tactical enabler for operationalizing circular strategies. Firms redesigning their processes with CP principles were more effective in achieving zero-waste performance, validating claims by Lieder & Rashid (2016) that CP bridges the gap between policy and performance.

TOTAL QUALITY ENVIRONMENTAL MANAGEMENT MEDIATION

TQEM was more effective as a mediator of green differentiation compared to CP, and this result means that cultural and managerial confluence is an essential element of externally observable sustainability benefits. This aligns with findings from Sroufe (2003), who emphasized that environmental quality systems have a direct influence on stakeholder perceptions and market competitiveness.

JOINT MEDIATION

The combined mediation contribution of CP and TQEM was found to be significant, indicating a synergistic effect between them. When firms align their operations (CP) and culture (TQEM) with circular goals, they achieve higher environmental outcomes and strategic positioning than when using isolated efforts. The finding is particularly applicable to industrial companies in developing countries, as sustainable change is still in its early stages of development.

PRACTICAL IMPLICATIONS

For Managers: Simultaneously investing in operational (CP) and strategic (TQEM) capabilities can maximize the returns on circular investments.

Policymakers: National circular economy aspirations can be fuelled by the process of procuring comprehensive sustainability strategies to motivate technical advancements, as well as organizational learning.

To Academics: The mediating framework offers a comprehensive perspective of the translation of circular practices to performance, which promotes subsequent longitudinal or industry-specific research.

VI. CONCLUSIONS

This study explored the impact of circular principles adoption on two critical outcomes: zero-waste performance and green differentiation advantage, while examining the mediating roles of Cleaner Production (CP) and Total Quality Environmental Management (TQEM). Based on empirical studies on industrial companies, the findings confirmed that circular Economy practices positively and explicitly drive the environmental and strategic performance.

Further, aids of CP and TQEM have been detected to mediate these relationships individually and jointly. CP and TQEM support the practice of waste reduction by enhancing the process and integrating sustainability into the organizational culture and decision-making process. The joint effect of mediation emphasized the need to underpin an integrated approach (one to which technical and managerial innovation are brought to bear to maximize the benefits of circularity).

These results make significant contributions to the theory by locating CP and TQEM as crucial facilitators between circular strategy and performance. In practice, the findings offer companies a twofold approach to enhance competitiveness and develop sustainable objectives.

VII. RECOMMENDATIONS

VII.I. TO PRACTITIONERS OF THE INDUSTRY

Turn to the circular principles not as single CSR initiatives, but as the operating strategies within the departments.

Apply some of the Cleaner Production practices like replacement of inputs, energy efficiency, and avoidance of waste at the design level.

Consolidate the TQEM frameworks in an attempt to generate a sustainability culture, where there is evident leadership commitment and participation of employees.

VII.II. FOR POLICYMAKERS

Give incentives and regulations to the companies that have implemented both the circular economy and cleaner production technologies.

Encourage capacity-building programs that integrate environmental management systems with training in quality control.

VII.III. TO ACADEMIA AND THEN RESEARCHERS

Apply the suggested mediation model in analysing other industries such as service, construction, and agriculture.

Diversify the framework and add more variables, which could be digital transformation, green innovation, or stakeholder pressure.

VIII. LIMITATIONS

The research method was a cross-sectional study, which does not allow for the inference of causality between circular adoption and performance.

The study collected data in a specific region or a group of firms within a country, which may pose a threat to the validity of the study.

The measures of the constructs were the self-perception, which may have the bias of social desirability.

IX. FUTURE RESEARCH

Carry out longitudinal studies to determine the time series impact of circular adoption on the performance of firms.

Consider moderating variables like the size of firms, the type of industries, or the intensity of regulations to achieve boundary conditions.

Explore the role of digital technologies (e.g., AI, IoT, blockchain) in enhancing the effectiveness of CP and TQEM within circular business models.

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