

**Organizational and external influences
on circular economy adoption in oil and gas:
A MENA perspective**

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Abstract

This study employs quantitative methods to develop a Circular Economy (CE) adoption scale in the MENA oil and gas sector. Using Exploratory Factor Analysis, Confirmatory Factor Analysis, and Structural Equation Modeling, it validates theoretical constructs derived from Literature review. A comprehensive literature review of 110 articles combined with data from 230 industry workers in various Middle East and North Africa (MENA) countries were analyzed to explore antecedents to CE adoption specifically in Oil and Gas sector. Findings reveal that innovation mediates the relationship between organizational drivers and external pressures, enhancing CE practices. While organizational inclination and external pressures positively affect innovation, moderation analysis shows that external pressures do not significantly amplify the impact on CE adoption. This research contributes to academic and practical discussions on integrating sustainability in the oil and gas sector, emphasizing innovation. Future studies should expand geographic scope, diversify sampling, and assess technological impacts on CE, providing crucial insights for policymakers and strategists in resource-heavy industries.

Keywords: circular economy, adoption, innovation, external pressure, organization, quantitative.

JEL classification: O33, L10, O35

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1. Introduction

The conventional linear economic paradigm, distinguished by extraction, utilization, and disposal processes, has historically served as the fundamental basis for contemporary industrial economies as depicted in Figure 1a, including the oil and gas (O&G) industry. This paradigm has resulted in notable environmental and energy security issues, namely in the oil and gas industry, which includes numerous sub-industries such as manufacturing, processing, transportation, and commercial sales

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(Mandegari et al., 2017; Kirchherr et al., 2017; Macini & Mesini, 2008). Petroleum refineries, which manufacture more than 2,500 products from crude oil, are significant contributors to worldwide pollution because of the hazardous chemicals they release, leading to severe threats to human health, aquatic ecosystems, and the economy (Cholakov, 2009; Thorat & Sonwani, 2022). The inherent lack of sustainability in the linear model has led to a transition towards a Circular Economy (CE) in the oil and gas industry. The primary objective of CE is to minimize waste while safeguarding valuable materials and products to optimize their utilization, so tackling environmental issues and resource scarcity (Hagelüken et al., 2016; MacArthur, 2013) as depicted in Figure 1b. The fundamentals of the CE model are intrinsically connected to sustainability; these include zero-waste design, a product-service system, and the restoration of the planet’s ecosystems. This strategy is particularly relevant when the oil and extracting industry emissions represent approximately 42% of global emissions while the industry is experiencing mounting demands to reduce emissions while maintaining production. (Malik & Askari, 2022).

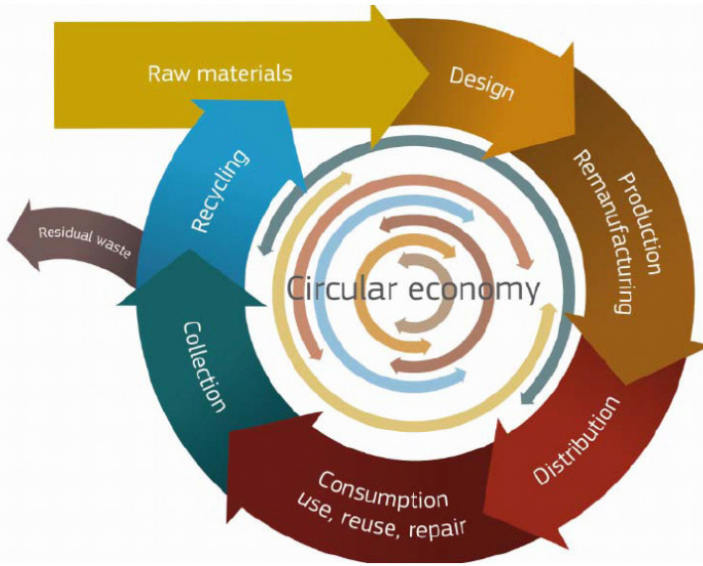
Figure 1a – Linear economy flow diagram



Source: Upadhayay & Alqassimi, 2018

Circular Economy (CE) has received interest regionally and globally, mainly due to the rising levels of waste produced by industrialization and the COVID-19 pandemic. In the MENA oil and gas industry context, CE profoundly reduces the seismic environmental and social impacts of landfilling and the sector’s massive reliance on extractive industries (Felix et al., 2022; Jain et al., 2020). CE promotes sustainable product design, material management, and provision of markets for related products, imperatives that are vital for sustainable economic development (Hysa et al., 2020). Changing to a Circular Economy in the Oil and Gas sector requires overcoming barriers like geographical scope, material complexity, and a long-established linear operating model (Hazen et al., 2017). Despite these obstacles, the implementation of circular economy principles is gaining momentum, as the notion of a “circular carbon economy” is emerging as a strategic method to tackle resource shortage and environmental contamination in the petrochemical and oil and gas sectors. The described methodology uses innovative technology and business solutions to progress in closing material and energy loops (Esposito et al., 2018; Palm et al., 2024; Lau et al., 2022).

Figure 1b – Circular economy



Source: Bonciu, 2014

This increased demand is mainly accounted for by oil and gas products, which implies that the industry has to come up with ways through which it can be able to meet this demand while at the same time minimizing the advancement of adverse environmental impacts (Newell et al., 2016). If implemented, the CE model can save up to \$ 1 trillion annually by 2025 and support the achievement of net-zero emission goals by 2050 as pointed out by Esposito et al. (2018) and Heo et al (2022). Also, Circular Economy(CE) aims at a sustainable balance between nature conservation and economic development, making it become a vital part of the oil and gas industry’s transformation toward sustainability (Wang, 2018). The Circular Economy offers substantial prospects for the Oil and Gas industry to improve its environmental performance, conform to worldwide climate objectives, and promote sustainable development, especially in the MENA region. The oil and gas industry can make a significant contribution to global sustainability through the implementation of environmentally responsible production methods and integrating a comprehensive value chain approach to product life cycles (Ibn-Mohammed et al., 2021; Zaleski & Chawla, 2020). Further section 2 outlines the research aim, motivation, and questions. A comprehensive literature review (Section 3) identifies three key antecedents – Organizational Inclination, Innovation, and External Pressure – supported by theoretical underpinnings. Section 4 presents the research methodology, detailing research design, data collection, sampling, and analysis techniques. Empirical validation using EFA, CFA, and SEM is discussed in Section 5. Section 6 presents hypothesis testing results, followed by implications in Section 7. Limitations and directions

for future research are addressed in Section 8, while Section 9 concludes the paper, emphasizing innovation's pivotal role in CE adoption.

2. Research aim and motivation

The time has come for practical sustainable industrial solutions, especially within the oil and gas industry, which is now under pressure to demonstrate its environmental footprint and sustainability performance (Malik & Askari, 2022; Lau et al., 2022). About eight MENA countries offer more than 30% of the global oil supply, implying that integrating the energy sector into international sustainability goals is crucially important (Jain et al., 2022). This paper builds on the analysis of identified themes based on literature review using Exploratory factor analysis (EFA), Confirmatory Factor Analysis (CFA), and Structural Equation Modeling (SEM). These methods provide a mathematical and coherent model, making the purported relationships and constructs in previous researches more accurate and statistically audited (Hazen et al., 2017; Bresanelli et al., 2019).

The broad purposes of this research is to offer practical recommendations to the relevant policymakers and strategic managers. Thus, this paper provides academic value by offering a methodologically sound and empirically tested study that enhances the academic literature on sustainable practices in the oil and gas industry while supplying tangible global strategies through industry counselors and policymakers about the circular economy (Esposito et al., 2018; Ibn-Mohammed et al., 2021). This approach highlights the emerging awareness of sustainability and environmental conservation in the MENA oil and gas industry through a quantitative model that may create a foundation for future works in this important field (Wang, 2018; Zaleski & Chawla, 2020). The following research questions (RQ) were identified.

RQ1. How effectively does the literature review represent the theoretical constructs influencing circular economy adoption in the MENA oil and gas sector?

This research question focuses on the extent to which previous researches captured the various theoretical models and, in the process, establishes the validity of the tool in measuring the proposed constructs.

RQ2. What is the objective reality of the conceptual map tested with methods of significance, such as Confirmatory Factor Analysis (CFA) and Structural Equation Modeling (SEM)?

This question seeks to validate the constructs and relationships quantitatively, determining their statistical robustness and relevance.

RQ3. To what extent does the empirically developed rational-actor model imply changes to the theoretical framework outlined in the conceptual map?

This question seeks to answer the following question: Does the empirical evidence suggest that method adjustments should be made to match the theoretical components, thereby increasing the model's usefulness

3. Literature review

A plan was developed to find pertinent material in order to do a comprehensive literature study on the adoption of the circular economy. Given the nature of the research topic, it was determined that a keyword search would be the most efficient method of obtaining pertinent results. To find the relevant studies, Scopus was searched using the following keywords in two stages in first stage "circular economy" AND "adoption." keywords were used to get a broad spectrum of literature. In second stage, to better align the review with the energy and resource-intensive nature of the oil and gas sector, the Scopus database was again searched using an expanded set of keywords: ("circular economy" AND "adoption") AND ("oil" OR "gas" OR "energy" OR "decarbonization" OR "carbon reduction" OR "energy efficiency" OR "MENA").

Since the database's creation, only English-language journal articles, review papers, and conference papers were included in searches. A search for a scholarly research was conducted in January 2025. Meeting papers, editorials, books, chapters, proceedings, and other resources were not included in the databases. The selection criterion was based on PRISMA (Figure 1). The first search yielded a total of 2549 items. After narrowing the search to only include peer-reviewed, open-access publications with full-text accessibility, 175 papers in all were gathered, and 110 of them underwent full-text reviews for a thorough literature assessment. Summary of comprehensive Literature review is provided in Appendix A, based on literature review three main antecedents were identified which comes out to be Organizational Inclination, Innovation and External pressure. Table 1 provide the summarized literature review leading to constructs. In second stage of search 31 documents were identified separately focusing on Circular economy adoption in oil and gas.

Although the circular economy (CE) literature is extensive across manufacturing, SMEs, and consumer goods sectors, relatively fewer studies explicitly address energy-intensive and carbon-intensive industries such as oil and gas, particularly within the MENA region (Blomsma & Brennan, 2017). Existing research suggests that, where applied to the oil and gas sector, circular economy strategies are increasingly framed around decarbonization pathways, energy-efficiency improvements, carbon circularity, waste-to-energy processes, and the extended utilization of hydrocarbon assets and infrastructure (Cherepovitsyn, A., & Rutenko, E. (2022); Dua & Jain, 2024; Jain et al., 2020). However, empirical and region-specific evidence remains fragmented, particularly for fossil-fuel-dependent economies in the MENA region, where circular economy adoption is closely intertwined with national energy-transition and net-zero objectives (Al Hosni et al., 2020; Munodawafa & Johl, 2022). Therefore, this review narrows its analytical focus toward studies that explicitly link circular economy adoption with energy systems, fossil fuel industries, and decarbonization objectives, while retaining broader organizational and institutional insights relevant to CE implementation.

Complete Literature review table is provided in Table A1 in Appendix.

Figure 1 – PRISMA statement

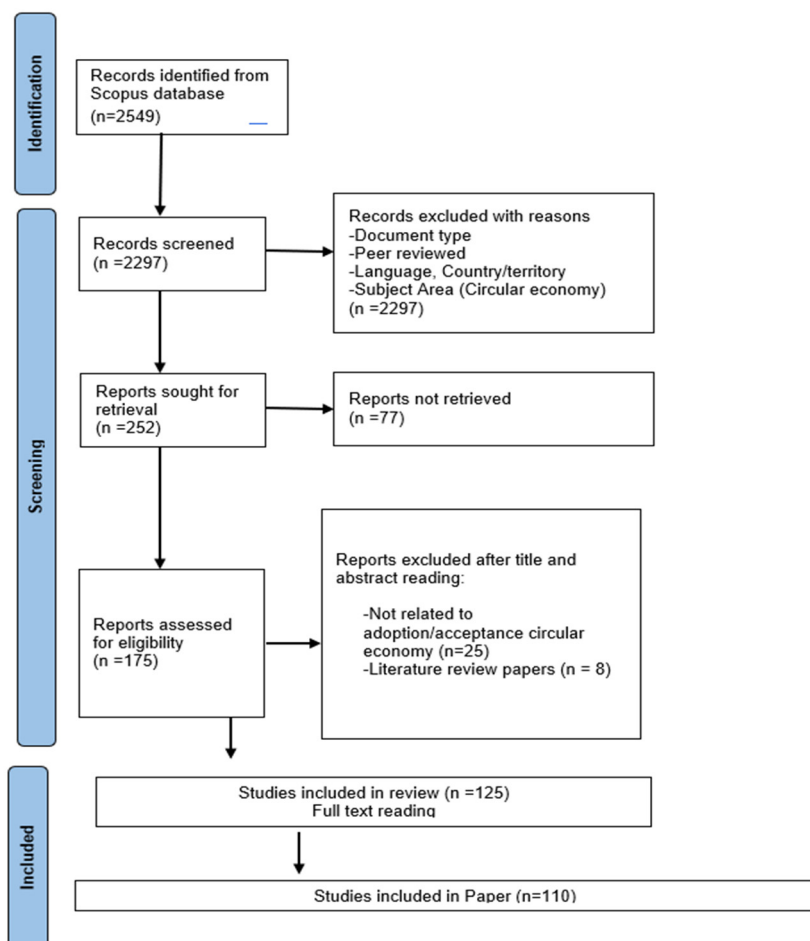


Table 1 – Summarized literature review

S.No	Extracted Construct	Relevant Literature
1	Organizational Inclination	Faisal et al., 2024; Al Rawashdeh et al., 2024; Kirchherr et al., 2018; Agyemang et al., 2019; Tura et al., 2019; Liu & Bai, 2014; Mura et al., 2020; Akinwale, 2024; Ormazabal et al., 2018; Al Rawashdeh et al., 2024; Soni et al., 2023; Castro-Lopez et al., 2023; Assmann et al., 2023; Govindan & Hasanagic, 2018; Al Rawashdeh et al., 2024; Sohal et al., 2022; Kwarteng et al., 2022; Ali et al., 2024; Barros et al., 2021; Barboza et al., 2022; Teixeira, 2025; Sivula, 2021; Bocken et al., 2018.
2	External Pressure	Segarra-Blasco et al., 2024; Castro-Lopez et al., 2023; Ranta et al., 2018; Calzolari et al., 2023; De Jesus & Mendonça, 2018; Jain et al., 2020; Melati et al., 2022; Jakhar et al., 2019; Ting et al., 2024; Moktadir et al., 2018; Schmidt et al., 2021; Nassani et al., 2023; Agyabeng-Mensah et al., 2024; Wang et al., 2022; Rizos et al., 2016.
3	Innovation	Sanchez-Garcia et al., 2024; Matameh et al., 2024; Laskurain-Iturbe et al., 2021; Despoudi et al., 2023; Luthra et al., 2021; Perotti et al., 2025; Dorrego-Viera et al., 2025; Yin et al., 2025; Jesus et al., 2025; Ai et al., 2024; Linder & Williander, 2017; Geissdoerfer et al., 2023; Pieroni et al., 2021; Lüdeke-Freund et al., 2019; Frishammar & Parida, 2019; de Padua Pieroni et al., 2019; Franco, 2017.

3.1. Organizational Inclination to circular economy adoption

Research is investigating the diverse aspects, including motivators, obstacles, and organizational facilitators, that affect the implementation of Circular Economy practices in SMEs and manufacturing sectors worldwide. Faisal et al. (2024) investigate the impact of individual and organizational factors on CE practices among SMEs in Bangladesh. Analyzing responses from 280 participants, the study highlights a strong correlation between CE adoption and elements such as environmental consciousness, innovation propensity, leadership commitment, and training programs—underscoring the significance of sustainability in SMEs. In a similar context, Akinwale (2024) explores CE adoption among 301 Saudi Arabian MSMEs, revealing high awareness but low actual implementation. Key enabling factors include employee training, financial resources, digital technology, top management commitment, and customer pressure.

Al Rawashdeh et al. (2024) repeatedly emphasize the influence of top management commitment and organizational motivation on CE adoption in the UAE, providing consistent insights for policymakers and stakeholders. Soni et al. (2023) expand this perspective by highlighting the role of distributed leadership in emerging markets. Their study emphasizes power-sharing, delegation, collaborative decision-making, and authority-sharing as trust-building mechanisms that facilitate CE integration and strengthen employee engagement. Barriers to CE adoption remain a recurrent theme. Kirchherr et al. (2018) conducted a large-N study across the EU and identified cultural barriers, consumer interest, and internal company culture as primary obstacles – more influential than technological barriers – indicating a niche discourse among sustainability professionals. This gap between awareness and practice is also addressed by Liu and Bai (2014), who find a significant discrepancy between firms’ declared awareness and their actual behavior, recommending strategies to bridge this gap.

From a sector-specific perspective, Agyemang et al. (2019) analyze Pakistan's automobile manufacturing industry and find that profitability, cost reduction, and environmental concerns are major drivers of CE, while ignorance, cost constraints, and lack of expertise function as critical barriers. Tura et al. (2019) provide a broad analytical framework encompassing environmental, economic, social, political, technological, supply chain, and organizational factors to systematically evaluate CE drivers and barriers across industries. In terms of operational practices, Mura et al. (2020) examine how SMEs implement CE principles, focusing on waste management, packaging, supply chain, and product design. Waste management emerged as the most widely adopted practice, reflecting its practicality and accessibility for smaller firms. Ormazabal et al. (2018) add a Spanish perspective, exploring CE potential in SMEs and identifying compliance, corporate image, and cost-saving as prominent motivators, alongside resource reutilization and financial advantages.

Institutional factors and agility are also essential. Castro-Lopez et al. (2023) explore how institutional pressures and organizational agility influence CE strategies and specific circular practices in manufacturing firms, revealing varying effects depending on context. Complementing this, Assmann et al. (2023) identify 54 determinants of circular business model adoption, categorizing them into themes such as culture, regulation, market orientation, strategy, business cases, collaboration, operations, and knowledge – providing granular insights for decision-makers. Policy influence plays a critical enabling role in CE adoption. Govindan and Hasanagic (2018) examine CE implementation in supply chains and argue that governmental tools – laws, risk reduction strategies, and strict governance – offer the most significant positive impacts. Similarly, Ali et al. (2024) assess how government support and organizational culture impact sustainable performance in manufacturing industries, emphasizing the importance of eco-innovation, adherence to policy, and a supportive organizational culture in driving CE and economic growth.

In the Indian context, Sohal et al. (2022) explore challenges and enablers for SMEs transitioning toward a circular economy. Applying socio-technical systems theory, the study underscores practices such as reducing waste, recycling, repurposing, and repairing as central to the shift. Kwarteng et al. (2022) analyze CE business models in Ghana and reveal a positive correlation with improved financial performance, moderated by organizational culture, thus linking circularity with economic value creation. Barros et al. (2021) delve into how CE practices influence diverse business areas, including strategic planning, cost management, supply chain, quality and environmental management, logistics, service operations, and R&D. Their findings advocate internalizing circularity principles across all operational domains for maximum impact. Barboza et al. (2022) focus on the cultural dimensions of CE, identifying 29 organizational values essential to fostering a circular economy culture and stressing the importance of soft factors and human resource management. Sivula (2021) investigates circular business model innovation (CBMI) in Finland's forest industry using empirical case studies from both SMEs and MNCs. The study identifies key enablers and barriers in CBMI processes and provides insights into types and design approaches for circular models. Similarly, Bocken et al. (2018) propose a CE experimentation framework emphasizing iterative processes, collaboration, and continuous learning. Their study highlights how low-risk experimentation can support sustainable transitions in business.

A macro-level comparison by Teixeira (2025) between Portugal and Sweden's CE progress, based on Eurostat data, reveals that Sweden has outperformed Portugal in areas such as workforce training, circular material usage, and consistent green job growth. This supports the alignment of national CE efforts with Sustainable Development Goals (SDGs). Collectively, this body of literature converges on the recognition that CE adoption is shaped by a confluence of individual, organizational, institutional, and policy-related factors. While drivers such as leadership, training, financial incentives, and eco-innovation are repeatedly emphasized, substantial barriers – including cultural inertia, cost concerns, and knowledge gaps – continue to impede progress. Regional and sectoral variances further underline the need for localized, flexible strategies. This comprehensive understanding offers vital direction for stakeholders aiming to accelerate the shift toward circularity, especially within SMEs and manufacturing ecosystems. In energy-intensive industries such as oil and gas, organizational inclination toward circular economy adoption is increasingly shaped by decarbonization commitments, energy-efficiency targets, and net-zero strategies (Jain et al., 2020; Munodawafa & Johl, 2022).

3.2. External pressure for circular economy adoption

Institutional frameworks and External Pressure play a pivotal role in the transition to a circular economy (CE), influencing adoption strategies, performance, and innovation across regions and sectors. Several studies highlight that the regulatory environment, stakeholder expectations, knowledge dissemination, and organizational agility significantly impact the CE trajectory. Segarra-Blasco et al. (2024) emphasize the importance of institutional frameworks in advancing CE, noting that knowledge and environmental spillovers positively influence adoption. They argue that policymakers should account for these factors to enhance CE implementation. In alignment, Castro-Lopez et al. (2023) examine the role of institutional pressures and organizational agility on CE strategies and practices within manufacturing firms. Their findings reveal that such pressures result in varying outcomes depending on organizational context, pointing to the complexity of institutional influence.

Expanding on institutional influence, Ranta et al. (2018) assert that the CE represents a sustainable alternative to the linear model. Their study reveals that recycling is the predominant CE action, often propelled by regulatory measures. However, they stress that diversified institutional support remains essential for comprehensive CE implementation. Similarly, Calzolari et al. (2023) explore the hierarchy of institutional pressures and supply chain integration in driving CE adoption. Their findings suggest that coercive market and regulatory pressures exert a stronger influence compared to other forms of pressure. Jain et al. (2020) delve into the Indian oil and gas sector, investigating how institutional pressures affect CE performance. They find that organizations with higher flexibility are more adept at responding to coercive pressures, demonstrating the moderating role of organizational characteristics. Melati et al. (2022) further contextualize these barriers, reporting that while companies are aware of the long-term economic and environmental benefits of CE, they often lack the necessary technical, financial, knowledge-based, regulatory, and institutional support. Adoption is thus primarily driven by access to information, peer networks, and regulatory incentives.

The role of innovation is central to overcoming institutional and technical obstacles. De Jesus and Mendonça (2018) analyze eco-innovation pathways and propose transformative innovation as a strategy to overcome sustainability-related challenges. They offer practical insights for shaping policy and organizational strategies in favor of CE. Jakhar et al. (2019) also investigate innovation dynamics, finding that stakeholder pressures on Indian manufacturing firms significantly affect CE efforts. Their results show that exploratory innovation supports CE adoption, while exploitative innovation has an inhibitory effect. Agyabeng-Mensah et al. (2024) expand on stakeholder engagement and innovation, exploring the impact of supply chain stakeholder pressure, circular innovation orientation, and environmental information exchange capability in Ghanaian SMEs. Using institutional and resource orchestration perspectives, they reveal that these pressures and capabilities jointly enhance CE supply chain adoption. Ting et al. (2024) present complementary insights from Malaysia's manufacturing sector, identifying motivators such as regulatory frameworks and internal drivers that positively influence CE business model adoption. Conversely, barriers inhibit sustainable production, even when adoption is achieved.

In the context of sustainable manufacturing in developing economies, Muktadir et al. (2018) focus on Bangladesh's leather industries. Their findings highlight the importance of CE-related knowledge in reducing waste and improving resource utilization. This complements findings by Nassani et al. (2023), who analyze the link between circular economy principles (CETP) and zero waste practices (IP), discovering that IP significantly influences CETP and acts as a mediator in shaping sustainable practices. Schmidt et al. (2021) analyze market orientation in relation to CE practices in German SMEs, particularly closed-loop strategies. They find that closed-loop orientation mediates the relationship between market orientation and only two types of CE practices, indicating limited but specific pathways for CE integration. On a broader policy level, Wang et al. (2022) highlight the global shortfall in meeting Paris climate targets, stressing that CE strategies must be accelerated to reduce emissions in key sectors including built environment, transportation, food, and clean energy. Rizos et al. (2016) contribute an early but still-relevant perspective by exploring barriers faced by SMEs in adopting CE models. Their study identifies financial limitations and lack of technical skills as primary constraints. They advocate for policy reforms aimed at fostering consumer preference for green products and enhancing support for SME transitions toward CE. For oil and gas firms, external pressures extend beyond generic regulatory compliance and increasingly stem from climate policies, decarbonization mandates, national energy-transition strategies, and international commitments such as net-zero targets (Dua, 2024). These pressures intensify the role of circular economy practices as mechanisms for improving energy efficiency, reducing carbon intensity, and maintaining sectoral legitimacy in fossil-fuel-dependent economies (Al Hosni et al., 2020).

3.3. Innovation in circular economy

The integration of technological innovation and novel business models has emerged as a critical enabler of circular economy (CE) transitions across sectors and geographies. Research highlights that technologies such as artificial intelligence, robotics, additive manufacturing, blockchain, and digital platforms, coupled with inno-

vative circular business models (CBMs) and open innovation strategies, are instrumental in addressing sustainability challenges and operationalizing CE principles. Sanchez-Garcia et al. (2024) explore the role of emerging technologies, specifically blockchain and artificial intelligence, in enhancing CE outcomes. They identify challenges related to supply chain transparency, skill gaps, and regulatory adaptation, and emphasize the need for further research to address these barriers. Extending this line of inquiry, Matarneh et al. (2024) examine how Industry 4.0 capabilities, green supply chain integration, and CE capabilities jointly influence corporate sustainability performance. Their findings underscore the transformative role of such technologies in enhancing CE capabilities and promoting long-term sustainable development.

Similarly, Laskurain-Iturbe et al. (2021) analyze the influence of key technologies – additive manufacturing, AI, and robotics – on core CE strategies such as reducing input consumption, reusing materials, recovery, recycling, and waste reduction. Additive manufacturing and robotics showed the most significant positive impacts, reinforcing the role of technology in facilitating CE goals. However, technology alone is insufficient without adaptive business models that enable CE implementation. Geissdoerfer et al. (2023) focus on business model innovation, comparing start-ups, diversification, transformation, and acquisition pathways. They identify 25 barriers and 10 drivers to CE adoption, particularly noting the influence of market and financial factors on start-ups and diversification models. Lüdeke-Freund et al. (2019) contribute to this domain by analyzing 26 CE business models through a morphological lens, identifying six dominant patterns – repair, maintenance, reuse, refurbishment, recycling, and cascading – that support resource flow closure.

Supporting this, Pieroni et al. (2021) propose sectorial CBM patterns to help manufacturers navigate the complexity and uncertainty associated with CE transitions. Their work provides insights into how pattern variations can guide sector-specific innovation. To facilitate structured transformation, Frishammar and Parida (2019) propose a roadmap for CBM transformation, offering a step-by-step approach to align companies with CE principles for economic, environmental, and social benefits. A complementary tool, the Circular Economy Business Model Configurator, introduced by de Padua Pieroni et al. (2019), is designed to help manufacturers develop tailored CBMs by addressing gaps in existing approaches. Open innovation (OI) is increasingly recognized as a catalyst in translating CE goals into practice. Perotti et al. (2025) examine two inter-organisational collaborative approaches that leverage OI strategies to promote circular business practices across supply chains and ecosystems. Dorrego-Viera et al. (2025) further explore how companies can overcome barriers to developing circular products through OI, emphasizing the importance of sourcing external knowledge, addressing technical issues, and involving consumers and academic institutions in co-creation.

In the Chinese context, Yin et al. (2025) show that OI significantly boosts CE practices, including trade credit provision, green patent accumulation, and enhanced information exchange. Their findings highlight regional disparities, with stronger effects observed in eastern China. Jesus et al. (2025) find that OI practices, particularly collaboration with external actors and co-creation, positively affect CE implementation. They also demonstrate that Industry 4.0 technologies mediate this relationship, although absorptive capacity does not moderate it. Reinforcing the role of national policy, Ai et al. (2024) assess the impact of China's Circular Economy Pilot Policy (CEPP) and find it significantly boosts green patent applications, especially in developed and educated cities with

lower resource dependency. Beyond the manufacturing sector, CE has found emerging applications in the food industry. Despoudi et al. (2023) examine CE implementation in Indian SMEs operating in the fruit and vegetable sector. Despite resource scarcity and food waste concerns, adoption remains limited. The study highlights both enablers and barriers, emphasizing the need for tailored strategies in emerging economies.

Franco (2017) analyzes the implementation challenges of CE within the European textile industry. Through case studies, the research identifies crucial factors influencing firms' transition to circular products, including product design and innovation in supplier-buyer relationships. Linder and Williander (2017) explore the uncertainties entrepreneurs face in adopting CBMs, noting that variants like Xerox's remanufactured photocopier model can, in some cases, exacerbate uncertainty rather than mitigate it. However, longitudinal action research provides useful counterexamples of successful transitions. Luthra et al. (2021) synthesize conceptual, theoretical, and empirical insights in their editorial on "Industry 4.0, Cleaner Production and Circular Economy". They emphasize synergies between decision-based tools, policy-guided research, and procedural innovations, contributing valuable knowledge for academia, industry, and society on ethical CE transitions. Within the oil and gas context, innovation-driven circular economy practices increasingly support decarbonization through technologies such as carbon capture and utilization, waste-heat recovery, process optimization, digital energy management, and circular carbon value chains (Cherepovitsyn et al., 2018). These innovations link circular economy adoption directly to measurable improvements in energy efficiency and emissions reduction, reinforcing the role of technological and digital capabilities in enabling circular energy transitions (Munodawafa & Johl, 2022).

3.4. Circular economy adoption in the oil and gas industry

In the oil and gas industry, the circular economy is increasingly conceptualized as a decarbonization-oriented framework that integrates resource efficiency, energy optimization, emissions reduction, and extended asset lifecycles (Cherepovitsyn et al., 2018; Hees et al., 2019; Jain et al., 2020). The context of the oil and gas sector has started to appreciate the importance of the circular economy (CE) principles in minimizing the adverse effects on the environment. This natural transformation will be caused by the scarcity of limited and depleting sources like fossil fuels and the increasing pressure to practice sustainability within this sector. Hees et al. (2019) have predicted that with more catalyst and processing technologies development, it is becoming possible to design and produce more complex, reusable, and value-added petroleum products to address CE and sustainable development objectives. This innovation shows that the industry can innovate and look for efficient ways of saving and reusing resources, as seen here. Additional evidence from Jain et al. (2020) has supported how EMS moderates the relationship between organizational flexibility and institutional concerns for improving CE efforts. Thus, Cherepovitsyn et al. (2018) have pointed to the following analytical and managerial implications for extended underutilized oil and gas resources as one of the sustainable development paths for the sector. They all suggest that the need for change in the industry, which is dictated by reducing hydrocarbon reserves, must be addressed.

Also, other possibilities for implementing CE principles can be observed during the decommissioning or the conversion of the offshore platforms, as indicated by Basile et al. (2021). These processes provide new insights, shift values, and modify behaviors to align with sustainable corporate goals, thus fostering the creation of sustainable business models. This approach addresses environmental concerns and considers the relationships with all stakeholders, proposing a multi-criteria decision-making methodology to evaluate and compare potential decommissioning options. Continued research into and the creation of different technologies for handling waste is also rooted in requiring the enhancement of CE in the oil and gas industry. Paukov et al. (2019) described the low-temperature, environmentally friendly technology for utilizing municipal solid waste to produce liquid products. This process works hand in hand with the other conventional refining processes, does not require an additional and expensive supply of energy, and does not emit any polluting materials; hence, it is a clear example of how CE principles have been implemented.

In Oman, it is widely believed that the adaptation of CE has been deemed necessary because the country needs to diversify its economy beyond the Oil and gas sectors. More recently, Al Hosni et al. (2020) discussed the barriers and found that governmental restrictions and insufficient facilitating legislation are the major hurdles to CE advancement. This study also underscored a strategy to give research the much-needed boost of governmental support by eliminating technical obstacles with adequate and proper regulations supported by trained experts. Munodawafa and Johl (2022) further explained how eco-innovations are necessary to counter the effects of environmental decay, energy vulnerability, and poor air quality. Their research developed an Eco-innovation Capabilities Scale specifically for oil and gas firms, emphasizing the necessity for such innovations to sustain the industry's competitiveness and environmental stewardship. In summary, the integration of circular economy principles in the oil and gas sector is increasingly recognized as essential for sustainable development. Overall, the literature suggests that the contribution of circular economy adoption in oil and gas lies not only in material circularity but also in measurable energy-efficiency gains, reduced carbon intensity, and alignment with national energy-transition and decarbonization agendas, particularly in hydrocarbon-dependent regions such as the MENA region (Al Hosni et al., 2020; Munodawafa & Johl, 2022; Nassani et al., 2023).

4. Theoretical underpinnings

A summarized content available literature of circular economy adoption across various industry with relevant theoretical underpinnings is presented in Table 2. According to Theory of planned behavior by Ajzen (1991), organizational Comprehensive plan for engaging in CE practices depends on their attitudes, perceived control, and subjective norms. This theory is useful in explaining Organization's Behavioral Intention towards CE Adoption, this postulates that organizational intentions are largely influenced by Organizational perceived Behavioral Control toward environmental stewardship (Ajzen, 1991). Moreover, Organizational Culture Theory by Schein (1992) sheds the light on the way Culture become so rooted and endorses or contradicts new practices like CE, which is important for Organization's Work Culture Inclination to CE Adoption as mentioned by Schein (1992). Further, the resources-based view on the beginning of Barney (1991)

underlines that only those capabilities in the organization organism, as, for example, then into the waved given organizational capability like managerial support, can be ideally suitable for the realization of sustainable competitive advantages beginning with the CE adoption in line with Organisation's Managerial Inclination to CE Adoption as on principle of forming-near Barney (1991).

It is therefore the innovations in CE that are central to change towards becoming more sustainable. The Diffusion of Innovations Theory (Rogers, 1962) is relevant to Technical Innovations for CE Adoption Some technologies are adopted when they have relative advantage over the older technologies, and are compatible with the existing operations (Rogers, 1962). Another theory that underpins Economical Innovations for CE Adoption includes the Economic Theory of Innovation as envisaged by Schumpeter in 1942 where it pointed out that economical innovations are capable of displacing current business patterns or developing new ones in the circulation of innovations (Schumpeter, 1942). Based on Transaction Cost Economics (TCE) developed by Williamson (1979), a model known as Outsourced Innovations for CE Adoption is used to identify the costs relating to a certain transaction and decide whether to outsource or internalize the practices of CE.

A key factor for influencing CE adoption is often exerted from outside. The Institutional Theory as proposed by DiMaggio and Powell (1983), connects to Government's Pressure for CE Adoption where organizational guidelines and policies, as well as government requirements force organisations to adopt CE practices (DiMaggio & Powell, 1983). Competitive Dynamics Theory which is encompassed in Competitive Forces for CE Adoption whereby competitive forces compel organizations to adopt CE to strengthen or defend their positions in the market (Porter 1985). Closingly, the last theory affecting the analysed factors is Globalization Theory (Giddens, 1990), explaining that global pressures cause organisations to adopt CE practices across borders (Giddens, 1990). Resume of the above discussion is given in Table 3.

5. Empirical validation through quantitative methods

It is the transition from a general idea or speculation to producing evidence to support the idea theory under the developmental process. In the case of quantitative research, Exploratory Factor Analysis (EFA) and Confirmatory Factor Analysis (CFA) contain the statistical tools required for assessing the soundness of measurement of constructs that are included in conceptual maps (Bressanelli et al., 2019).

Another quantitative research technique used in validating the conceptual maps is Structural Equation Modeling (SEM). This method enables the researcher to establish a connection between the latent variables and provides a holistic framework for the factors (Esposito et al., 2018). Combined with these quantitative measures, they enhanced the quality of the research by backing theoretical claims with empirical data, which produced deeper insights into policy and strategic decisions. Moreover, because quantitative research is based on the accumulation of numerical data and computations, such research also allows the creation of models of prediction that, in turn, are quite helpful when it comes to understanding possible impacts of certain factors and being rational when choosing. Qualitative and quantitative methods in social sciences or environmental disciplines can assess the size of a particular phenomenon and the effectiveness of various approaches to a large extent (Creswell & Clark, 2017).

Table 2 – Relevant literature for theoretical underpinning of Circular Economy Adoption

S.No.	Title	Authors	Industry Focus	Theoretical Framework(s)	Key Insights
1	Implementation of Circular Economy in a Developing Economy's Mining Industry Using Institutional Theory: The Case of Namibia	Kahupi et al., 2024	Mining	Institutional Theory	Analyzes adoption of circular economy practices in the mining sector of Namibia through the lens of institutional theory.
2	Circular economy–From review of theories and practices to development of implementation tools	Kalmykova et al., 2018	Various sectors	General Theoretical Review	Provides an extensive review of existing theories and practices related to the circular economy, offering insights into the development of practical implementation tools.
3	Adoption of circular economy practices in small and medium-sized enterprises: Evidence from Europe	Dey et al., 2022	Small and Medium Enterprises (SMEs)	Multiple Theories	Explores the adoption of circular economy practices in European SMEs and identifies key barriers and drivers.
4	Barriers to the adoption of circular economy practices in micro, small and medium enterprises: Instrument development, measurement and validation	Mishra et al., 2022	Micro, Small, and Medium Enterprises (MSMEs)	Barrier Theory	Develops and validates an instrument to measure barriers to circular economy adoption, highlighting the theoretical underpinnings of these barriers.
5	Evaluating the barriers and drivers of adopting circular economy for improving sustainability in the mining industry	Osei et al., 2023	Mining	Sustainability Theories	Identifies and evaluates the barriers and drivers of circular economy adoption in the mining industry, integrating sustainability theories into the analysis.
6	Circular economy applications in the construction industry: A global scan of trends and opportunities	Guerra et al., 2021	Construction	Industry-specific Theoretical Review	Provides a global scan of circular economy adoption in the construction industry, discussing the gap between theory and practice.
7	Barriers to the adoption of digital technologies in a functional circular economy network	Kandasamy et al., 2023	Industry 4.0 & Circular Economy	Technology Adoption Theories	Discusses the barriers to adopting digital technologies in Industry 4.0 and circular economy networks, offering a theoretical perspective on technology adoption.
8	How does circular economy work in industry? Strategies, opportunities, and trends in scholarly literature	Silvério et al., 2023	Various Industries	Conceptual Reference Model	Analyzes strategies and opportunities for circular economy adoption across different industries, providing a conceptual model for industry adoption.
9	Adoption of additive manufacturing for sustainable operations in the era of circular economy: Self-assessment framework with case illustration	Priyadarshini et al., 2022	Additive Manufacturing	Graph Theory Matrix	Studies the challenges of adopting additive manufacturing for circular economy goals using the Graph Theory Matrix approach.

S.No.	Title	Authors	Industry Focus	Theoretical Framework(s)	Key Insights
10	An extended institutional theory perspective on the adoption of circular economy practices: Insights from the seafood industry	Do et al., 2022	Seafood	Institutional Theory	Offers an extended perspective on how institutional theory can explain circular economy adoption in the seafood industry.
11	Circular economy adoption by SMEs in emerging markets: Towards a multilevel conceptual framework	Malik et al., 2022	Small and Medium Enterprises (SMEs)	Multilevel Conceptual Framework	Proposes a multilevel conceptual framework for understanding circular economy adoption in SMEs in emerging markets.
12	How can open innovation contribute to circular economy adoption? Insights from a literature review	Jesus & Juggend, 2023	Various Industries	Actor Network Theory, Industrial Network Theory	Explores the role of open innovation in circular economy adoption, with a focus on network theories.
13	Research gaps and future directions on social value stemming from circular economy practices in agri-food industrial parks: Insights from a systematic literature review	Atanasovska et al., 2022	Agri-food	Social Value Theories	Identifies research gaps in the circular economy practices in agri-food industrial parks, focusing on social value.
14	Mapping the barriers to circular economy adoption in the construction industry: A systematic review, Pareto analysis, and mitigation strategy map	Wuni. 2022	Construction	Barrier Theory, Pareto Analysis	Provides a systematic review of barriers to circular economy adoption in the construction industry, offering a Pareto analysis and mitigation strategies.
15	Industry 4.0 and the circular economy: a proposed research agenda and original roadmap for sustainable operations	Jabbour et al, 2018	Various Industries	Management Theories	Proposes a research agenda and roadmap for integrating Industry 4.0 with circular economy principles, based on management theories.

Table 3 – Theoretical underpinning the Literature review for identified constructs

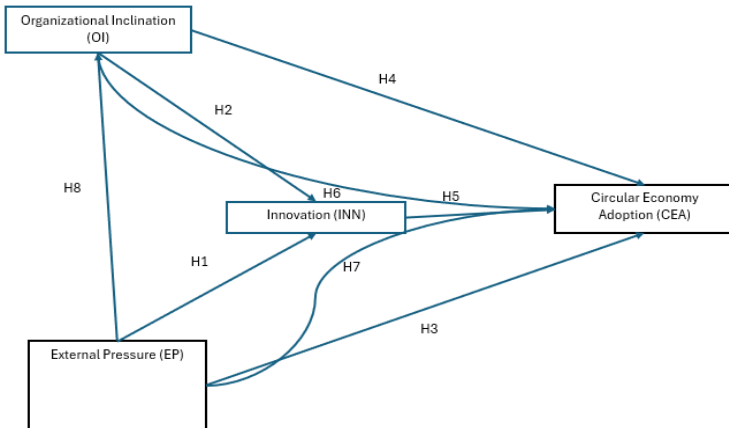
Subtheme	Relevant Theory	Key Reference
Organizational Inclination	Theory of Planned Behavior	Ajzen, 1991
	Organizational Culture Theory	Schein, 1992
	Resource-Based View	Barney, 1991
Innovation	Diffusion of Innovations	Rogers, 1962
	Economic Theory of Innovation	Schumpeter, 1942
	Transaction Cost Economics	Williamson, 1979
External Pressure	Institutional Theory	DiMaggio & Powell, 1983
	Competitive Dynamics Theory	Porter & Advantage, 1985
	Globalization Theory	Giddens & Pierson, 1998

6. Methodology

6.1. Research design

The study employed quantitative research that helped in the development of measuring the scale of circular economy potential determinants in the oil and gas industries in the MENA region. This research employed the following five-step process: literature-based map construction, construction of a measurement scale, data collection via survey, analysis of data using SPSS, and presentation of results using a frequency table. This research method corresponds to other research studies carried out by Larimian et al. (2020), Tang et al. (2018), Shah (2019), Fatma et al. (2016), and Cabral & Dhar (2019), who have been able to devise and assess the reliability of the scale of measurements for their research thus establishing the methodological soundness of this study. Theoretical model for empirical analysis is developed based on the literature review and presented in Figure 2.

Figure 2 – Theoretical Framework



Direct relationships

H1: External Pressure (EP) positively influences Innovations (INN) in CE adoption.

H2: Organizational Inclination (OI) positively influences Innovations (INN) for CE adoption.

H3: External Pressure (EP) positively influences Circular Economy Adoption (CEA).

H4: Organizational Inclination (OI) positively influences Circular Economy Adoption (CEA).

H5: Innovations (INN) positively influence Circular Economy Adoption (CEA).

Mediation

H6: The relationship between Organizational Inclination (OI) and Circular Economy Adoption (CEA) is mediated by Innovations (INN).

H7: The relationship between External Pressure (EP) and Circular Economy Adoption (CEA) is mediated by Innovations (INN).

Moderation

H8: The effect of Organizational Inclination (OI) on Circular Economy Adoption (CEA) is moderated by External Pressure (EP), such that the relationship is stronger when EP is high.

Data collection

The second phase entailed developing and disseminating survey instruments, which were questionnaires bearing quantitative measures of the circular economy in the MENA oil and gas sector. For this reason, a digital survey with 38 statements was provided to up to 600 industry workers in Nigeria, Kuwait, Saudi Arabia, UAE, Bahrain, Oman, and Qatar. The survey was electronic, where participants were emailed a brief on the projects, instructions on how to fill out the survey, and a link (<https://forms.gle/ptUszP27vuLpsjVM9>) to the online survey. To meet the multilingual nature of the region, the questionnaire was translated into both Arabic and English, and further improvements were made based on what was observed during the pilot testing.

Participant sampling

Using convenience sampling, we tried to reach about 600 employees of the oil and gas industries in the MENA region through an online survey that was forwarded via email. This method helped carry out fast data collection from effortlessly conspicuous people. These countries are Kuwait, Saudi Arabia, UAE, Bahrain, Oman, Qatar, and Nigeria because they are primary producers and consumers in the oil and gas industries and play a very instrumental part in the global oil market. The actions of these countries in moving to sustainable practice are very informative in understanding the applicability and implications of circular economy and their results under comparable geopolitical and economic circumstances. Two hundred and thirty responses were received, which yielded a 38 percent response rate. Given the current sampling level, it is believed that the subsequent analyses are adequate; moreover, according to Boomsma (1985), at least 100 observations are required for conducting exploratory and confirmatory factor analysis. The demographic information section, including the age, gender, employment position, and years of experience of the participants, is presented in Table 4 to afford a general view of the participants' demography and their roles in the industry.

Analysis techniques

The third phase of the study tested the applicability of exploratory factor analysis to the data employed by the PCA with Varimax rotation – an orthogonal rotation technique. This step was essential to deciding based on 38 survey statements and determining components or factors without expecting any relationship. Therefore, in the fourth phase, the Confirmatory Factor Analysis (CFA) was undertaken using Analyses of Moments Structures (AMOS 18) to confirm the measurement model and the theoretical relationships postulated in the EFA. This step helped establish the model's fitness in the study and test the reliability and validity of the constructs used. Following the validation of the measurement model through CFA, hypotheses

were developed to test the relationships among the identified factors. Structural Equation Modeling (SEM) was then employed to analyze these relationships, facilitating a deeper understanding of the dynamics influencing the adoption of circular economy practices in the oil and gas sector of the MENA region.

Table 4 – Demographic Characteristics of Sample (N=230)

Category	Variable	Number	Percentage (%)
Gender	F	59	25.7
	M	171	74.4
Age	20-30	20	8.7
	30-40	32	13.9
	40-50	121	52.6
	50-60	57	24.8
Location	Bahrain	34	14.8
	Kuwait	88	38.3
	Nigeria	2	0.9
	Oman	36	15.7
	Qatar	10	4.4
	Saudi	52	22.6
	UAE	8	3.5
Experience	0-5	17	7.4
	5-10	16	7.0
	10-15	13	5.7
	15-20	49	21.3
	20-25	65	28.3
	25-30	43	18.7
	30-35	27	11.7

7. Data analysis

7.1. Exploratory Factor Analysis (EFA)

The suitability of the data for exploratory factor analysis was evaluated prior to factor extraction. There were two tests run. First, the Kaiser-Meyer-Olkin (KMO) test assessed the sample's adequacy. Second, Bartlett's sphericity test was run. Using Principal Component Analysis (PCA) with Varimax rotation, a kind of orthogonal rotation, four dimensions were obtained from the 38 statements. Table 5 demonstrates that all four dimensions have eigenvalues above Kaiser's criterion of 1, collectively explaining 69.608 percent of the underlying variation. The factor loadings of the items are shown in Table 5, while the items under examination and their respective values are provided in Table 6.

Table 5 – Rotated Component Matrix^a

	Component			
	1	2	3	4
INN1	0.79			
INN2	0.827			
INN3	0.787			
INN4	0.861			
INN5	0.822			
INN6	0.813			
INN7	0.828			
INN8	0.798			
INN9	0.818			
INN10	0.813			
OI1		0.838		
OI2		0.752		
OI3		0.8		
OI4		0.804		
OI5		0.787		
OI6		0.807		
OI7		0.779		
OI8		0.801		
OI9		0.844		
OI10		0.822		
EP1			0.788	
EP2			0.816	
EP3			0.811	
EP4			0.757	
EP5			0.793	
EP6			0.804	
EP7			0.791	
EP8			0.815	
EP9			0.803	
EP10			0.756	
CEA1				0.803
CEA2				0.784
CEA3				0.83
CEA4				0.802
CEA5				0.79
CEA6				0.837
CEA7				0.831
CEA8				0.817
Eigen Value	7.123	6.939	6.764	5.625
% of Variance	18.745	18.262	17.799	14.802
Cronhbach's Alpha	0.953	0.947	0.950	0.951

Table 6 – Statements for enquiry

Dimension	Statement
O11	Our organization actively seeks new methods to integrate circular economy (CE) principles.
O12	There is a strong willingness within our organization to adopt CE practices.
O13	Our leaders regularly discuss the importance of CE.
O14	Employees are encouraged to propose ideas related to CE.
O15	CE is considered a priority in our strategic planning.
O16	Our organization rewards initiatives that promote CE.
O17	Training about CE is regularly offered to employees.
O18	Senior management leads by example in the implementation of CE.
O19	Our organization's mission statement includes commitments to CE.
O110	There is a clear policy for adopting CE practices in our operations.
INN1	Our organization invests in new technologies that promote recycling and reuse.
INN2	Innovative technologies are deployed to reduce resource consumption.
INN3	We actively participate in technology forums focused on CE.
INN4	Our technical teams are trained specifically in CE technologies.
INN5	CE practices have reduced costs in our operations.
INN6	Investments in CE have shown a positive return on investment.
INN7	We collaborate with external experts to enhance our CE practices.
INN8	Partnerships with academic institutions have enhanced our CE efforts.
INN9	We use technology to track and reduce our carbon footprint.
INN10	Economic assessments include sustainability performance.
EP1	Government regulations require us to adopt certain CE practices.
EP2	We are influenced by national policies on sustainability.
EP3	Competitive advantages gained through CE are crucial for our success.
EP4	Pressure from market leaders in CE drives our own efforts.
EP5	International trends in CE shape our strategies.
EP6	Global environmental concerns compel us to adopt CE practices.
EP7	We adapt to global market demands for sustainable products.
EP8	International agreements and commitments influence our CE policies.
EP9	Our CE efforts are influenced by international thought leaders.
EP10	Global supply chain pressures necessitate CE adaptations.
CEA1	Our organization has a clear and actionable plan for CE in the oil and gas sector.
CEA2	We have successfully integrated CE principles into our core operations.
CEA3	CE is a critical factor in our competitive strategy.
CEA4	Our investments in CE have significantly reduced environmental impacts.
CEA5	We measure the success of our CE initiatives through specific KPIs.
CEA6	We have achieved noticeable improvements in resource efficiency through CE.
CEA7	Our company has made substantial progress in reducing waste through CE practices.
CEA8	The leadership actively supports and promotes the expansion of CE initiatives within the company.

7.2. Confirmatory Factor Analysis (CFA)

Confirmatory Factor Analysis (CFA) was conducted using AMOS 18.0 to validate the previously proposed correlations in the measurement model (Netemeyer et al., 2003). Prior to determining the accuracy of the measurement model, the adequacy of the model's fit was verified. A model fit index of satisfactory quality was achieved, as shown in Table 7. Although the Chi-square ($\chi^2 = 832.411$, $p < .000$) is significant, which typically suggests a lack of fit, this test is known to be sensitive to large sample sizes, where even small discrepancies can lead to significant results. To address this, the CMIN/DF (Normed Chi-Square) value of 1.263, which is well below the threshold of 2, suggests a good model fit. The Root Mean Square Residual (RMR) value of .113, while not extremely close to zero, remains within an acceptable range, especially when other fit indices are favourable. The Goodness-of-Fit Index (GFI = .847) and Adjusted Goodness-of-Fit Index (AGFI = .828) are slightly below the ideal threshold of 0.90, indicating a marginal but still reasonable fit.

Table 7 – Goodness- and badness-of-fit indices of first-order CFA

Goodness-of-fit Indices	Model Values
Absolute Goodness-of-fit Index	
Chi-Square (CMIN)	832.411
Degree of Freedom (DF) 679	659
Probability Level	0
Normed Chi-Square (CMIN/DF)	1.26314264
Goodness of Fit Index (GFI)	0.847
Absolute Badness-of-fit Index	
Root Mean Square Error of Approximation (RMSEA)	0.034
Incremental Fit Measure	
Adjusted GFI	0.828
Comparative Fit Index (CFI)	0.975
Parsimony Fit Measurement	
Parsimony GFI	0.753
Parsimony CFI	0.914
Parsimony Normed Fit Index	0.834

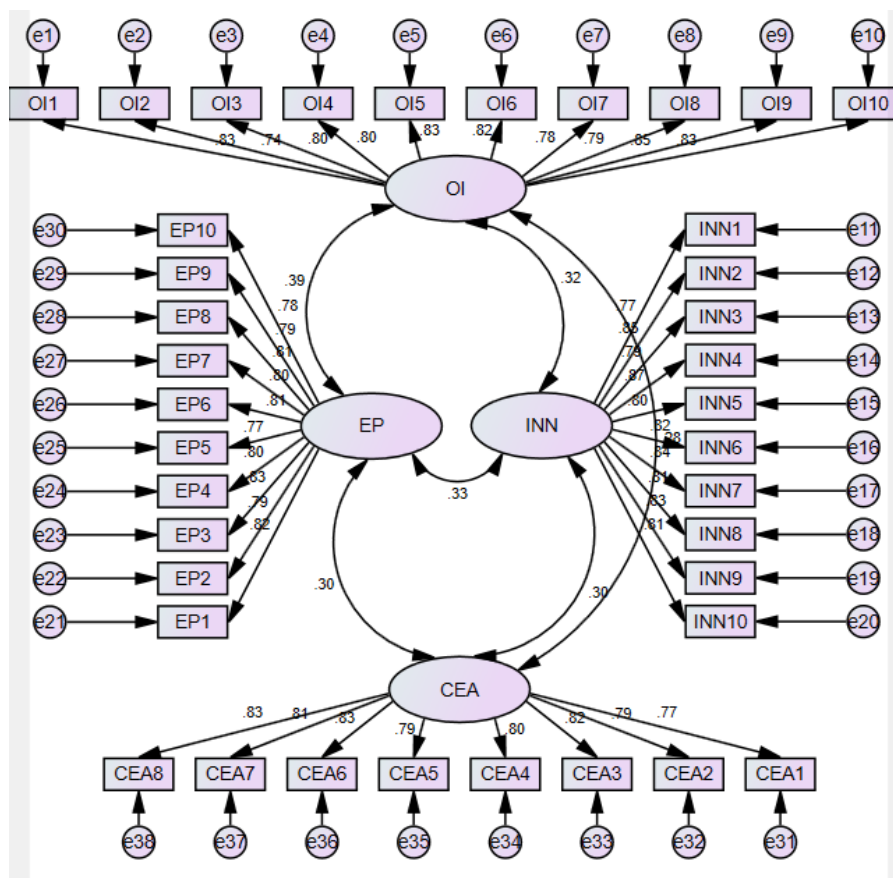
We assessed both the discriminant and convergent validity of the measurement model depicted in Figure 2. According to Steenkamp and Van Trijp (1991), convergent validity is verified by evaluating how closely each measurement is related to other observations of the same core factor and if the range of statements are consistent on a single factor across the estimation procedure. Convergent validity was assessed using the Hair et al. (2010) technique, which suggests that the average variance extracted (AVE) should be 0.5 or higher and that the composite reliability (CR) should be more than the AVE. According to Hair et al. (2010), discriminant validity is the lack of any association between several constructs, signifying that each notion is unique and distinguished by catching events that the other conceptions do not capture. The Hair et al. (2010) technique, which suggests that the maximum shared var-

iance (MSV) should be less than the average variance extracted (AVE), was used to evaluate discriminant validity. The model's constructs exhibit good dependability and distinct discriminant validity, as seen in Table 8. The results of confirmatory factor analysis (CFA) and exploratory factor analysis (EFA) offer strong evidence for the measurement model's discriminant validity. The CFA model is displayed in Figure 3.

Table 8 – Validity of the measurement model

	CR	AVE	MSV	MaxR(H)	EP	OI	INN	CEA
EP	0.947	0.640	0.154	0.947	0.800			
OI	0.950	0.653	0.154	0.951	0.393	0.808		
INN	0.953	0.671	0.110	0.954	0.331	0.325	0.819	
CEA	0.937	0.650	0.093	0.937	0.298	0.275	0.305	0.806

Figure 3 – CFA Model

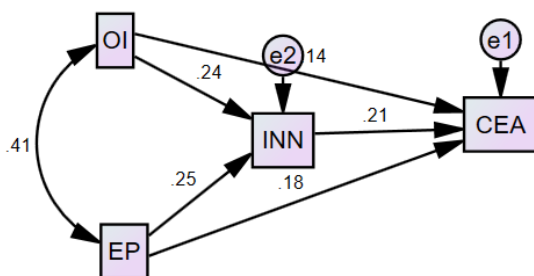


7.3. Hypotheses testing (structural model)

Direct relationship testing

To examine the relationship between organizational inclination (OI), Innovation (INN), External pressure (EP) and Circular Economy Adoption (CEA) in oil and gas industry we used the structural equation modelling using the AMOS path analysis by imputing the Factor Score from CFA using AMOS. As part of hypotheses testing, we tested INN as a mediator and EP and a moderator in relationship between OI and CEA. Figure 4 shows the graphical representation of structural model followed by results.

Figure 4 – Measurement model



The analysis reveals several significant relationships between variables. Organizational inclination (OI) has a positive impact on innovation (INN) with a standardized coefficient of .213, indicating that higher organizational inclination is associated with higher levels of innovation. This relationship is statistically significant, with a p-value less than .001. Similarly, external pressure (EP) positively influences innovation with a coefficient of .221, also significant at the $p < .001$ level, suggesting that increased external pressures lead to greater innovation within organizations.

In terms of circular economy adoption (CEA), organizational inclination contributes positively, though the effect is relatively weaker with a coefficient of .132 and a p-value of .034. This indicates a significant but modest relationship between organizational inclination and the adoption of circular economy practices. External pressure also impacts circular economy adoption, with a coefficient of .165 and a p-value of .007, reinforcing the idea that external pressures can effectively encourage the adoption of these practices. Additionally, innovation plays a crucial role in promoting circular economy adoption, evidenced by a significant coefficient of .213 and a p-value of .002, suggesting that innovations within an organization significantly boost the adoption of circular economy practices. Table 9 shows Direct relationship Hypothesis testing.

Table 9 – Hypothesis testing results

H. No.	Paths	Estimate	S.E.	C.R.	P	Remarks
H1	EP→INN	0.221	.059	3.771	<0.001***	H1 Supported
H2	OI→INN	0.213	0.059	3.583	<0.001***	H2 Supported
H3	EP→CEA	0.165	0.062	2.675	.007**	H3 Supported
H4	OI→CEA	0.132	0.062	2.122	0.034*	H4 Supported
H5	INN→CEA	0.213	0.067	3.153	0.002**	H5 Supported

***<.001, **<.01, *<.05

Mediation testing

The mediation analysis is conducted by treating OI, EP as independent variables, CEA as dependent variable, and INN as mediator. The mediation analysis is based on the analysis of indirect effects based on the guideline by Baron and Kenny (1986) classical approach We performed mediation analysis by using the direct and indirect effects based on bootstrap procedures (2000 samples) and bias-corrected bootstrap confidence interval (90%). The results are provided in the following table.

Table 10 – Mediation Analysis

H. No.	Path	Total Effects	Direct Effects	Indirect Effects	Remarks
H6	OI→INN→CEA	0.212**	0.165*	0.047***	H6 Supported
H7	EP→INN→CEA	0.178**	0.132*	0.045***	H7 Supported

***<.001, **<.01, *<.05

Hypothesis H6, examined the pathway from Organizational Inclination (OI) through Innovation (INN) to Circular Economy Adoption (CEA). The findings revealed a total effect of 0.212, significant at the .01 level, indicating a strong combined influence of direct and mediated paths from OI to CEA. The direct effect of OI on CEA was also significant at the .05 level with a value of 0.165, suggesting that organizational inclination has a substantial independent impact on circular economy adoption. Furthermore, the indirect effect through innovation was highly significant at the .001 level with a value of 0.047, highlighting that a notable portion of OI’s impact on CEA is mediated by innovation. These results support H6, confirming that innovation mediates the effect of organizational inclination on circular economy adoption.

Hypothesis H7, focused on the impact of External Pressure (EP) on Circular Economy Adoption (CEA) through the mediator Innovation (INN). This analysis demonstrated a total effect of 0.178, significant at the .01 level, reflecting a robust overall influence of EP on CEA through both direct and mediated routes. The direct effect of EP on CEA was significant at the .05 level, recorded at 0.132, indicating that external pressure directly and significantly promotes circular economy adoption. The indirect effect, significant at the .001 level with a value of 0.045, confirmed that a significant portion of EP’s influence on CEA is channeled through innovation. This

result lends support to H7, verifying that innovation acts as a critical mediator in the relationship between external pressure and circular economy adoption.

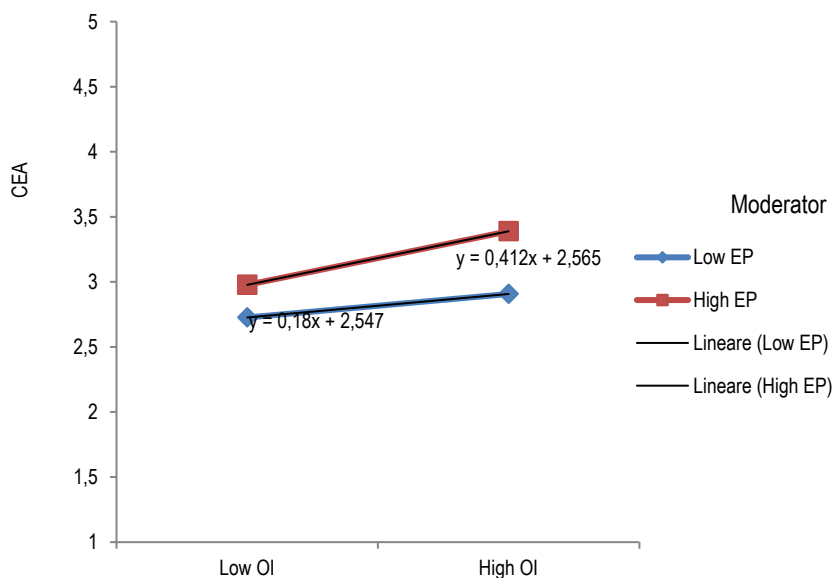
Moderation Testing

The moderation analysis is conducted by treating OI and INN as independent variables, CEA as dependent variable, and EP as moderator variable. The results are calculated by creating interaction terms from standardized score of variables using SPSS. We tested EP as moderator, results indicate interaction term of EP and OI exert positive but insignificant influence on CEA.

Table 11 – Moderation Testing

H. No.	Interaction	Estimate	S.E.	C.R.	P	Remarks
H8	EP*OI→CEA	0.058	0.063	0.926	0.355	Not Supported

Figure 5 – Interaction graph – External pressure (EP) as Moderator between Organizational Inclination (OI) and Circular Economy Adoption (CEA)



8. Results and discussion

The analysis of the structural equation modeling provided robust evidence for significant relationships between organizational inclination (OI), external pressure (EP), innovations (INN), and circular economy adoption (CEA) within the MENA region's oil and gas sector. Specifically, Hypotheses H1 through H5 were validated, confirming that OI and EP significantly drive innovation with standardized coefficients of 0.213 and 0.221, respectively, both significant at less than 0.001. This indicates a strong impetus for innovation influenced by both internal dispositions and external demands. Furthermore, EP and OI were found to have direct, positive impacts on CEA, with coefficients of 0.165 and 0.132 and p-values of 0.007 and 0.034, respectively, underlining a modest yet significant direct relationship between these pressures and the adoption of circular economy practices.

Moreover, innovation emerged as a crucial mediator, significantly bridging the gap between internal and external motivators and the adoption of circular economy principles, as evidenced by a significant coefficient of 0.213 and a p-value of 0.002 for Hypothesis H5. The mediation analysis (H6 and H7) further supported this, revealing robust indirect effects where OI and EP influence CEA significantly through INN, with total effects recorded at 0.212 and 0.178, respectively. Both direct and indirect effects were significant, highlighting innovation's role not merely as a byproduct but as a necessity for integrating sustainable practices effectively within the sector.

Contrastingly, the moderation hypothesis (H8) tested whether external pressure (EP) could intensify the impact of organizational inclination (OI) on circular economy adoption (CEA). The results indicated an insignificant interaction effect ($p = 0.355$), suggesting that while external pressures do shape organizational strategies towards sustainability, they do not significantly amplify the impact of organizational inclination on the adoption of circular economy practices within the studied context.

These findings elucidate the complex interplay of internal motivations and external pressures in fostering sustainable practices within the oil and gas industry. They extend previous research, offering a clearer understanding of the mechanisms through which the sector can progress towards sustainability. The significant roles of innovation and external pressure reflect the industry's dynamic response to global sustainability trends and regulatory pressures, making this study particularly relevant for policymakers and corporate strategists focused on enhancing sustainability initiatives in resource-intensive industries.

9. Implication

The practical implications of this study are significant for the oil and gas sector in the MENA region, emphasizing the critical role of innovation in driving the adoption of circular economy practices. Companies should invest in innovative technologies and processes that facilitate recycling, reduce resource consumption, and improve efficiency. This investment not only aligns with global environmental standards but also positions firms to leverage regulatory pressures as a catalyst for sustainable growth, enhancing competitiveness in an increasingly eco-conscious market.

This research contributes to academic literature by delineating the mediation role of innovation between organizational inclination and external pressures, and their collective impact on circular economy adoption. It provides empirical evidence that supports the theoretical linkages within circular economy frameworks, particularly in resource-intensive industries. Future studies could explore these relationships in different contexts or industries, thereby testing the generalizability of these findings and further refining the theoretical models that govern sustainable business practices.

From a managerial perspective, the findings underscore the necessity for strategic alignment of innovation initiatives with organizational goals towards sustainability. Managers should prioritize fostering an internal culture that actively supports sustainable practices through continuous training, rewards, and leadership engagement. Additionally, understanding the external pressures and effectively utilizing them can enhance the organization's sustainability efforts, turning compliance into opportunity. Managers can leverage these insights to better navigate the complex landscape of regulatory requirements and market expectations.

10. Limitations and future research direction

This study, while insightful, has several limitations that offer avenues for future research. Firstly, the convenience sampling method, although practical, may limit the generalizability of the findings across the broader oil and gas industry in the MENA region. Future studies could employ a stratified random sampling technique to enhance the representativeness of the sample. Additionally, the study's reliance on self-reported data could introduce response bias. Implementing methods such as triangulation, involving secondary data analysis, could provide more robust validation of the findings. Furthermore, this research focused primarily on the MENA region, which, while providing critical insights, also limits the applicability of the findings to other geographical areas with different regulatory and cultural contexts. Subsequent research might explore similar models in different global contexts or compare regions to explore how regional variations influence the adoption of circular economy practices. Lastly, the impact of technological advancements and digital transformation on the adoption of circular economy practices remains an underexplored area that could significantly advance our understanding of sustainable practices in the oil and gas industry.

11. Conclusion

This study successfully explored the influence of organizational inclination and external pressures on the adoption of circular economy practices within the MENA region's oil and gas sector, highlighting the pivotal role of innovation as a mediator. The findings reveal that both internal motivations and external demands robustly drive sustainable practices through innovative processes. These insights not only enrich the academic discourse around sustainable development in resource-intensive industries but also provide practical strategies for companies aiming to enhance their environmental footprint. This research serves as a foundation for further inquiry into sustainable practices across different regions and industries.

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Appendix

Table A1 – Detailed literature review table

Author Name (APA)	Journal Name	Methodology	Identified Constructs	Objective	Findings
Faisal-E-Alam et al. (2024)	<i>Sustainability</i>	Survey (n = 280), regression analysis	Environmental consciousness, Innovation propensity, Leadership commitment, Training and development	To examine individual and organizational factors influencing CE implementation in Bangladeshi SMEs	Both individual and organizational factors significantly predict CE adoption.
Al Rawashdeh et al. (2024)	<i>International Journal of Organizational Analysis</i>	Survey (n = 438), SEM	Top management commitment, Organisational motivation	To assess impact of leadership and motivation on CE adoption in UAE SMEs	Motivation partially mediates leadership impact; both constructs positively influence CE.
Kirchherr et al. (2018)	<i>Ecological Economics</i>	Survey (n = 208), 47 interviews	Cultural, Market, Governmental, Technological barriers	To identify CE barriers in the EU	Cultural and market barriers dominate; tech barriers not significant.
Agyemang et al. (2019)	<i>Management Decision</i>	Survey and interviews	Drivers: Profit, Cost reduction, Environment; Barriers: Awareness, Cost, Expertise	To identify CE drivers and barriers in Pakistan's auto industry	Profit and cost savings drive CE; lack of awareness and expertise are key barriers.
Tura et al. (2019)	<i>Journal of Cleaner Production</i>	36 interviews, 4 case orgs	Environmental, Economic, Social, Political, Tech, Supply chain, Org. factors	To develop framework of CE drivers and barriers	Practical framework offered; barriers and drivers vary across areas.
Liu & Bai (2014)	<i>Resources, Conservation and Recycling</i>	Survey (n = 157), interviews	Awareness vs. behavior gap	To explore awareness and behavior gap in CE in China	Firms aware but not proactive; reasons for gap explored.
Mura et al. (2020)	<i>Journal of Cleaner Production</i>	Multi-method: survey, interviews, FGDs	CE practices, Barriers, Enablers, Strategy-performance link	To explore CE actions and perceptions in Italian SMEs	Waste separation common; resource saving rare; CE seen as opportunity.
Akinwale (2024)	<i>Problems and Perspectives in Management</i>	Survey (n = 301), logistic regression	Awareness, Leadership, Training, Finance, Tech, Product upgrade	To assess CE awareness and its effect on performance in Saudi MSMEs	Awareness high; adoption low; drivers improve financial performance.
Ormazabal et al. (2018)	<i>Journal of Cleaner Production</i>	Survey in Spain, Factor analysis	CE perception: Material, Reuse, Finance; Barriers: Hard, Human-based	To explore CE challenges and potential in Spanish SMEs	Cost-saving focus; barriers categorized for tailored solutions.
Soni et al. (2023)	<i>Journal of Business Research</i>	Semi-structured interviews (n = 30)	Distributed leadership, Collaboration, Delegation, Trust	To examine leadership influence on CE in Indian SMEs	Distributed leadership promotes CE adoption through empowerment.
Castro-Lopez et al. (2023)	<i>Journal of Business Research</i>	Survey (n = 218)	Institutional pressures, Organizational agility	To test external/internal factors influencing CE at strategic level	Organizational capability drives innovation; external forces affect recycling.
Assmann et al. (2023)	<i>Business Strategy and the Environment</i>	Systematic literature review (67 articles)	54 determinants across 8 categories	To review CE business model adoption factors	Comprehensive categorization of drivers and barriers.
Govindan & Hasanagic (2018)	<i>International Journal of Production Research</i>	Systematic review	Drivers, Barriers, Practices in supply chain	To map CE trends in supply chains	Government role most impactful for CE success.
Sohal et al. (2022)	<i>Journal of Business Research</i>	Qualitative, 4 SME case studies	STS theory, Motivation, Enablers, Strategy	To study CE transition in Indian SMEs	CE practices informal; social and technical factors key.

Author Name (APA)	Journal Name	Methodology	Identified Constructs	Objective	Findings
Kwarteng et al. (2022)	<i>Social Responsibility Journal</i>	Survey (n = 617)	CE initiatives, Organizational culture	To assess CE effects on financial performance in Ghana	CE improves financials; culture strengthens positive effect.
Ali et al. (2024)	<i>Sustainable Futures</i>	Survey (n = 200), SEM	Gov. support, Org. culture, CE, Eco-innovation	To evaluate mediators between support and sustainable performance	CE and EI mediate effects of support; culture plays direct role.
Barros et al. (2021)	<i>Cleaner Environmental Systems</i>	Systematic review	CE impact across 10 business areas	To map CE influence across business functions	Key-impact map developed for strategic integration.
Barboza et al. (2022)	<i>Revista de Administração de Empresas</i>	Multi-method, Case study	29 organizational values	To identify values that support CE culture	HRM crucial for nurturing circular values.
Teixeira (2025)	<i>Merits</i>	Statistical analysis using Eurostat	SHRM strategies, Green skills, Circular materials	To compare CE workforce strategy in Portugal vs. Sweden	Sweden outperforms; SHRM vital to SDGs.
Sivula (2021)	Unpublished (case study)	Case study of 10 forestry firms	CBMI process, External/internal barriers	To study CE innovation in Finnish forestry	Linear model structures hinder CE innovation.
Bocken et al. (2018)	<i>Environmental Innovation and Societal Transitions</i>	Action research, 8 case studies	Business model experimentation	To explore experimentation in CE transitions	Iterative learning and collaboration are key enablers.
Segarra-Blasco et al. (2024)	<i>Business Strategy and the Environment</i>	Merged Flash Eurobarometer surveys (2015, 2017, 2021); Factor analysis; Multivariate probit model	Knowledge spillovers, Environmental spillovers	To analyze institutional factors influencing CE adoption in European SMEs	Both spillovers positively influence CE; environmental impact is increasing over time.
Castro-Lopez et al. (2023)	<i>Journal of Business Research</i>	Survey (n = 218), Model testing	Institutional pressures (mimetic, coercive, social), Organizational agility	To examine how pressures and capabilities affect circular business model and practices	Capabilities impact innovation/production; external pressures affect recycling.
Ranta et al. (2018)	<i>Resources, Conservation and Recycling</i>	Multiple case study across China, US, Europe	Institutional drivers and barriers	To compare CE drivers/barriers across regions	Recycling dominant due to regulation; reuse hindered by cultural norms; China relies more on informal sector.
Calzolari et al. (2023)	<i>Journal of Cleaner Production</i>	Delphi-like panel (30 experts), Qualitative synthesis	Institutional pressures, Supply chain integration	To explore how pressures and integration affect CE practice adoption	Coercive pressures most impactful; integration promotes incremental CE but may hinder radical shifts.
De Jesus & Mendonca (2018)	<i>Ecological Economics</i>	Literature synthesis	Eco-innovation drivers/barriers	To understand factors influencing CE via eco-innovation	Transformative innovation essential; framework aids in designing supportive policy.
Jain et al. (2020)	<i>Business Strategy and the Environment</i>	Survey (n = 280), Moderated mediation analysis	Institutional pressures, EMS, Organizational flexibility	To examine how pressures and flexibility affect CE via EMS	Flexible orgs leverage EMS more effectively to achieve CE goals.
Melati et al. (2022)	<i>Stockholm Environment Institute</i>	Policy brief (qualitative insights)	Drivers: Info access, Consumer/supplier/investor support; Barriers: Finance, Knowledge, Policy	To identify barriers/drivers to CE in enterprises	Firms aware of CE benefits but lack support; knowledge and finance are key barriers.
Jakhar et al. (2019)	<i>Management Decision</i>	Survey, SEM	Stakeholder pressure, Innovation capability (exploratory/exploitative)	To explain CE adoption heterogeneity under stakeholder pressure	Exploratory innovation fosters CE adoption; exploitative hinders it.

Author Name (APA)	Journal Name	Methodology	Identified Constructs	Objective	Findings
Ting et al. (2024)	Environment, Development and Sustainability	Survey (n = 102), PLS-SEM	Motivators, Barriers	To assess CE adoption and impact on sustainable production in Malaysia	Motivators aid CE adoption and sustainability; barriers inhibit both.
Moktadir et al. (2018)	Journal of Cleaner Production	Graph theory, Matrix approach	Drivers of sustainable manufacturing	To prioritize CE drivers in Bangladesh leather sector	CE knowledge key to sustainability; guides strategy formulation.
Schmidt et al. (2021)	Business Strategy and the Environment	Survey (n = 121), SEM	Market orientation, Closed-loop orientation	To study mediation of closed-loop between market and CE practice	Closed-loop orientation mediates market orientation's impact on CE implementation.
Nassani et al. (2023)	Sustainability	Survey (n = 273), SPSS, SEM	Institutional pressures, Zero waste, Enviropreneurship	To assess mediating/moderating role in CE target performance	Zero waste mediates; enviropreneurship moderates positive CE outcomes.
Agyabeng-Mensah et al. (2024)	Business Strategy and the Environment	Survey (n = 290), PLS-SEM	Stakeholder pressure, EIEC, CIO	To study how pressure drives CSC practices in Ghana SMEs	Pressure drives CSC; EIEC weakens link, CIO enhances it.
Wang et al. (2022)	Not specified	Literature synthesis	CE strategies across sectors	To assess CE as a climate strategy	CE complements decarbonization; most impact from design and consumption-side measures.
Rizos et al. (2016)	Sustainability	Literature review and SME case analysis	Barriers: Finance, Skills; Enablers: Consumer demand, Market value, Policy support	To identify barriers and enablers for CE in SMEs	Barriers remain despite awareness; policy needed to boost enabling conditions.
Sanchez-Garcia et al. (2024)	Environmental Technology & Innovation	Bibliometric analysis	Technologies (AI, blockchain), Resource efficiency, Sustainable models	To explore challenges and opportunities of integrating new tech in CE	New tech enables CE advancement but faces skill gaps and regulatory barriers.
Matameh et al. (2024)	Environmental Technology & Innovation	Survey (n = 256)	I4.0, Green Supply Chain Integration (GSCI), Sustainable SC Flexibility (SSCF), CE Capabilities	To assess I4.0, GSCI, SSCF impacts on CE capabilities and corporate sustainability	All elements positively influence CE capabilities and sustainability.
Laskurain-Iturbe et al. (2021)	Journal of Cleaner Production	Survey (n = 120), 27 case studies	I4.0 techs (e.g., AI, robotics), CE activities (reduce, reuse, recycle)	To assess I4.0 technologies' influence on CE actions	Additive manufacturing and robotics show strongest CE impact.
Despoudi et al. (2023)	Annals of Operations Research	15 semi-structured interviews, Thematic + cluster analysis	Barriers/enablers to I4.0-CE integration in food SMEs	To explore CE via I4.0 adoption in Indian food SMEs	Identified key resource and capability needs; CE boosts competitiveness.
Luthra et al. (2021)	Journal of Cleaner Production	Editorial review of 21 studies	I4.0, Cleaner Production, CE dimensions	To summarize I4.0-CE-CP theoretical and empirical intersections	Decision-based studies most common; integration promising but underexplored.
Perotti et al. (2025)	Business Ethics, the Environment & Responsibility	Multiple case study (13 orgs)	Open innovation, Circular supply chain/ecosystem	To explore collaborative open innovation for CE	Two OI pathways (supply chain/ecosystem) support circular production.
Dorrego-Viera et al. (2025)	Journal of Innovation & Knowledge	Multiple case study (4 firms)	Open innovation, Technical barriers	To assess how OI supports circular product development	Inbound OI helps overcome barriers; co-creation and university ties vital.
Yin et al. (2025)	Journal of Innovation & Knowledge	Panel data (2003-2022), Two-way fixed effects model	Open innovation, CE practices, Green patents	To quantify OI's effect on CE in Chinese firms	OI boosts CE via patents and collaboration; regional effects matter.

Author Name (APA)	Journal Name	Methodology	Identified Constructs	Objective	Findings
Jesus et al. (2025)	Creativity and Innovation Management	Survey (n = 163), SEM	Open innovation, I4.0, Absorptive capacity	To examine how OI and I4.0 drive CE implementation	OI and I4.0 positively influence CE; absorptive capacity not significant.
Ai et al. (2024)	IEEE Trans. on Engineering Management	Panel data (284 Chinese prefectures)	CE pilot policy, Green innovation	To assess CE policy's effect on innovation	Policy boosts green patents; stronger in developed and southern cities.
Linder & Willander (2017)	Business Strategy and the Environment	Longitudinal action research	Circular business models, Uncertainty	To identify CE model transformation challenges	Uncertainty hinders CE; capital-intensive models are risky but overcome in some cases.
Geissdoerfer et al. (2023)	Business Strategy and the Environment	Comparative literature review + 21 cases	Drivers/barriers for CBMI types	To categorize CBMI drivers/barriers	Startups driven by markets; incumbents face internal/market/legal barriers.
Pieroni et al. (2021)	Journal of Cleaner Production	Multidimensional scaling of 180 CE firms	Sectoral BM patterns	To reduce uncertainty in sector-specific CBM innovation	Sector patterns help visualize and implement CE models.
Lüdeke-Freund et al. (2019)	Journal of Industrial Ecology	Morphological analysis (26 models)	6 CE business model patterns	To consolidate CE business model types	Six main patterns support CE (e.g., remanufacture, reuse, recycle).
Frishammar & Parida (2019)	California Management Review	Multiple case study (8 firms)	Transformation roadmap	To develop CE model transformation steps	Stepwise roadmap helps incumbents shift to circular models.
de Padua Pieroni et al. (2019)	Proc. of Design Society: Int. Conf. on Engineering Design	Design research methodology	CEBM configurator tool	To support CE business model development	Proposed tool meets practical and conceptual CE model needs.
Franco (2017)	Journal of Cleaner Production	Multiple case studies (Cradle to Cradle firms)	Micro-level CE challenges	To analyze textile firms' CE struggles	Collaboration and product design complexity affect CE implementation speed.