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Circular Economy Challenges within the Road Freight Transport: Case Study of Portuguese Companies

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Abstract

Nowadays, environmental concerns have significantly influenced business management and societal practices, leading to a strong focus on minimizing environmental damage and embracing sustainable development. This has prompted the adoption of greener supply chain practices and the transition towards a circular economy (CE). Companies are under pressure to incorporate green innovation practices, aiming for environmentally friendly and low-carbon development. This research aligns with the principles of the CE, an emerging economic model that emphasizes resource preservation and energy efficiency. CE is also recognized as a key driver for achieving sustainable development goals. However, the road freight transport sector, which is vital for goods transportation, faces challenges in becoming more sustainable due to its significant greenhouse gas emissions. This study analyzes the feasibility of achieving both environmental and financial sustainability in the road freight transport sector in Portugal. This piece of research aims to determine if combining these two concepts is practically viable and explores how transitioning to a circular economy can generate value and enhance environmental sustainability in the sector.

Drawing upon the interview results, existing literature, and principles of the circular economy, an analysis was conducted to understand the current obstacles faced by companies in the sector and explore potential solutions. The main findings indicate that implementing the circular economy in the sector requires better technological advancements to ensure the use of fully renewable energy sources and facilitate the reuse of materials in vehicles. Additionally, it is crucial for all stakeholders to participate actively, as the transition to a circular economy is a structural change that necessitates collective efforts from everyone involved.

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1. Introduction

The growing environmental concerns directly impact business management and social practices, prompting a strong emphasis on minimizing environmental harm, such as climate change, resource depletion, and pollution [1], [2]. This pressure has driven the adoption of greener supply chain practices to achieve sustainable development and transition towards a circular economy (CE). Companies face internal and external pressures to incorporate green innovation practices, leading to a global focus on pursuing environmentally friendly, low-carbon development [3], [4]. Within this context, companies are increasingly oriented toward production improvement by using sustainable and efficient resources to reduce environmental impact and shift to achieve a closed-loop supply chain, called a CE.

This research aligns with the principles of Circular Economy CE, an emerging economic model centered around establishing a cycle that preserves resources and energy [5], [6]. By prioritizing recycling and reuse, the CE aims to minimize waste generation, reduce greenhouse gas emissions, and use resources. This innovative production model holds the potential to mitigate environmental impacts while driving economic growth [7]–[9]. Furthermore, the CE facilitates the transition towards a more sustainable system, as it has been recognized as a key driver for achieving the United Nations' sustainable development goals in 2019 [3].

Trying to apply these concepts to road freight transport, it can be seen that these vehicles are responsible for emitting large amounts of greenhouse gases, yet they are essential for transporting goods [10]–[12]. Within this context, freight vehicles and the companies that use them face obstacles that jeopardize their attempts to be more sustainable [11], [13], [14].

This piece of research analyses the feasibility of achieving both environmental and financial sustainability for companies operating in the road freight transport sector in Portugal. The study aims to determine whether it is practically feasible to reconcile these two concepts and whether companies can effectively combine environmental and financial sustainability. Additionally, the research aims to explore how the transition from a linear economy to a CE can generate value and contribute to the environmental sustainability of companies within the road freight transport sector.

2. Theoretical Background

The Sustainable Development Goals (SDGs) and the CE are both important frameworks that aim to address the pressing challenges facing our planet and promote sustainable development. The SDGs, adopted by all United Nations member states in 2015, provide a comprehensive roadmap for achieving a more equitable, inclusive, and environmentally sustainable world by 2030 [15]–[17]. The CE, on the other hand, is an economic model that seeks to transform the way we produce, consume, and manage resources. It is based on the principles of designing out waste and pollution, keeping products and materials in use for as long as possible, and regenerating natural systems. By transitioning from the traditional linear "take-make-dispose" model to a circular one, resource extraction can be reduced, waste generation minimized, and a more sustainable and resilient economy can be created [6], [18]–[22].

The CE and the SDGs are closely aligned and mutually reinforcing [22]. Many of the SDGs directly relate to the principles and objectives of the circular economy. For example, SDG 12 on responsible consumption and production specifically calls for the promotion of sustainable resource management, waste reduction, and recycling. Similarly, SDG 9 on industry, innovation, and infrastructure encourages the adoption of sustainable practices, including resource efficiency and cleaner production methods. On the other hand, the CE contributes to the achievement of the SDGs by offering practical solutions to some of the world's most pressing challenges. It helps address poverty (SDG 1) by creating new job opportunities. It supports sustainable cities and communities (SDG 11) by promoting efficient resource use, circular urban planning, and sustainable transportation. It also contributes to climate action (SDG 13) by reducing greenhouse gas emissions through practices such as energy-efficient manufacturing, recycling, and the use of renewable energy sources. Furthermore, the CE fosters innovation and collaboration, which are essential for achieving the SDGs [23]. It encourages cross-sectoral partnerships and knowledge sharing, promoting the development of sustainable technologies, business models, and practices. By adopting CE principles, businesses and

governments can drive sustainable innovation, improve resource efficiency, and enhance competitiveness in the global market [24], [25].

The integration of the circular economy into sustainable development strategies can lead to numerous benefits [26]–[28]. It can help create a more resilient and circular economy that is less dependent on finite resources, reducing environmental degradation and promoting long-term sustainability [29]. It can also contribute to social inclusiveness by providing opportunities for job creation, skills development, and economic empowerment [30]–[32].

Implementing circular economy principles in road freight transport is highly relevant for several reasons. Firstly, the road freight transport sector is a significant contributor to environmental pollution and resource depletion [11], [33]. By transitioning to a circular economy model, the sector can reduce its environmental footprint by minimizing waste generation, promoting the reuse and recycling of materials, and adopting more sustainable practices [34], [35]. On the other hand, circular economy practices in road freight transport can contribute to resource efficiency and cost savings. By optimizing the use of resources, such as fuel, packaging materials, and vehicle components, companies can reduce their operational costs and improve their overall efficiency [36], [37]. This can lead to significant economic benefits while reducing dependence on finite resources [38]. Furthermore, the circular economy can foster innovation and drive the development of new business models and technologies in the road freight transport sector [34]. By encouraging the reuse and remanufacturing of products and materials, companies can explore new revenue streams and create value from waste or discarded items [7], [14]. This can stimulate job creation and promote economic growth while reducing reliance on raw material extraction [22].

Implementing circular economy principles also enhances the resilience and sustainability of the road freight transport sector. By reducing waste generation and promoting resource conservation, companies can mitigate risks associated with resource scarcity, price volatility, and regulatory changes. This enables companies to adapt to evolving market conditions and enhance their long-term competitiveness [39].

Overall, implementing circular economy principles in road freight transport can bring about numerous benefits, including reduced environmental impact, improved resource efficiency, cost savings, innovation, and alignment with sustainability goals. By embracing circularity, the sector can contribute to a more sustainable and resilient future [10], [35], [38].

However, the implementation of circular economy principles in road freight transport faces several challenges that need to be addressed. One of the key challenges is the complex and fragmented nature of the supply chain in the transport industry. The involvement of multiple stakeholders, including manufacturers, distributors, retailers, and logistics providers, makes it difficult to coordinate efforts and align interests towards circularity [40]. Collaboration and cooperation among these stakeholders are essential to establish closed-loop systems and enable the reuse, repair, and recycling of products and materials [41]–[44]. Another challenge lies in the need for innovative business models and technologies that support circular practices in road freight transport. This includes the development of efficient reverse logistics systems, advanced tracking and tracing technologies, and the establishment of networks for sharing resources and optimizing transportation routes. Investment in infrastructure and equipment is required to facilitate the collection, sorting, and processing of materials for recycling or remanufacturing [45], [46]. Regulatory barriers can also hinder the adoption of circular economy practices in the road freight sector. Policies and regulations need to be revised and adapted to encourage and support sustainable practices, such as extended producer responsibility and the promotion of circular supply chains [47]–[49]. Additionally, there may be limited awareness and understanding of circular economy concepts within the industry. Education and training programs, along with information-sharing platforms, can help raise awareness and build capacity among industry stakeholders.

Addressing these challenges requires a multi-faceted approach that involves collaboration among stakeholders, supportive policies and regulations, technological advancements, and raising awareness about the benefits of circular economy practices in road freight transport. By overcoming these challenges, the industry can unlock opportunities for improved resource efficiency, reduced waste, and a more sustainable and resilient road freight sector. The combination of this practices may lead road freight companies to achieve both environmental and financial sustainability. However, there is not that much research in this direction. This piece of research aims to cover this gap.

3. Methodology

This research employs an exploratory case study methodology due to limited existing knowledge and the early stages of the study. Five Semi-structured interviews were conducted with heads of Portuguese road freight companies to identify challenges faced in improving financial and ecological performance. The interviews were conducted via online Zoom, with three companies allowing for recording and two not. The interviews were conducted using a predefined set of 17 open-ended questions based on literature and information from the sector and the companies. They cover aspects related to resource efficiency, environmental pollution, waste generation and innovation, grouped into 3 sections: management, ecologic products, and operations†.

The interviews aimed to gather information, maintain the conversation, and gain a comprehensive understanding of the current state of the sector.

4. Results

A comprehensive analysis was conducted on the results obtained from the interviews. All the respondents were managers in strategic position in the company analyzed. General details of the companies are shown in table 1. All of them correspond to companies operating in Portugal. Each manager's responses were individually analyzed for each topic, while maintaining the anonymity of the respondents.

Table 1. Characteristics of the sample companies

Company	Scope	Type of services	Number of vehicles	Number of employees	Turnover in 2021
1	National & international	Cargo of heating oil & storage of goods	410	470	22M€
2	Iberian Peninsula	General cargo & food sector	100	150	34M€
3	Iberian Peninsula & occasionally Europe	General cargo & logistics	1200	2361	242M€
4	Europe	General cargo & logistics	1200	1200	107M€
5	National & international	General cargo & special goods	350	550	65M€

The conclusions drawn pertain to the sector as a whole and do not specifically identify any particular company. The primary objective is to provide insights into the sector without compromising the privacy or confidentiality of any individual company.

4.1. Value chain and route definition

Companies have different processes for responding to demand, with three transporting general goods and two transporting both general and special goods. They receive orders digitally, using software to organize information and optimize routes for outbound and return trips. Key pillars considered are financial and legal factors, aiming to minimize fuel consumption and costs while maximizing legal driving time limits. Decision-making includes reducing kilometers traveled, fuel consumption, and managing driver hours. Companies can be categorized into regular and non-regular customers, with planning done well in advance.

Routing is organized in a consolidating manner, with different orders included in a single trip. Normal goods can be consolidated, while special goods require thorough engineering and logistics studies to ensure safe transportation

† More information about the questionnaire and the details of the responses, available upon request to the authors

and smooth unloading. Return routes differ for special and general goods transport, with approximately 80% of trips with special goods being empty due to delivery locations being far from urban areas and vehicles being equipped for the goods transported on the outbound trip. In contrast, general goods transport plans routes considering pickup locations, ensuring proximity and reducing empty kilometers

4.2. Alternative fuels

Fossil fuels remain the most advantageous choice for logistics, fuel consumption, vehicle performance, and prices among five companies. Gas vehicles are currently unviable due to increased gas prices, making them financially unviable for transporting special goods. Electric vehicles are not viable due to limited range and lack of charging infrastructure. Hydrogen and natural gas are considered promising alternatives due to environmental benefits and better performance, but improvements in vehicle availability, load capacity, and refueling infrastructure are needed.

4.3. Fleet renewal and vehicle recycling

Vehicle fleets vary among companies, with some having an average age of three years, others four, and others five years. Companies renew a portion of their fleet annually, with fuel consumption being the primary selection criterion. Vehicles contain recycled components, but manufacturers do not provide data on recycled materials. Transport companies buy new vehicles for improvements, driver conditions, and fuel consumption reduction. At the end of their lifespan, they have three options: enter a buyback agreement with manufacturers, sell used vehicles to third parties, or dispose of degraded vehicles as waste.

Both buybacks and sales to third parties are essential to give vehicles a second lifespan. Due to high demand and long delivery lead times, transport companies must be well-organized and attentive to their future needs to avoid resource shortages or outdated vehicles.

4.4. Ecologic footprint

Transport companies face challenges in measuring their ecological footprint, with two out of three companies not having an automated system. These companies are still in the discovery phase, focusing on operational questions like accident impact calculations. Internal efforts are being made within quality and environmental departments, while the third company does not show significant difficulties. Managers of companies without automated systems express a need for more training on the subject.

Reducing footprints is a different scenario, with all companies striving to be more environmentally friendly. They implement measures such as modern fleets, tire pressure control, and driver training. They also comply with energy audits and rationalization plans. Only one out of five companies publishes an annual sustainability report, while one is preparing to publish one.

4.5. Driver training

Transport companies are required to provide driver training every two years, with each company adapting its programs based on their specific needs. Manufacturers provide training to drivers and traffic managers when purchasing new trucks, focusing on efficient driving techniques. Data analysis from onboard computers helps identify drivers needing assistance, resulting in reduced costs, fuel consumption, and ecological impact. Safety is crucial in special goods transportation, with drivers needing knowledge of balance points, traction forces, friction forces, engineering, and electronics. Mandatory and periodic continuous training is essential for drivers to acquire these skills.

4.6. Circular Economy

The logistics chain in Portugal is crucial for a sustainable logistics chain, but transporters are often disrespected and have long waiting times for loading. This negatively impacts the environment and finances, as well as the destination location. The attitude towards transport is different in Portugal, with production prioritizing transportation

and companies seeking the cheapest options. Vehicles are acquired by manufacturers, complying with minimum legal requirements for recycling materials. However, manufacturers are partially limited in technology, and some products are not recyclable.

Companies are considering extending vehicle lifespans and servicing them every 100,000 kilometers. The industry paradigm is heavily reliant on manufacturers, and transport companies are reliant on manufacturers for vehicle acquisition. Four companies use renewable and non-renewable energy sources, with one increasing solar panels to achieve self-sufficiency. The fifth company relies solely on non-renewable sources.

4.7. Barriers to sector development

The transportation sector faces numerous challenges, including marginalization, lack of strategic thinking, and a shortage of skilled drivers. Drivers often face unfavorable conditions, such as inadequate facilities and personnel at loading and unloading sites. This lack of respect and respect for all stakeholders is crucial for significant development. Insufficient organization within the supply chain leads to limited productivity and unexpected costs for suppliers.

The shortage of skilled drivers is a significant concern, with long waiting times, limited restroom access, and disrespectful treatment from customers. Industry associations like Antram and Astic in Portugal and Spain negotiate with governments to address issues like load and unload times, but structural support from governments and the European Union is necessary for lasting change.

Fuel-related issues also raise concerns, with increasing fuel prices and the scarcity of fossil fuels. Companies must find ways to manage and adapt to these challenges. Additionally, the transportation sector is characterized by fragmentation, low specialization, and intense competition, which can hinder sustainable growth and development.

To address these challenges, collective efforts from industry stakeholders, governments, and regulatory bodies are needed. Implementing proactive policies, promoting coordination within the supply chain, and investing in alternative fuels and transportation technologies are essential steps towards a sustainable and efficient transportation sector.

4.8. Sustainable future of the sector

The transportation sector faces uncertainty regarding environmental sustainability in the future. Managers agree that awareness is crucial, but action must follow. Manufacturers play a crucial role in the sector, and change must start from the top of the supply chain. Transport companies must ensure clients are aware of the importance of transportation, as increasing control and security requirements may lead to competitors. Professional training for drivers is essential for efficient and sustainable transportation.

Fuels like gas and hydrogen are uncertain, but electric vehicles are not a viable option. Refueling infrastructure on highways faces logistical challenges, and reducing the number of diesel vehicles and increasing load capacity are important objectives. Gas and hydrogen vehicles have less power compared to diesel vehicles, resulting in lower load capacity. In the short term, diesel vehicles will dominate long-distance trips, but in the long term, all trips will be made using alternative fuels. Maintaining a low average fleet age is important for cleaner and more efficient technologies, while promoting vehicle reuse and increasing fleet age is another perspective.

5. Discussion

The study discusses the importance of environmental sustainability in the transportation sector, focusing on financial and environmental aspects. Carriers aim to reduce travel time and costs by reducing total kilometers and empty kilometers, which are beneficial in both financial and environmental aspects. They also emphasize improving customer satisfaction through fleet management software.

As the energy landscape evolves, carriers must be open and prepared for change, driven by scientific advancements in hydrogen technologies. However, there is still uncertainty in the sector, with managers holding different opinions due to the lack of options and studies.

Ecological and social focus are becoming important variables in the competitive landscape, with increasing demands from stakeholders. Fleet renewal becomes even more critical, considering environmental requirements.

Companies must always have vehicles equipped with the latest and most efficient technologies and engines. However, there is a trade-off between extending the lifespan of vehicles and increasing their ecological footprint over time. Reusing vehicle materials on a larger scale may be a solution, but this practice is still under development.

Ecological footprint is a topic of interest, as sustainability is currently much discussed but not adequately measured. Environmental indicators are useful tools for assessing ecological impact, but freight transport companies in Portugal are still in an early stage when it comes to measuring the environmental impacts of their activities.

In terms of driver training, understanding organizational values that stimulate sustainable innovation and attitudes is crucial for transitioning to a circular economy. Carriers should adapt organizational culture and maintain trust and respect with transporters.

The dependence on science and brand manufacturers is real, but it cannot be an excuse for carriers to remain passive in relation to this change of economic model. Carriers should focus on driver training, constant evaluation, energy self-sufficiency in warehouses, and measuring their ecological footprint. Doing the best possible with what you have is not only financial results and customer satisfaction but also the satisfaction of the planet.

6. Conclusion

This piece of research discusses the potential of the CE in solving environmental problems in the road freight transport sector while creating value for companies. The study examines three main questions and presents the following conclusions.

The CE offers solutions and challenges for both the environmental and financial aspects of the sector. Measures such as reusing vehicle materials, using renewable fuels, redefining routes, reducing empty kilometers, increasing load capacity per trip, achieving energy self-sufficiency in warehouses, measuring and improving ecological footprint can address the sector's environmental issues and have positive financial implications. However, challenges remain, including identifying sustainable future fuels, effectively measuring ecological footprints, making the profession of driver more attractive, fostering a holistic view among supply chain stakeholders, and extending the lifespan of materials for reuse in new vehicles.

Transport companies face challenges in implementing circular economy practices due to their dependency on suppliers and manufacturers. Stakeholder involvement is crucial, but their vehicle utilization experience can help address needs. High transition costs, scarcity of alternatives, customer demands, and financial constraints hinder immediate adoption.

The study suggests that circular economy (CE) can address environmental challenges in road freight transport by maximizing resource efficiency, reuse, and environmental preservation. Collaboration among suppliers, manufacturers, transport companies, and customers is crucial, with science, manufacturers, and government support playing vital roles. Sustainability should be a shared objective among all stakeholders.

7. Limitations, contributions and recommendations

This study faces limitations, including difficulty in contacting and conducting interviews with carriers, limited sample size, and qualitative nature.

Findings cannot be generalized to a larger population or context, but provide a deeper understanding of the case. The study raises awareness among carriers and manufacturing brands on sustainability and proposes multiple potential solutions.

Future research should include manufacturing companies, as they play a pivotal role in driving the transition towards a CE model.

8. References

[1] I. E. Nikolaou and T. A. Tsalis, “What does corporate strong sustainability actually mean in the real market world? A response to Bjørn and Røpke,” *Journal of Cleaner Production*, vol. 247. 2020. doi: 10.1016/j.jclepro.2019.119149.

[2] S. Pizzi, F. Rosati, and A. Venturelli, “The determinants of business contribution to the 2030 Agenda:

Introducing the SDG Reporting Score," *Bus. Strateg. Environ.*, vol. 30, no. 1, pp. 404–421, 2021, doi: 10.1002/bse.2628.

[3] E. D. de Souza, J. C. Kerber, M. Bouzon, and C. M. T. Rodriguez, "Performance evaluation of green logistics: Paving the way towards circular economy," *Clean. Logist. Supply Chain*, vol. 3, p. 100019, Mar. 2022, doi: 10.1016/J.CLSCN.2021.100019.

[4] K. Campbell-Johnston, W. J. V. Vermeulen, D. Reike, and S. Brullot, "The Circular Economy and Cascading: Towards a Framework," *Resources, Conservation and Recycling: X*, vol. 7. Elsevier B.V., Sep. 01, 2020. doi: 10.1016/j.rcrx.2020.100038.

[5] D. Alba-Patiño *et al.*, "Social indicators of ecosystem restoration for enhancing human wellbeing," *Resour. Conserv. Recycl.*, vol. 174, Nov. 2021, doi: 10.1016/J.RESCONREC.2021.105782.

[6] A. Halog and S. Anieke, "A Review of Circular Economy Studies in Developed Countries and Its Potential Adoption in Developing Countries," *Circ. Econ. Sustain.*, vol. 1, no. 1, pp. 209–230, 2021, doi: 10.1007/s43615-021-00017-0.

[7] B. Kalar, K. Primc, R. S. Erker, M. Dominko, and M. Ogorevc, "Circular economy practices in innovative and conservative stages of a firm's evolution," *Resour. Conserv. Recycl.*, vol. 164, Jan. 2021, doi: 10.1016/j.resconrec.2020.105112.

[8] F. Di Maio, P. C. Rem, K. Baldé, and M. Polder, "Measuring resource efficiency and circular economy: A market value approach," *Resour. Conserv. Recycl.*, vol. 122, pp. 163–171, 2017, doi: 10.1016/j.resconrec.2017.02.009.

[9] M. Del Giudice, R. Chierici, A. Mazzucchelli, and F. Fiano, "Supply chain management in the era of circular economy: the moderating effect of big data," *Int. J. Logist. Manag.*, 2020, doi: 10.1108/IJLM-03-2020-0119.

[10] P. Centobelli, R. Cerchione, and E. Esposito, "Environmental sustainability in the service industry of transportation and logistics service providers: Systematic literature review and research directions," *Transp. Res. Part D Transp. Environ.*, vol. 53, pp. 454–470, Jun. 2017, doi: 10.1016/j.trd.2017.04.032.

[11] T. Meyer, "Decarbonizing road freight transportation – A bibliometric and network analysis," *Transp. Res. Part D Transp. Environ.*, vol. 89, p. 102619, Dec. 2020, doi: 10.1016/J.TRD.2020.102619.

[12] P. Centobelli, R. Cerchione, and E. Esposito, "Pursuing supply chain sustainable development goals through the adoption of green practices and enabling technologies: A cross-country analysis of LSPs," *Technol. Forecast. Soc. Change*, vol. 153, no. January, 2020, doi: 10.1016/j.techfore.2020.119920.

[13] O. S. Oduniyi, "Factors Driving the Adoption and Use Extent of Sustainable Land Management Practices in South Africa," *Circ. Econ. Sustain. 2021 22*, vol. 2, no. 2, pp. 589–608, Nov. 2021, doi: 10.1007/S43615-021-00119-9.

[14] I. Uvarova, D. Atstaja, T. Volkova, J. Grasis, and I. Ozolina-Ozola, "The typology of 60R circular economy principles and strategic orientation of their application in business," *J. Clean. Prod.*, vol. 409, p. 137189, Jul. 2023, doi: 10.1016/J.JCLEPRO.2023.137189.

[15] I. S. Rampasso *et al.*, "Analysis of the perception of engineering students regarding sustainability," *J. Clean. Prod.*, vol. 233, pp. 461–467, 2019, doi: 10.1016/j.jclepro.2019.06.105.

[16] D. Le Blanc, "Towards Integration at Last? The Sustainable Development Goals as a Network of Targets," *Sustain. Dev.*, vol. 23, no. 3, pp. 176–187, 2015, doi: 10.1002/sd.1582.

[17] F. Rosati and L. G. D. Faria, "Business contribution to the Sustainable Development Agenda: Organizational factors related to early adoption of SDG reporting," *Corp. Soc. Responsib. Environ. Manag.*, vol. 26, no. 3, pp. 588–597, May 2019, doi: 10.1002/csr.1705.

[18] European Commission, "Next Steps for a Sustainable European Future. European Action for Sustainability: European action for sustainability," p. 19, 2016.

[19] I. E. Nikolaou, N. Jones, and A. Stefanakis, "Circular Economy and Sustainability: the Past, the Present and the Future Directions," *Circ. Econ. Sustain.*, vol. 1, no. 1, pp. 1–20, Jun. 2021, doi: 10.1007/S43615-021-00030-3.

[20] D. Mulvaney, R. M. Richards, M. D. Bazilian, E. Hensley, G. Clough, and S. Sridhar, "Progress towards a circular economy in materials to decarbonize electricity and mobility," *Renew. Sustain. Energy Rev.*, vol. 137, Mar. 2021, doi: 10.1016/j.rser.2020.110604.

[21] R. Ajwani-Ramchandani, S. Figueira, R. Torres de Oliveira, and S. Jha, "Enhancing the circular and modified linear economy: The importance of blockchain for developing economies," *Resour. Conserv. Recycl.*, vol. 168, p. 105468, May 2021, doi: 10.1016/J.RESCONREC.2021.105468.

[22] P. Schroeder, K. Anggraeni, and U. Weber, "The Relevance of Circular Economy Practices to the Sustainable Development Goals," *J. Ind. Ecol.*, vol. 23, no. 1, pp. 77–95, Feb. 2019, doi: 10.1111/JIEC.12732.

[23] S. Witjes and R. Lozano, "Towards a more Circular Economy: Proposing a framework linking sustainable public procurement and sustainable business models," *Resour. Conserv. Recycl.*, vol. 112, pp. 37–44, Sep. 2016, doi: 10.1016/j.resconrec.2016.04.015.

[24] M. T. Bosch-Badia, J. Montllor-Serrats, and M. A. Tarrazon-Rodon, "Corporate social responsibility: A real options approach to the challenge of financial sustainability," *PLoS One*, vol. 10, no. 5, May 2015, doi: 10.1371/JOURNAL.PONE.0125972.

[25] P. P. Walsh, E. Murphy, and D. Horan, "The role of science, technology and innovation in the UN 2030 agenda," *Technol. Forecast. Soc. Change*, vol. 154, May 2020.

[26] Y. Fan and C. Fang, "Circular economy development in China-current situation, evaluation and policy implications," *Environ. Impact Assess. Rev.*, vol. 84, Sep. 2020, doi: 10.1016/J.EIAR.2020.106441.

[27] V. Elia, M. G. Gnoni, and F. Tornese, "Measuring circular economy strategies through index methods: A critical analysis," *J. Clean. Prod.*, vol. 142, pp. 2741–2751, Jan. 2017, doi: 10.1016/j.jclepro.2016.10.196.

[28] European Comission, "Circular economy action plan," 2022. Accessed: Sep. 30, 2022. [Online]. Available: https://environment.ec.europa.eu/strategy/circular-economy-action-plan_en

[29] C. Schulz, R. E. Hjaltadóttir, and P. Hild, "Practising circles: Studying institutional change and circular economy practices," *J. Clean. Prod.*, vol. 237, p. 117749, Nov. 2019, doi: 10.1016/J.JCLEPRO.2019.117749.

[30] J. Rincón-Moreno, M. Ormazábal, and C. Jaca, "Stakeholder Perspectives in Transitioning to a Local Circular Economy: a Case Study in Spain," *Circ. Econ. Sustain.*, vol. 2, no. 2, pp. 693–711, Jun. 2022, doi: 10.1007/S43615-021-00098-X.

[31] M. Lieder and A. Rashid, "Towards circular economy implementation: A comprehensive review in context of manufacturing industry," *J. Clean. Prod.*, vol. 115, pp. 36–51, Mar. 2016, doi: 10.1016/j.jclepro.2015.12.042.

[32] J. Korhonen, A. Honkasalo, and J. Seppälä, "Circular Economy: The Concept and its Limitations," *Ecol. Econ.*, vol. 143, pp. 37–46, Jan. 2018, doi: 10.1016/j.ecolecon.2017.06.041.

[33] L. D. Poulikakos, K. Heutschi, and P. Soltic, "Heavy duty vehicles: Impact on the environment and the path to green operation," *Environ. Sci. Policy*, vol. 33, pp. 154–161, Nov. 2013, doi: 10.1016/j.envsci.2013.05.004.

[34] M. Saidani, B. Yannou, Y. Leroy, and F. Cluzel, "Heavy vehicles on the road towards the circular economy: Analysis and comparison with the automotive industry," *Resour. Conserv. Recycl.*, vol. 135, pp. 108–122, Aug. 2018, doi: 10.1016/J.RESCONREC.2017.06.017.

[35] M. Sharma, S. Luthra, S. Joshi, A. Kumar, and A. Jain, "Green logistics driven circular practices adoption in industry 4.0 Era: A moderating effect of institution pressure and supply chain flexibility," *J. Clean. Prod.*, vol. 383, p. 135284, Jan. 2023, doi: 10.1016/J.JCLEPRO.2022.135284.

[36] C. Scheel, E. Aguiñaga, and B. Bello, "Decoupling Economic Development from the Consumption of Finite Resources Using Circular Economy. A Model for Developing Countries," *Sustain. 2020, Vol. 12, Page 1291*, vol. 12, no. 4, p. 1291, Feb. 2020, doi: 10.3390/SU12041291.

[37] M. Niero and S. I. Olsen, "Circular economy: To be or not to be in a closed product loop? A Life Cycle Assessment of aluminium cans with inclusion of alloying elements," *Resour. Conserv. Recycl.*, vol. 114, pp. 18–31, Nov. 2016, doi: 10.1016/j.resconrec.2016.06.023.

[38] Y. Van Fan, C. T. Lee, J. S. Lim, J. J. Klemeš, and P. T. K. Le, "Cross-disciplinary approaches towards smart, resilient and sustainable circular economy," *J. Clean. Prod.*, vol. 232, pp. 1482–1491, Sep. 2019, doi: 10.1016/J.JCLEPRO.2019.05.266.

[39] C. Baah and Z. Jin, "Sustainable Supply Chain Management and Organizational Performance: The Intermediary Role of Competitive Advantage," *J. Manag. Sustain.*, vol. 9, no. 1, p. 119, May 2019, doi:

10.5539/JMS.V9N1P119.

[40] D. M. Salvioni and A. Almici, "Transitioning Toward a Circular Economy: The Impact of Stakeholder Engagement on Sustainability Culture," *Sustain. 2020, Vol. 12, Page 8641*, vol. 12, no. 20, p. 8641, Oct. 2020, doi: 10.3390/SU12208641.

[41] P. K. Mallick, K. B. Salling, D. C. A. Pigosso, and T. C. McAloone, "Closing the loop: Establishing reverse logistics for a circular economy, a systematic review," *J. Environ. Manage.*, vol. 328, Feb. 2023, doi: 10.1016/j.jenvman.2022.117017.

[42] L. Meherishi, S. A. Narayana, and K. S. Ranjani, "Sustainable packaging for supply chain management in the circular economy: A review," *J. Clean. Prod.*, vol. 237, p. 117582, Nov. 2019, doi: 10.1016/J.JCLEPRO.2019.07.057.

[43] D. Battini, M. Calzavara, A. Persona, and F. Sgarbossa, "Sustainable Packaging Development for Fresh Food Supply Chains," *Packag. Technol. Sci.*, vol. 29, no. 1, pp. 25–43, Jan. 2016, doi: 10.1002/PTS.2185.

[44] K. Govindan and M. Hasanagic, "A systematic review on drivers, barriers, and practices towards circular economy: a supply chain perspective," *Int. J. Prod. Res.*, vol. 56, no. 1–2, pp. 278–311, Jan. 2018, doi: 10.1080/00207543.2017.1402141.

[45] D. R. David, A. Nait-Sidi-moh, D. Durand, and J. Fortin, "Using Internet of Things technologies for a collaborative supply chain: Application to tracking of pallets and containers," *Procedia Comput. Sci.*, vol. 56, no. 1, pp. 550–557, 2015, doi: 10.1016/j.procs.2015.07.251.

[46] G. Durán-Romero, A. M. López, T. Beliaeva, M. Ferasso, C. Garonne, and P. Jones, "Bridging the gap between circular economy and climate change mitigation policies through eco-innovations and Quintuple Helix Model," *Technol. Forecast. Soc. Change*, vol. 160, p. 120246, Nov. 2020, doi: 10.1016/J.TECHFORE.2020.120246.

[47] H. Wilts, N. von Gries, and B. Bahn-Walkowiak, "From waste management to resource efficiency-the need for policy mixes," *Sustain.*, vol. 8, no. 7, Jul. 2016, doi: 10.3390/SU8070622.

[48] M. Demartini, M. Ferrari, K. Govindan, and F. Tonelli, "The transition to electric vehicles and a net zero economy: A model based on circular economy, stakeholder theory, and system thinking approach," *J. Clean. Prod.*, vol. 410, p. 137031, Jul. 2023, doi: 10.1016/J.JCLEPRO.2023.137031.

[49] P. Ghisellini, C. Cialani, and S. Ulgiati, "A review on circular economy: The expected transition to a balanced interplay of environmental and economic systems," *J. Clean. Prod.*, vol. 114, pp. 11–32, Feb. 2016, doi: 10.1016/j.jclepro.2015.09.007.

[50] E. Leising, J. Quist, and N. Bocken, "Circular Economy in the building sector: Three cases and a collaboration tool," *J. Clean. Prod.*, vol. 176, pp. 976–989, Mar. 2018, doi: 10.1016/J.JCLEPRO.2017.12.010.

[51] M. Massaro, F. Dal Mas, C. J. Chiappetta Jabbour, and C. Bagnoli, "Crypto-economy and new sustainable business models: Reflections and projections using a case study analysis," *Corp. Soc. Responsib. Environ. Manag.*, vol. 27, no. 5, pp. 2150–2160, Sep. 2020, doi: 10.1002/CSR.1954.

[52] P. Puntillo, "Circular economy business models: Towards achieving sustainable development goals in the waste management sector—Empirical evidence and theoretical implications," *Corp. Soc. Responsib. Environ. Manag.*, vol. 30, no. 2, pp. 941–954, Mar. 2023, doi: 10.1002/CSR.2398.

[53] M. Massaro, S. Secinaro, F. Dal Mas, V. Brescia, and D. Calandra, "Industry 4.0 and circular economy: An exploratory analysis of academic and practitioners' perspectives," *Bus. Strateg. Environ.*, vol. 30, no. 2, pp. 1213–1231, Feb. 2021, doi: 10.1002/BSE.2680.

[54] P. K. Dey, C. Malesios, D. De, P. Budhwar, S. Chowdhury, and W. Cheffi, "Circular economy to enhance sustainability of small and medium-sized enterprises," *Bus. Strateg. Environ.*, vol. 29, no. 6, pp. 2145–2169, Sep. 2020, doi: 10.1002/BSE.2492.

[55] G. Guest, A. Bunce, and L. Johnson, "How Many Interviews Are Enough?: An Experiment with Data Saturation and Variability," *Field methods*, vol. 18, no. 1, pp. 59–82, 2006, doi: 10.1177/1525822X05279903.