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ADVANCES AND CHALLENGES OF THE CIRCULAR ECONOMY IN THE TIRE INDUSTRY

AVANÇOS E DESAFIOS DA ECONOMIA CIRCULAR NA INDÚSTRIA DE PNEUMÁTICOS

AVANCES Y DESAFÍOS DE LA ECONOMÍA CIRCULAR EN LA INDUSTRIA DEL NEUMÁTICO

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ABSTRACT
The Circular Economy (CE) is an economic model that has been spreading in the productive and service sectors of contemporary society, as it seeks to redefine the linear production and consumption model, proposing a structure aligned with the principles of circularity. However, challenges emerge for the dissemination and application of this management paradigm. The main goal of this work was to analyze the advances and challenges of the circular economy in the Brazilian tire industrial sector, with emphasis on the case study of the Michelin company. The research, of a descriptive and bibliographic nature, examined actions such as product redesign, reverse logistics, tire retreading, use of renewable raw materials and social responsibility initiatives. The results showed that Michelin adopts circular practices on different fronts, especially in reducing the carbon footprint, reusing inputs and social inclusion. However, structural barriers were identified, such as high national production costs, international competition and limitations in the natural rubber supply chain. It is concluded that the consolidation of the circular model depends on public policies, technological investments and collective engagement.

Keywords: Reverse Logistics. Environmental Management. Material Recovery. Sustainability.

RESUMO
A Economia Circular (EC) é um modelo econômico que vem se difundindo nos setores produtivos e de serviços da sociedade contemporânea, pois busca redefinir o modelo de produção e consumo linear, propondo uma estrutura alinhada aos princípios da circularidade. Todavia, desafios emergem para a disseminação e aplicação desse paradigma de gestão. O objetivo desse trabalho foi avaliar os avanços e desafios da economia circular no setor industrial de pneumáticos brasileiro, com ênfase no estudo de caso da empresa Michelin. A

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pesquisa, de caráter descritivo e bibliográfico, examinou ações como redesenho de produtos, logística reversa, recapagem de pneus, uso de matérias-primas renováveis e iniciativas de responsabilidade social. Os resultados mostraram que a Michelin adota práticas circulares em diferentes frentes, especialmente na redução da pegada de carbono, reaproveitamento de insumos e inclusão social. No entanto, foram identificadas barreiras estruturais, como os custos elevados de produção nacional, concorrência internacional e limitações na cadeia de suprimentos de borracha natural. Conclui-se a consolidação do modelo circular depende de políticas públicas, investimentos tecnológicos e engajamento coletivo.

Palavras-chave: Logística Reversa. Gestão Ambiental. Recuperação de Materiais. Sustentabilidade.

RESUMEN

La Economía Circular (EC) es un modelo económico que se ha ido extendiendo en los sectores productivos y de servicios de la sociedad contemporánea, ya que busca redefinir el modelo lineal de producción y consumo, proponiendo una estructura alineada con los principios de circularidad. Sin embargo, surgen desafíos para la difusión y aplicación de este paradigma de gestión. El objetivo de este trabajo fue analizar los avances y desafíos de la economía circular en el sector industrial de neumáticos brasileño, con énfasis en el estudio de caso de la empresa Michelin. La investigación, de carácter descriptivo y bibliográfico, examinó acciones como el rediseño de productos, la logística inversa, el recauchutado de neumáticos, el uso de materias primas renovables y las iniciativas de responsabilidad social. Los resultados mostraron que Michelin adopta prácticas circulares en diferentes frentes, especialmente en la reducción de la huella de carbono, la reutilización de insumos y la inclusión social. Sin embargo, se identificaron barreras estructurales, como los altos costos de producción nacional, la competencia internacional y las limitaciones en la cadena de suministro de caucho natural. Se concluye que la consolidación del modelo circular depende de las políticas públicas, las inversiones tecnológicas y el compromiso colectivo.

Palabras clave: Logística Inversa. Gestión Ambiental. Recuperación de Materiales. Sostenibilidad.

1 INTRODUCTION

The growing concern about the environmental impacts of human activities has driven the search for more sustainable economic models. The linear model, based on the “take-make-use-waste” logic, was conceived from the premise that there would be a source of inexhaustible resources (natural and energy), in addition to the environment being able to absorb all the environmental impact of pollution, waste and contamination (Velenturf & Purnell, 2021). However, the population increase associated with the culture of disposable consumption and planned obsolescence have promoted the depletion of various sources of natural resources, causing environmental imbalances and waste across the planet (Suchek et al., 2021). A reflection of this imbalance is related to the global annual generation of solid waste, expected to be 2.59 billion tons for 2030, and 3.4 billion tons for 2050 (Suchek et al., 2021).

According to data from the United Nations (UN), the global population of approximately 5.6 billion inhabitants in mid-1994 is expected to reach a peak of 10.3 billion people in 2084 (Lam, 2025). Such a panorama, associated with the generation of waste, indicates a potentiation of the environmental imbalances of the "take-make-use-waste" model, with concerns about the environment, growing inequality, and economic stability emerging and, consequently, about sustainability (Velenturf & Purnell, 2021).

In this context, the circular economy (CE) emerges as an economic model that seeks to redefine traditional production and consumption patterns, proposing a regenerative and restorative structure from its planning (Geissdoerfer et al., 2017). Its main objective is to keep products, materials, and resources in use for as long as possible, eliminating the concept of "waste" and promoting reuse in continuous cycles (Chabowski et al., 2025; Figge et al., 2023; Suchek et al., 2021). Confronting the linear economy bias, the CE adopts a review of all stages of the product, from needs, functionalities, relationships and waste generation. Thus, it becomes necessary to rethink goods and the production process as a chain, seeking solutions for post-consumption, and considering the product's life cycle (Velenturf & Purnell, 2021).

An extensive literature review on the concept of the Circular Economy, undertaken by Figge et al. (2023), indicates the definition elaborated by Kirchherr et al. (2017), as one of the most widespread. Kirchherr et al. (2017) establish that the circular economy describes an economic system based on business models that replace the concept of 'end-of-life' by reducing, reusing, recycling and recovering materials in production/distribution and consumption processes, operating at the micro scale (products, companies, consumers), meso scale (eco-industrial parks) and macro scale (city, region, nation and beyond). In this approach, the goal of CE is to achieve sustainable development, creating environmental quality, economic prosperity, and social equity, for the benefit of current and future generations (Kirchherr et al., 2017).

In the Circular Economy chain, two main cycles occur: the technical and the biological (Paes et al., 2021). According to these authors, in the technical cycle, the raw material/materials must be inserted in a cycle of reuse, repair and remanufacturing, in addition to recycling; While in the biological cycle, the materials that make up the product are biodegradable and returned to nature for their regeneration, through composting.

The financial potential of the circular economy, especially through waste recycling, has been reported for different sectors, such as metallurgy (Ramos et al., 2025), municipal solid waste management (Paes et al., 2021), cement industry (Mancini et al., 2021), and in the production of renewable fuels (Mujtaba et al., 2023).

The tire market reaches crucial and strategic industrial sectors for the Brazilian economy, such as the automobile and aerospace industries. These sectors have boosted the circular economy in the tire industry, based on international energy efficiency standards (ISO 50.001) and the environmental management system (ISO 14.001), promoting the search for new methodologies and technologies in the various stages of its production process (ABIARB, 2025).

In view of this scenario, challenges emerge for the tire industry, related to the dissemination and consolidation of CE principles, through the renewal and circularity of production processes, the reuse and recycling of resources, and adding environmental values to its business. Mancini et al. (2021) point out some of these challenges in the Brazilian scenario, such as geographic inequality in the distribution of industrial parks, road network, and innovation and research centers, concentrated in the Southeast and South regions, and which favor recycling in these territorial spaces.

The objective of the present work was to analyze the advances and challenges of the circular economy in the industrial sector of tires, through a case study of the company Michelin.

2 METHODOLOGY

2.1 MICHELIN COMPANY

The present research evaluated the company Sociedade Michelin de Participações Ltda., for being one of the largest global companies in the tire manufacturing, in addition to its consolidated presence in Brazil. The Michelin Society is a multinational company headquartered in France and has more than 130 years of history. Its main activity in Brazil is focused on the manufacture of tires for buses, trucks, motorcycles, bicycles, automobiles, pickup trucks, handling and industries, as well as tires for use in the mining, agriculture, earthmoving, among others. (Michelin, 2025)

2.2 BIBLIOGRAPHIC AND INFORMATION SURVEY

The research was carried out through a bibliographic review of the descriptive literature, with the aim of understanding and examining the circular economy scenario for a tire industry, both in economic and environmental aspects, prioritizing the case study of the multinational company Sociedade Michelin de Participações Ltda.

Bibliographic research was carried out in the Google Scholar database, retrieving scientific articles and official reports in the public domain, dissertations and theses. In the review process, the following keywords were used: circular economy, linear economy, sustainability, Michelin and tires.

The research was based on all public information released by Michelin through annual reports, performance reports, and videos of objectives released to the external public on its official website. No confidential or restricted information was used.

3 RESULTS AND DISCUSSION

3.1 MICHELIN'S BUSINESS MODEL

The "Everything Sustainable" strategy is the central pillar of Michelin's global operating model. It is an approach that unites the three axes of the ESG (Environmental, Social and Governance) model (Michelin, 2021). The ESG concept can be understood as a set of principles to guide a company's operations aimed at investors, with the objective of demonstrating corporate social responsibility, mapping investment opportunities and identifying risks for the company (Kuzmina & Lindemane, 2017).

However, at Michelin, the ESG concept is verbalized as 3P (People, Planet and Performance), a fundamental piece to build a balanced, resilient and future-proof business. In addition to an institutional guideline, "Sustainable Everything" is the basis on which Michelin structures its transition to the circular economy (Michelin, 2021).

In the social dimension, Michelin promotes actions aimed at inclusion, diversity, human development and well-being of employees, communities and partners, through the implementation of female leadership programs. Such programs aim to promote gender equity in the business environment, in addition to supporting rubber extracting communities from rubber trees in the Amazon (Michelin, 2024).

In the Brazilian North region, the "Together for the Amazon" program seeks to strengthen the extractive chain of native rubber, valuing the traditionality of the business of extractive communities and the family culture of the inhabitants, in addition to generating income (Michelin, 2025).

The Michelin ecological reserve (REM) was created in 2007 between the municipalities of Igrapiúna and Ituberá, in the south of State of Bahia, Brazil. This 3,950 ha area of Atlantic Forest aims to promote environmental protection, ecological restoration, ecotourism, scientific research, and environmental education (Michelin, 2025). The incentive to research in REM has led to the development of scientific investigations related to the fauna and flora of the Atlantic Forest, such as Roseno et al. (2024), Souza et al. (2025), Nascimento et al. (2025), among others.

In the environmental dimension, Michelin works with impact reduction targets, such as climate change, a category of environmental impact that has been evaluated by the different production systems (Araujo et al., 2025, Barbosa et al., 2025) and services (Oliveira et al., 2022) in Brazil, seeking to reduce net CO_2eq emissions. In this context, Michelan reduced its net CO_2eq emissions by 37% in 2024, considering Scopes 1 and 2 compared to 2019, and its target is a 47% reduction by 2030 (Michelan, 2025).

3.2 ALTERNATIVES FOR REDUCING WASTE GENERATION AND POLLUTION IMPACTS

3.2.1 The Redesign

The starting point for CE at Michelin is based on the redesign of products and services, considering the environmental consequences. The main objective of tire companies, when considering redesign, is to reduce fuel consumption and, consequently, greenhouse gas emissions (Araujo-Morera et al., 2021, Chicu et al., 2020).

An example is Michelin's Tweel tyre, an integrated airless tyre and wheel assembly, in which the rubber tread is fused to the wheel core with polyurethane rods. The Tweel tire addresses better performance levels by its shear tread design, additional suspension and reduced rolling resistance, generating a decrease in fuel consumption (Bras & Cobert, 2011).

Another tire production line announced by this industry was the "AXIOBIB 2", which has technologies to operate with greater productivity, by reducing tire pressure, adapting to the load and speed and allowing fuel savings of up to 9% (Michelin, 2025).

The second challenge of the redesign is to facilitate the recyclability of the tire, as approximately 75% of its composition corresponds to rubber, as it is a material of high resistance to degradation during use on the road. However, its separation is extremely difficult, creating a barrier to disassembly and reuse after it becomes unusable (Araujo-Morera et al., 2021).

Michelin launched the tire with "Vision" technology in 2017, without the need for air, built entirely from recycled materials and using 3D printing (Chicu et al., 2020). The concept of this tire is an example of the redesign applied, as it was inspired by corals with honeycomb structures that allow greater flexibility and maintain their initial strength (Araujo-Morera et al., 2021).

In the tire market, Bridgestone has invested heavily in solutions aimed at sustainability, including airless tires that exclude the need for frequent changes and advanced tire tracking systems, promoting better recycling efficiency (Poulose, 2025).

Manufacturing tires from natural and renewable resources is a clear goal to achieve the circular economy and reduce dependence on fossil fuels (Lee, 2024). In this context, research has focused on replacing and/or modifying silica as a compound in tire tread, an alternative considered by Michelin and other tire manufacturers, such as Bridgestone and Goodyear (Chicu et al., 2020). Silica, aligned with rubber, can reduce energy losses, leading to the production of tires with low rolling resistance and, consequently, lower fuel consumption (Araujo-Morera et al., 2021).

Michelin incorporated 31% renewable and recyclable raw material, such as biomass, into its tires in 2024 (Michelan, 2025). The company's goal is to use 100% sustainable materials in the production of tires by 2050 (Poulose, 2025). To achieve this goal, the company has been exploring bio-based alternatives, such as natural rubber and synthetic rubber derived from renewable sources, to reduce reliance on fossil raw materials (Poulose, 2025).

Bridgestone has invested heavily in sustainable mobility solutions, including airless tires that eliminate the need for frequent changes and advanced tire tracking systems to improve recycling efficiency (Polouse, 2025). Such actions demonstrate the insertion of new technologies, the search for the reuse of materials, the increase in the recyclability efficiency of the final product, and the commitment of tire manufacturers to reduce environmental impact and support global sustainability goals.

In summary, it can be inferred that the tire industrial segment has developed strategies to reduce its environmental impacts through product redesign, prioritizing the reduction of fuel consumption and incorporating raw materials of non-fossil origin. In this regard, Knapcikova & Marticek (2025) highlight the following ways to evolve sustainability in tire production: increasing service life and reducing its maintenance; develop technologies that monitor tire wear and pressure; enhancing the proper recycling of used tires. These authors emphasize the support for the circular economy of tires, through the recycling process and its reuse.

3.2.2 Disposal of waste tires

The global generation of waste tires is close to one billion units or 17 million tons (Lee, 2024).

The unserviceable tire is one of the main liabilities generated by Michelin. Poulose (2025) states that 40% of waste tires generated globally are destined for recycling, 38% for energy recovery, and the remaining 22% disposed of in landfills or in the environment. The global distribution of waste tire recycling destinations includes rubberized asphalt (30% of the total); sports fields and playground surfaces (20%); industrial products, such as rubber belts, conveyor belts and molded components (15%); tire retreading (10%); the recovery of oil and black carbon, based on pyrolysis (15%) (Poulose, 2025).

In the view of the EC, the first step in the waste tire recycling process is to consider the production of shredded rubber from used tires. This shredded rubber can be produced from whole tires or from the tread remnants of the retreading process (Araujo-Morera et al., 2021).

There are different techniques by which waste tires can be reduced in size (Hoyer et al., 2020). Among them, the manufacture of covers for playgrounds, floor covering, tiles for sidewalks and running tracks stands out. In addition, tires can compose a variety of rubber products, such as conveyor belts, tubes, molded and extruded profiles, shoe soles, car mats, among others (Araujo-Morera et al., 2021).

Shredded tire rubber can also be incorporated into virgin rubber for the manufacture of new tires. However, Formela et al. (2016) and Yehia et al. (2004) highlight that some physical properties, such as tensile strength, product elasticity and longer curing time are negative aspects of the insertion of shredded rubber for the manufacture of new tires.

In addition, there are technologies for the recovery of vulcanized rubber, which consists of preserving the original elastomers of the rubber to use them in the manufacture of new tires (Rodgers & D'Cruz, 2015). The most promising techniques are microwave and ultrasonic devulcanization, due to the good properties of the devulcanized material, the possibility of high productivity, and the ease of implementation (Araujo-Morera et al., 2021).

The pyrolysis process of waste tires produces a series of valuable chemical compounds in the solid, liquid, and gaseous phases, which can become value-added products such as additives and raw materials to generate other products in the petrochemical, energy, or steel industries (Bockstal et al., 2019). Its viability is strongly affected by the high costs of operation and maintenance, in addition to the absence of a large market for the consumption of the products obtained (Isayev, 2013).

Michelin inaugurated in Chile, in 2024, a recycling-only operation for large tires, used in mining activity. To this end, it used its own technologies for cutting waste tires, with the objective of using the shredded material as raw material (Michelin, 2025).

It is understood that Michelin is growing in the tire recycling market, in addition to maintaining the plurality of its business by investing in emerging technologies such as pyrolysis. Despite the high costs, it will be able to achieve a circular economy model for tires.

3.3 THE REVERSE LOGISTICS OF WASTE TIRES

In Brazil, after the National Solid Waste Policy (PNRS), those responsible for the tire logistics chain (manufacturers, traders, distributors, and importers) were required to develop and implement reverse logistics for waste tires.

CONAMA Resolution 416, of September 30th, 2009, provides for the environmental degradation caused by waste tires and their environmentally appropriate disposal and provides for other measures. This resolution guides the responsibilities for the correct disposal of waste tires with a unit weight of more than 2.0 kg. However, these companies are granted the possibility of outsourcing the collection of tires from manufacturers and importers but not exempting them from their responsibility for complying with their obligations (Brasil, 2009).

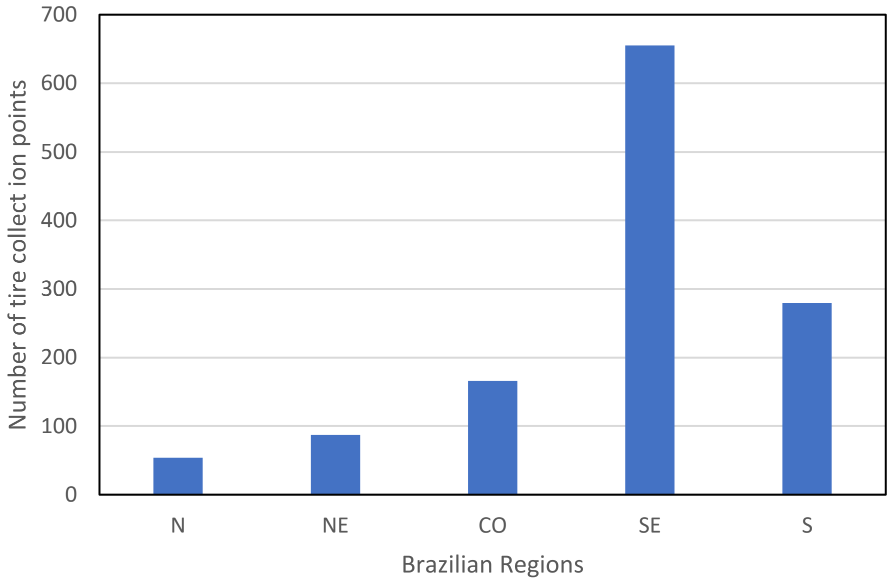
In 1999, the National Association of the Tire Industry (ANIP) implemented the National Program for the Collection and Disposal of Waste Tires in Brazil. Later, this program was improved by the companies Bridgestone, Goodyear, Michelin and Pirelli, when Reciclanip was created, an entity dedicated to the collection and disposal of waste tires in Brazil, in 2007 (Floriani et al., 2006). Reciclanip collects waste tires at collection points made available to consumers through its official website (Reciclanip, 2025), disposing of them to companies duly licensed by the competent environmental agencies and authorized by the Brazilian Institute of the Environment and Renewable Natural Resources (IBAMA) (Floriani et al., 2006).

It is estimated that the Brazilian tire industry disposed of around 418,000 tons of waste tires in 2023 (ANIP, 2024). According to the same source, from 2011 to 2023, about 5.1 million waste tires were disposed of. These scrap tires can be recovered, remanufactured, or co-processed (Rodrigues & Bezerra, 2021). Also noteworthy is the lamination process, when non-radial tires are cut into sheets that are used for the manufacture of shoes, rainwater pipelines, among other artifacts (Rodrigues & Bezerra, 2021).

As pointed out by Roy et al. (2006), the efficient implementation of large-scale collection logistics, especially in regions with low population concentration, requires the structuring of a transport network with the participation of outsourced companies, aiming at reducing operating costs. This process raises challenges in terms of economic viability, as the transportation of tires from collection points to recycling sites has a high cost for the industry, distributors and traders (Chan et al., 2012). Figure 1 shows the distribution of waste tire collection points in Brazil, based on information provided by Reciclanip (Reciclanip, 2025).

Figure 1

Distribution of the waste tire collection network in Brazil (N: North region; NE: Northeastern region; CO: Central-West region; SE: Southeastern region; S: South region)



Source: Reciclanip database (2025).

In the North region, which covers most of the Amazon, there are only 54 collection points (CP) of waste tires, or 4.4% of the Brazilian total (1241 CP), although this region corresponds to about 40% of the Brazilian territory. Such a scenario presents challenges to reverse logistics for tires in this Brazilian region, due to the scarcity and low quality of roads, lower population concentration and industrial parks, according to Oliveira et al. (2021), Oliveira et al. (2022), Mancini et al. (2021).

The Southeast region has the highest concentration of tire collection points, corresponding to a total of 655 CP or 52.8% of the total, followed by the South region (279 CP or 22.5%), the Midwest region (166 CP or 13.4%) and the Northeast region (87 CP or 7.0%). In 2020, this Reciclanip structure collected and disposed of about 380,000 tons of waste tires, or approximately 42 million units of passenger car tires (ANIP, 2021). However, the sale of tires in 2024 reached 52 million units, which suggests a probable deficit between the generation and proper disposal of waste tires in Brazil.

3.4 TIRE RETREADING

Retreading consists of renewing tires by replacing the tread, the part responsible for direct contact with the ground, with new rubber (Poulose, 2025). According to this author, retreading significantly reduces the number of tires discarded in the waste stream, allowing their reuse, in addition to reducing the demand for virgin rubber. It is a cost-effective and sustainable alternative to new tires and is considered part of the reuse processes prioritized by the European Waste Hierarchy (Duval et al., 2024)

Michelin has a retreading unit installed in Rio de Janeiro to extend the life of used tires (Michelin, 2025). Michelin retreading requires an average of 20 kg of raw material, which represents more than 65% savings compared to a new tire and doubles its useful life, reducing fuel consumption without sacrificing safety (Michelin, 2024). According to this source, retreading has a 40% lower value compared to a new tire and still has the possibility of new retreading, depending on wear. According to Joseph et al. (2025), a well-maintained tire can be retreaded at least twice and reach 960,000 km of mileage in the road conditions of the United States, while in India this distance reaches 225,000 km. These authors developed a predictive model for sustainable tire retreading and resource optimization in public transportation. The main results of this study point to a substantial improvement in tire mileage, from 20% to 30%, cost reduction by 15% to 25%, and environmental impacts by up to 25%.

Michelin retreads not only its own tires, called "Premier", but also those of competitors, called "Flex". In its process, tires go through the stages of selection, verification, repair and coating of the carcass through the tread to ensure the life cycle with safety and quality (Michelin, 2024).

It can be inferred that retreading and reverse logistics are fundamental factors to preserve the value of the tire, from its economic to environmental dimensions. Factors such as the disclosure of collection points and retreading points to the end consumer are essential to maintain and extend the useful life of these products.

3.5 CIRCULAR ECONOMY BARRIERS AND OPPORTUNITIES

The National Company of Industry listed five lines of action to increase the advancement of the circular economy: Public Policies; Education; Research, Development and Innovation; Financing and Market (CNI, 2019).

One of the main barriers found for the increase of CE are the regulatory ones, highlighting the absence of regulations, such as the insertion of innovative products, equipment or processes in the market. In this context, government action plays an essential role in accelerating changes, promoting sufficient conditions for the transition from a linear to a circular economy. However, once established policies will only be successful with the engagement of companies (ENEC, 2025).

In the Education dimension, Tan et al. (2022) recommend mechanisms such as reward and recognition programs for the correct disposal of products that require reverse logistics, promoted by states and municipalities.

In the field of research, development and innovation in the tire industry has technological limitations for the sorting and reuse of complex materials, such as rubber and steel compounds present in tires (Poulose, 2025). This author recommends investing in screening with artificial intelligence (AI) technology, automated shredding, and advanced devulcanization.

Nowaczek et al. (2024) researched the biggest barriers to CE implementation in Poland's tire sector, from the perspective of producers and recyclers. These authors listed the following barriers: non-existent or incomprehensible legal regulation; high environmental requirements for tire recyclers; lack of adequate regulation; long waiting times for decisions; lack of appropriate technology; low level of social awareness and little acceptance of products generated from waste; competence gap; and uncertainties.

In the economic dimension, the price practiced in the Brazilian market to produce natural rubber is high when compared to the Asian market, due to the manual process of implantation and maintenance of the rubber plantations. In this scenario, labor can represent 75% of the production cost. In Asian countries, working conditions are less restrictive in relation to Brazilian legislation, contributing to the reduction of crop costs and, consequently, the marketing price (CNI, 2017).

Another gap refers to the development of markets for reusable, reconditioned and recycled products, by encouraging the use of secondary materials as by-products and co-products of the industrial process. In this bias, it is necessary to develop tax and economic incentives so that tire by-products have added value (ENEC, 2025).

The transition to the Circular Economy in Latin America and the Caribbean has significant potential, estimated to create around 8.8 million formal jobs, in addition to reducing dependence on non-renewable resources. This change favors the emergence of new sustainable business models (ENEC, 2025).

The adoption of the circular economy offers a wide range of possibilities to transform the Brazilian productive sector, especially when associated with Industry 4.0 technologies (Chicu et al., 2020). This integration represents not only environmental gains, but also innovation, competitiveness, and the generation of new business models (FAESP, 2023).

In addition, CE allows the creation of more resilient businesses seeking to strengthen the entire value chain, with incentives for research and development on safer and renewable raw materials, in addition to reducing the use of primary resources through the redesign of products (CNI, 2021).

As a reference to these opportunities that CE provides, Michelin inaugurated in 2023, in France, the "HydrogenLab" research laboratory for the study of polymers, looking for actions through the study of Hydrogen as a fuel to reduce its environmental impact. In addition, it has professionals focused on the study of the circular economy in its business model (Michelin, 2025).

4 FINAL CONSIDERATIONS

In this work, Michelin's strategies aimed at sustainability and Circular Economy were detailed. In the reduction of waste and pollution, the redesign of Michelin's tires stands out, through technologies seeking to reduce the fuel consumption of vehicles, promoting the reduction of CO_2 emissions and the extension of the tire's useful life. In addition, Michelin is involved with technological companies in the environmental sector and seeks alternatives for the disposal of waste tires, incorporating emerging technologies, such as pyrolysis, and new raw materials that enhance recycling. The significant initiative for the reverse logistics of waste tires, through Reciclanip, still comes up against the quantity and distribution of collection points, concentrated in the South and Southeast regions, in Brazil.

Tire retreading has been consolidated as an effective strategy to preserve the value of tires, aligning sustainability, economy, and safety.

Therefore, Michelan's results and practices show that the transition to the circular economy is not only desirable but brings significant returns to the environment with the reduction of waste, CO_2 emissions and lower consumption of raw materials, promoting changes in the market.

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