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Actions to promote circular economy: case study of multinational manufacturers in the automotive and fast-moving consumer goods in Mexico

Acciones para fomentar la economía circular: estudio de caso de manufactureras multinacionales en los sectores automotriz y de bienes de consumo rápido en México

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Abstract

The overuse of natural resources as manufacturing inputs demands enterprises to support sustainable development through a transition from a linear model of production to a circular and resource-efficient model. This work applies a multiple-case research design based on secondary information to explore the advancement of circular economy (CE) among six subsidiaries of multinationals that operate in Mexico. The qualitative analysis shows that reduction of natural resources and closing the loop of water, followed by closing the package cycle and using renewables, are the main approaches applied by companies in the automotive and fast-moving consumer goods sectors. Slowing the product life cycle and closing the supply chain are the least used approaches. Results show a limited advancement in the implementation of circular economy models and provide guidelines to other companies as well as recommendations for the establishment of a legal framework that complements the bottom-up efforts of enterprises located in a developing country.

Keywords: Circular economy; sustainable development; multiple case study; Mexican subsidiaries.

Resumen

La sobreutilización de recursos en la manufactura demanda que las empresas apoyen el desarrollo sustentable mediante la transición hacia un modelo circular y eficiente en la utilización de recursos. Este trabajo utiliza un diseño de investigación de caso múltiple basado en información secundaria para explorar el avance en economía circular para seis subsidiarias de multinacionales que operan en México. El análisis cualitativo muestra que reducir el uso de recursos naturales y cerrar el ciclo del agua, seguido del cierre del ciclo en paquetes y el uso de recursos renovables, son los enfoques principales implementados por compañías en los sectores automotriz y de bienes de consumo rápido. Prolongar el ciclo de vida del producto y cerrar la cadena de suministro son enfoques escasamente utilizados. Los resultados indican un avance limitado en los modelos de economía circular y proporcionan guías para otras empresas, así como recomendaciones para establecer un marco legal que complemente los esfuerzos empresariales en países en desarrollo.

Palabras clave: Economía circular; desarrollo sustentable; estudio de caso múltiple; subsidiarias mexicanas.

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Introduction

Industrial and economic development have contributed to the gradual deterioration of the environment. The World Conservation Strategy claimed sustainable development and the rational utilization of ecosystems and natural resources in 1980, but it was not until 2002 that the World Summit on Sustainable Development included economic, social, and environmental aspects in a definition: "Sustainable development is a collective responsibility to advance and strengthen the interdependent and mutually reinforcing pillars of sustainable development at local, national, regional, and global levels" (Robert *et al.*, 2005).

Sustainable development requires the participation of diverse entities (government administrations, private firms, environmental organizations, research and education institutions, technology developers, civil associations, and individuals) who must coordinate their efforts and perspectives to meet the needs of current and future generations. One of the accepted solutions to achieve sustainable development is the circular economy (CE) paradigm.

CE is based on the cradle-to-cradle principle in which natural resources are transformed into products, distributed in the market, consumed, and then recovered to close the flow of materials. The CE paradigm refers to an economic system based on business models in which resources and products can be recurrently reused to optimize their environmental, social, and economic values throughout their lifecycles (Geissdoerfer *et al.*, 2018; Velenturf & Purnell, 2021). Recycling, reusing, increasing resource efficiency (materials, water, and fuel), and using renewable energy sources at the micro (products, companies, and consumers), meso (eco-industrial parks), and macro level (city, region, and country) are the main approaches that support the shift from a linear production model to CE (Kirchherr *et al.*, 2017, as cited by Cordova-Pizarro *et al.*, 2019).

CE has resulted in novel business models; for example, at the meso level is the green (ecological) cluster where the Government and private organizations, research centers, and universities collaborate to create synergy around the production of some type of renewable energy or the use of waste as raw material (Chinie, 2014). At the micro or firm level of CE, Geissdoerfer *et al.* (2020) propose the following general models: "circularity" or "closing loops", where products and materials are designed to be returned to the manufacturer to be reused in the production of new products, to be repaired, or to be reprocessed; "extending resource loops", which implies a long-lasting and timeless design that encourages longer use or repurposing; and "dematerializing resource loops", which refers to providing product utility through substitution with service and software solutions such as upgrading and automatic maintenance. Although these models mainly refer to products, the recovery, reuse, and recycling of water to close the cycle of this vital resource qualifies as a CE model (Fernandes & Cunha, 2023), just as waste reduction, the efficient management of energy, and the substitution of fossil energies by renewable energies (Cortinas & Rosillo, 2022).

The literature review of Panchal *et al.* (2021) concludes that the assessment of current circularity at the micro level in developing countries requires further research to establish the CE potential contribution to sustainable development. To fill this gap, this work explores actions that support the CE paradigm among multinationals (MN) with facilities in Mexico that established sustainable goals and stated environmental gains associated with these actions. Secondary documents, mainly technical reports available on the internet that may exhibit some bias but are comprehensive, endorsed, and published by the companies selected as case studies -along with news of reputable newspapers (e.g., Mexico Business News) or sources (e.g., Asociación Mexicana Automovilística), technical reports of accredited associations (e.g. Grupo de Trabajo Agenda 2030), and academic articles that cite the ecological actions of some of the enterprises selected (e.g. Munoz-Melendez *et al.*, 2021)- were analyzed to identify, categorize, and compare the current CE actions that firms in two key contrasting manufacturing sectors (automotive and fast-moving consumer goods [FMCG]) have implemented.

By using the concept of sustainable business models (SBM), this work contributes to the understanding of how subsidiaries of MN incorporate CE into their sustainability agenda in a developing country, so that other manufacturers can identify opportunities or difficulties to implement the CE concepts in their products and processes.

Overview of circular economy models in Latin America

The concept *business model* refers to a framework or conceptual tool that describes how a business creates and delivers value (value proposition) at an appropriate cost to different stakeholders based on the firm's internal processes and financial, human, and natural resources (Peric *et al.*, 2017).

Traditionally, the goal of business is the generation of profits and the achievement of competitive advantage. However, the acknowledgment of the most urgent world problems expressed in the Sustainable Development Goals (SDG) has compelled organizations to assume their corporate citizenship and to participate in a global effort toward sustainability. Firms have looked to balance their economic, environmental, and social goals to respond to all their stakeholders' expectations by changing their profit-driven models to sustainable business models (SBM) (Stubbs & Cocklin, 2008). CE business models are a subcategory of SBM linked to changes in product, technology, and production process to shift to a resource-efficient system where already existing materials, products, waste, and resources are used as inputs to reduce the firm's environmental footprint (Ferraso *et al.*, 2020).

The Organization for Cooperation and Economic Development (OECD, 2019) acknowledges five CE business models: replacement of material with renewable, recovered, or innovative inputs that use fewer virgin materials; recovery and recycling of waste by other industries or processes; extension of the life cycle of a product, for example, by repairing it and updating it; sharing of under-utilized products or extra resources; and product service system models that provide incentives for green product design and purchase.

The extant literature reports several cases of organizations that have successfully implemented CE models. For example, the EU-LAC Foundation, a bi-regional working alliance between Europe, Latin America, and the Caribbean that promotes sustainable economic growth with social inclusion and environmental safeguard, discusses a series of case studies using a holistic approach to analyze the environmental impact of CE models that consider the materials, water and energy cycles, and the minimization of resource exploitation (Bocken *et al.*, 2014; Kowszyk & Maher, 2018; Velenturf & Purnell, 2021). Sixteen cases of companies and institutions were identified as benchmarks; seven of them correspond to CE business models. The CE cases are from three South American companies (e.g., Neptuno Pumps from Chile) and the other four from the Economic Union (e.g., Closing the Loop and Better Future Factory from the Netherlands, a leading nation in CE). Two companies, one from each region, have public funding and the rest rely on private funding to support their CE models. Funding and leadership are acknowledged as essential to ensure the success and upkeep of CE. All companies report a positive environmental impact; for example, customers that purchase pumps from Neptuno attain up to 70% energy consumption savings, and the company's reduction of 75% in solid waste decreases 70% in the CO_2 emissions of clients. Regarding economic gains, closing the loop has increased its number of employees and revenues in the last three years. Concerning social impact, the Better Future Factory, for example, educates over 250 thousand people, mostly children, about CE through information about their activities posted on innovative websites, talks, and presentations.

An eight-step guide for the implementation of CE was derived from the case analysis. The guidelines comprise mapping the status of CE (identification of current CE activities and improvement potential); engaging key stakeholders to create strategic partnerships, assure the top management compromise, define and communicate CE vision according to the company's expertise and experience, and develop a business case and measurable goals by defining key performance indicators (KPI); creating CE champions and building capacity (e.g., reverse logistics capabilities); and planning process-product-business innovation models, beginning with the least disruptive changes and, finally, communicating CE efforts and achievements.

Aguiñaga & Treviño (2022) argue that despite its growing acceptance among Latin American enterprises, there is limited information about successful CE cases. The ReSOLVE framework proposed by the Ellen MacArthur Foundation was used by the authors to classify circular initiatives according to six dimensions: regenerate, share, optimize, loop, virtualize, and exchange. A guide of Good Practices in Circular Economy based on the analysis of six cases was developed by the authors. Grupo AlEn, a manufacturer of cleaning products located in Monterrey Mexico, is recognized as a benchmark in the *regeneration* of natural forests because the company's palm oil plant is energy self-sufficient; AlEn supports the ecosystems restoration and the biodiversity of four Mexican states. Arca Continental, the Coca-Cola Company's second-largest bottler in Latin America, *shares* treated water with 18 000 farmers who use it in several agroforestry activities, thus contributing to preserving this natural resource. Bio Pappel has a CE model called "Urban Forest", which *optimizes* waste generation by manufacturing high-quality paper and paper products from 100% recycled raw materials, thus extending the life cycle of paper and saving about 15.7 million trees. Coca-Cola FEMSA is acknowledged as a successful company in the repair dimension. The company evaluates refrigerator components at points of sale and recovers and reuses most of them. FEMSA also promotes the extraction of biochemical products from organic waste, energy cogeneration, and recycled PET bottles. All these activities close the *loop* of its supply chain. The Mexican petrochemical company Braskem Idesa has also advanced the loop dimension through the innovation of a high-density polyethylene resin made from post-consumer recycled material. The company reports a reduction of around 80% of its carbon footprint. Natura, the Brazilian cosmetics company, is another company that has achieved full circularity (loop) in its packaging by making it reusable, recyclable, or compostable; and by using more than 95% renewable, natural, and biodegradable ingredients.

Aguiñaga & Treviño (2022) refer to the fundamental role of the project of electric vehicles (EV) in achieving zero CO_2 emissions and the three basic principles (environment, economy, and social sustainability) of SBM among automotive companies located in Mexico. The reduction of the EV environmental impact across the entire life cycle of the product, from manufacturing to optimizing the use of battery energy and its recycling (lead-acid batteries, waste portable batteries, and lithium-ion batteries), is accredited as another example of closing the loop of the supply chain and *virtualize* processes at the sector level. The reuse and recycling of wastewater during the manufacturing process in automobile assembly plants and its impact on the availability of this essential resource in the region (share), along with the use of clean energy in all production processes and the *exchange* of materials and technologies (e.g., EV in transportation), is also cited as a project that demonstrates how to move from a linear economy to a circular model.

Munoz-Melendez *et al.* (2021) discuss several cases at different levels, legislation, and current conditions for the implementation of CE practices in Mexico. The study findings indicate there is a large potential to adopt the CE paradigm and contribute to the national compromise to perform scientific and technological studies aimed to protect the environment, restoring ecological equilibrium, and fighting climate change (Instituto Nacional de Ecología y Cambio Climático [INECC], 2012). In general, economic, and social benefits associated with CE practices include increased profits for companies and the generation of employment.

Through the revision of secondary sources, Munoz-Melendez *et al.* (2021) conclude that the approach of "product recovery for reuse" is mainly backed by open informal initiatives that do not support the integration of forward and reverse product flows. Perhaps, except for FEMSA, firms operating in Mexico have not closed their supply chains and are far from CE because of the complex cultural context, the informal mafia-type recycling, and economic and political interests.

At the firm level, PetStar is presented as a recovery-and-reuse successful CE (Munoz-Melendez *et al.*, 2021). The company reports a recovery of around 70% of PET bottles that are transformed to resin thru a conversion process that uses clean energy (e.g., eolic). Regarding product innovations involving reprocessing of materials, for example recycled fibers, no cases were identified.

Moreover, at the meso-level, sectors such as the fashion and textile industry only report a diagnosis of the legal framework that applies to the industry involving the adoption of the CE paradigm (Carrillo, 2019, as cited by Munoz-Melendez *et al.*, 2021). However, in the case of the electronics sector, the informal processing of cell phones provides an acceptable channel for repair, reuse, and update with a positive environmental impact. The survey of recycling facilities and repair stores performed by Cordova-Pizarro *et al.* (2019) reveals that the national/international certifications for safety and quality, working conditions, and environmental and social benefits vary between recycling facilities, depending on their e-waste processing volume and between formal versus informal repair stores. Findings indicate that informal repair shops unevenly compete with formal shops. However, informality is a self-organized workforce that offers customers a similar quality of work at a lower price and time. Regarding recycling, of the 4488 tons of e-waste, mainly consisting of domestic appliances, only a small percentage of laptops and tablets (19%) and cellphones (7%) were processed during 2015 by the 12 surveyed facilities. Finally, the material flow analysis indicates that Mexico captures a value of 0.679 million USD of materials through formal cellphone recycling. The total value of these materials is estimated at 12.485 million USD per year. Therefore, a proper return on investment for end-processing technologies is difficult, unless there is a substantial advance toward a CE model.

Opportunities for improving resource efficiency, particularly water, were identified by Munoz-Melendez *et al.* (2021). The case of wastewater treatment for the Presa Guadalupe sub-basin in the state of Mexico confirms that the adoption of the CE concept could support water availability and quality. The revision concludes that a CE hybrid model where private and public organizations collaborate would be desirable, given the incipient legislation in Mexico. This model would require connecting new ways of thinking and planning with interinstitutional coordination and governance schemes.

Currently, in Mexico, the Joint Public Declaration following the Second Meeting of the Environment Committee of the Free Trade Agreement among Mexico, the United States, and Canada (T-MEC, from its Spanish acronym) recognizes CE as a key aspect for the preservation and care of the environment (Chapter 24) and deliberates about the collaboration among different sectors (Centro de Estudios para el Desarrollo Rural Sustentable y la Soberanía Alimentaria [CEDRSSA], 2022; Secretaría de Economía, 2022). However, the circular economy law has not yet been endorsed. Martínez *et al.* (2021) applied the principles of CE to propose a legal framework and a roadmap for the adoption of CE models in Mexico, based on the experience of other countries that have achieved meaningful outcomes.

The transition from linear to circular models considers two phases: (1) maximizing the use of materials and the reduction of waste through the optimization of the efficiency of current linear production processes and the introduction of new technologies, and (2) implementing CE models. The supervision of eco-designs, the regulation of the use of new eco-friendly materials, the sanction of pollutant productive processes, the backing of new ventures based on the circularity principles, the change to renewable sources of materials and energy, and the reuse of water and energy along with the access to private and public funds are projected to support the transition to circularity at the micro-level in the long run (from 2030 to 2050). The ministries of Economy, Social Welfare, and Environment and Natural Resources are proposed as suitable leaders of the national CE strategy.

Materials and methods

A qualitative research approach based on multiple case studies built on secondary data was applied to explore the CE initiatives that Mexican subsidiaries of multinationals (MN) have implemented. Case study research is a convenient inductive approach when there is limited knowledge about the research subject. The method explores a real-life bounded system (the case) through detailed and in-depth data collection from several sources of information, including relevant documents of a particular organization, when a good collection of secondary data already exists (Yin, 2014). Single case studies focus on the intensive study of a company and then generalize findings over similar companies, whereas multiple case study design permits to examine data across several situations to identify similarities and differences between cases that, if properly explained, provide stronger support and confidence in the representativeness of research findings (Gustafsson, 2017).

The analysis of the information was guided by the research question: what CE actions have been implemented by Mexican subsidiaries and what is their environmental impact according to the company's assessment? Information collected from several sources was triangulated and compared with the extant literature to assure reliability. Secondary data may not be judged as valid and reliable as primary data because the researcher has no control over the quality of the collection process, and data is reported with a particular view. However, if the data reasonably covers the research question (relevance), comes from reputable sources such as government and companies with a good market position and image (authority), has publisher information and copyright statements, is not inconsistent or notoriously inaccurate or incomplete (accuracy), exhibits a notoriously biased perspective (purpose), and is consistent with other secondary data sources, then data are considered credible (Emerald Group Publishing, n. d.).

The report of case studies can be organized by themes either defined by a theoretical framework or by those emerged after the analysis. In this work, the case coding was based on the framework proposed by Bocken *et al.* (2014). The framework first categorizes different sustainability approaches into environmental, social, and economic dimensions. In this work, the CE models implemented by the MN subsidiaries were coded only according to the environmental dimension that comprises three main approaches: maximizing material and energy efficiency, closing resource loops, and substitution with renewables and natural processes (Ritala *et al.*, 2018, as cited by Agwu & Bissant, 2021).

The technical cycle of CE is acknowledged as one of the subcategories of the closing resource loop approach that captures the value of by-products or waste (e.g., products at the end of their lifecycle) through the activities of recycling, remanufacturing/refurbishing, reusing/redistributing, and repairing/maintenance (Panchal *et al.*, 2021). "Extending resource loops" was included as an additional category because it corresponds to one of the general models proposed by Geissdoerfer *et al.* (2020), that is, slowing the resource lifecycle through the design of long-lasting products and the extension of their useful life through repair or upgrading. Thus, this approach can be appealing and convenient to manufacturers due to the reduction of material costs and the exploitation of product innovations (Bocken *et al.*, 2015). During the coding stage, it was evident that the timeless design of products was uncommon, thus the category was extended to include another code with infrequent quotes: the establishment of measurable, achievable, relevant, and time-bound objectives, not only imprecise goals and the development of measurement frameworks of the level of circularity. These actions are important because they allow companies to communicate their commitment and quantify the impact and advances of their circularity actions.

The scientific rigor of case studies is often criticized because they do not allow testable generalization. However, the organization of data through coding and grouping according to theoretically based categories supports the impartiality of the analysis. The categories of interest in this work are the corporate sustainability goals that drive the companies' decision to engage in circularity, current CE projects ongoing in Mexico and their demonstrated environmental benefits, and additional initiatives declared as CE actions by companies. The analysis of several sources of empirical data for each company (sustainability reports and online technical documents, news, and academic articles) was performed independently by the authors. Individual analyses were then discussed until a consensus was reached before the cross-examination of the cases.

The number of cases depends on how much is known and the amount of new information obtained if additional cases are included (saturation); therefore, it is a matter of judgment. In this research, six case studies were conducted because they provide a global perspective of the MN's CE actions in the sectors of interest. The selection criteria for the cases were: the economic importance of the company's manufacturing sector, the years and market position of the company, and the availability of open secondary information, especially technical reports regarding the company's sustainability efforts and achievements. According to the National Institute of Statistics and Geography (INEGI, 2022a), the main sectors of Mexican economy are services, manufacturing, commerce, agriculture, mining, energy production, and financial industry. Manufacturing has a long tradition as one of the most important and the one that contributes most to the national gross domestic product (PIB) (18.8% during 2022) and non-oil exports (87%) (INEGI, 2023).

The three most prominent manufacturing industries are automotive, aerospace, and electronics. Within the automotive sector, General Motors, Ford, and Chrysler have been operating in the country since 1930; Volkswagen and Nissan have been running since the 60s; and Toyota and Honda began operations at the beginning of the 2000s. Three of these companies (Nissan, General Motors, and Ford) have detailed sustainability reports on the internet and, thus, were selected for the study.

The Mexican Association of the Automotive Industry (AMIA) and the Mexican Association of Automotive Distributors (AMDA) report the sales of automotive companies in Mexico from January to November 2022 using information provided by INEGI. The cumulative sales are 965 196 units, of which 15.1% correspond to General Motors, followed by Nissan with a participation of also 15.1%, Volkswagen Group is in the third place with 10.1%, followed by Toyota with 8.8%, and Kia with 8.5%. Other brands included in the top 10 are Stellantis (6.8%), MG Motor (4.4%), Mazda (4.3%), Hyundai (3.9%), and Ford Motor (3.8%) (AMIA, 2022; AMDA, 2022; INEGI, 2022b, 2023).

The FMCG sector includes manufacturers of products that are sold quickly at a relatively low price. The FMCG manufactured goods include processed food and beverages, medicines, and home and personal care products. FMCG manufacturers either distribute their products through several wholesale and retail channels or do they sell them directly to the end consumer (direct distribution). The use of multiple distribution channels contrasts with automakers that distribute only through automotive agencies. Thus, not only the characteristics of the product (durable versus non-durable and price) but also the higher involvement in the product's distribution differentiates the two sectors. The most outstanding company in the FMCG sector is Coca-Cola-FEMSA. But the case of FEMSA has been reported in other works (e.g., EU-Lac foundation); therefore, other leading multinationals operating in Mexico were selected: Heineken, Danone, and Unilever, all of them are among the world's largest companies that compete in the FMCG industry (Kenton, 2023). The first two belong to the food sector, one of the largest and most dynamic industries with a PIB of 5.15 billion pesos and a growing rate of 3.4% reported in 2022 (Gobierno de México, n. d.). On the other hand, the value of the industry of home and personal care products was estimated in 9.2 million USD in 2017, with growth rates above the annual rates of the manufacturing industry as a whole (Cámara Nacional de la Industria de Productos Cosméticos [Canipec], 2023).

Description of case studies

Automotive Sector

Nissan Mexicana S. A. de C. V. (https://www.nissan.com.mx/) is a subsidiary of Nissan Motor Co., Ltd., a Japanese company, established in Mexico in 1961. The company's facilities in the cities of Aguascalientes, Mexico City, Cuernavaca, Toluca, and Manzanillo include the functional areas of marketing, sales, manufacturing, distribution, and design. Currently, it employs more than 15 thousand employees, and it is one of the top three sellers of light automobiles in Mexico. The Nissan Green Program's environmental goals are to reduce CO_2 emissions and increase recycling. The sustainability compromise of Nissan Mexicana also includes providing social assistance through the ANDANAC Foundation/Nissan and Social Assistance Fund, which includes building primary schools and supporting children with cancer.

General Motors (GM) de México (https://www.gm.com.mx), a subsidiary of American General Motors Company, has operated in Mexico for more than 87 years. It currently employs more than 21 thousand people in its four manufacturing locations (Toluca, Silao, San Luis Potosí, and Ramos Arizpe), a Regional Engineering Center in the State of Mexico, and its headquarters in Mexico City. The company's vision is to achieve a world with zero collisions, zero emissions, and zero congestion. The company is committed to the development of new technologies and platforms to electrify vehicles and increase to 100% the accessibility of EV and reduce collisions caused by human errors. The development of autonomous vehicles increases access to mobility for different people, improves road safety, and reduces traffic. Regarding social sustainability, GM is committed to being a more inclusive company, generating new jobs, and promoting the transition of its products and operations to carbon neutrality without disregarding support to local communities through various social programs.

Ford de México (https://www.ford.mx), a subsidiary of the American Ford Company, began operations in Mexico in 1925 and has remained among the leading vehicle sales brands and automakers of light vehicles. The company currently employs 8700 workers to produce vehicles, engines, and transmissions in its six plants located in several states, an assembly plant in Hermosillo and Cuautitlán, three engine factories located in Chihuahua, and a transmission plant in Irapuato. The company's sustainability perspective is aligned with its corporative goals and includes aspects related to environmental responsibility, diversity and inclusion, social responsibility, profitability in its operations, and corporate ethics. Among the company's social programs is the Global Week of Caring program, where Mexican employees actively participate in social actions such as reforestation, rehabilitation of homes and dog shelters, eco-technical techniques, and emerging housing to improve society's living conditions. Additionally, since 1966, in collaboration with its network of distributors (193 active), Ford has contributed to the construction of 212 public elementary schools through its Civic Committee of Ford and Distributors.

Manufacturers of FMCG

Heineken NV (https://www.theheinekencompany.com/) is a brewing company headquartered in Amsterdam, Netherlands. The company produces and markets a portfolio of alcoholic beverages that commercializes under several brand names through its wholesalers, pubs, and other third parties. The company has business operations across America, Africa, the Middle East, Europe, and Asia-Pacific. Providing a better world through environmental innovations and social initiatives is stated in the Global Sustainability Strategy of the company, which has the compromise to meet its goals a year ahead of schedule and consolidate its position as the #1 brewer in sustainable development comprising humanity, habitat, and a holistic view. Heineken was the first company in Mexico to make a public compromise to adopt the CE paradigm in 2016. In 2019, the company announced it attained "zero waste", and it expects that 66% of the electricity it uses would come from renewable sources.

Unilever Plc (https://www.unilever.com/) is a manufacturer and wholesaler of FMCG headquartered in London, UK. The company's product portfolio comprises food products, beauty, and personal care products, beverages, home care products, vitamins, minerals, and supplements. The company commercializes its products under several brand names, among them are Knorr, Axe, Dove, Lux, Rexona, Vaseline, and Comfort. The company operates in America, Europe, Asia-Pacific, Africa, and the Middle East. Unilever declared, as a strategic objective, to make sustainable living commonplace, and it is determined to be the global leader in sustainable business by acting on social and environmental issues through the development and selling of innovative, sustainable, and high-quality products while growing consistently and producing financial results in the top third of its industry.

Danone S. A. (https://www.danone.com/) is a French multinational food-products corporation located in Paris. Danone sells its products in 120 markets, and it reported a 2018 total sale of €24.65 billion; 29% of sales came from specialized nutritional preparations, 19% from branded bottled water, and 52% from dairy and plant-based products. The company's portfolio includes international (e.g., Evian) and national brands (e.g., Bonafont in Mexico and Brazil). The Danone Institute, a non-profit organization launched in 1997, promotes research, information, and education about nutrition, diet, and public health. By 2007 the company has created 18 institutes in several countries, including Mexico, aimed to address local public health issues. As part of its CSR, Danone also operates several funds to support environment-related projects such as reforestation. CE is acknowledged as critical to advance the sustainability strategy of the company and focused on the reduction of natural resources and the extension of their life cycle. The Chief Sustainability and Strategic Business Development Office leads the sustainability agenda and integrates all sustainability-related programs of the "One Planet. One Health" framework that supports SDG12 (responsible production and consumption) and SDG-13 (climate action).

Results

Table 1 to Table 6 summarize the coding of the secondary information for each case study according to the environmental archetypes of Bocken *et al.* (2014). The design of long-lasting products and the increase of their longevity are included in the extending loop model, while the reduction in the use of natural resources (water and energy), materials, and dematerialization of product packing fit into the eco-efficiency approach. Recovery, reuse, reburnishing, and recycling are actions aimed to close the materials loop. Finally, zero emissions initiatives and the use of renewable energy sources represent an approach to reducing the use of natural resources through substitution with renewables and natural processes.

The four main codes are not ranked, however, extending the life cycle and closing product loops require major financial investment in the research and development of long-lasting products, as well as in the design and operation of the reverse logistics network while future revenues are uncertain. In contrast, the recycling and reuse of secondary materials, such as packages and paper waste, and the eco-efficiency in manufacturing imply the acquisition of existing technologies that can represent a lower investment that can be recovered in the short to medium term by the savings in the use of resources (water, energy, and raw materials). These differences may explain why the reported CE actions are mainly related to eco-efficiency. CE actions reported are complementing and non-substitutable because all are covered under the umbrella of the CE concept.

Table 1. Coding of CE approaches for automotive companies: Nissan.

Extending resource loops, setting goals and measures	Reducing material and natural resources	Closing resource loops	Substitution with renewables and natural process
-A pioneer of EV and the leader in second-life battery initiatives. -EV36Zero, the goal of the $1.7 billion Nissan EV Center (UK) is to create a world-first EV manufacturing ecosystem that links EVs, renewable energy, and battery production. -The Nissan Node, part of EV36Zero to be completed in 2022 in collaboration with the Melbourne company Relectrify. -Commitment to reduce exhaust emissions of vehicles and encourage that 100% of new models be electric in 2030.	-Nissan Aguascalientes and Cuernavaca plants recycle 100% of the water. -Global objective 2050 is the reduction of the company's carbon footprint throughout the entire value chain. Carbon neutrality is projected for all operations and the product's life cycle. -Nissan Casting Australia project forecasts to cut annual CO_2 emissions from 259 tons, saving 128 megawatts of energy each year. The reuse of batteries at the end of their useful life is also included.	-CE project considers the reuse of the batteries of its electric model at the end of the useful life of the batteries. -Relectrify has developed a battery management and inverter technology that extend battery life, reduces battery system costs, and enables the reuse of second-life batteries from EVs. -ReVolve battery energy storage system is the first product built from end-of-life Nissan LEAF (Leading, Environmentally Friendly, Affordable Family car) batteries.	-The electric model is manufactured with renewable energy. -The EV chargers of staff vehicles are supplied with renewable energy. -Creation of a renewable energy microgrid that will power the EV and battery production at Nissan's Sunderland manufacturing facility, with a reduction of 55 000 tons of carbon per year.

Source: Author's own elaboration based on Nissan Mexicana, S. A., de C. V. (2022).

Remarks: Nissan is focusing on manufacturing with renewable energy, it is committed to the reuse of batteries at the end of their useful life in EV in the long-term, and it advances in the implementation of CE in Mexico, specifically by using 100% recycled water in two of its plants.

Table 2. Coding of CE approaches for automotive companies: GM.

Extending resource loops, setting goals and measures	Reducing material and natural resources	Closing resource loops	Substitution with renewables and natural process
-The basic objective is environmental care through water protection, energy efficiency, waste management, and biodiversity preservation. -Zero-waste company by recycling 100% of operations' waste. -By 2030 the company commits to using 100% returnable, reused, or recycled materials for packing.	-2016 record of waste-free operations at 23 new facilities, a total of 152 industrial plants globally classified as "Landfill Free", Toluca, Mex. is one of them. -Almost 390 704 m^2 of flora and fauna are protected via the certification program Wildlife Habitat Council in the Mexican facilities of Ramos Arizpe, San Luis Potosi, and Silao. -Hydric amount to be reduced by 35% in manufacturing facilities by 2035. -More than 4200 kWh saved at all sites during Earth Hour.	-The materials management plan aims to procure more sustainable materials by reducing carbon emissions, process innovation, increasing recycled material content of products, and renewable energy. -67% of the packaging used in Mexico was returnable, and the rest was made of recyclable material in 2016. -42% of the water in the production process is reused. -Procurement and Supply Chain team plans to enroll 100% of strategic Tier 1 suppliers in the sustainability goals framework.	-17% of the energy consumed in Mexico facilities comes from renewable sources. -Development of new technologies and platforms to electrify vehicles and increase their accessibility. -Strategic plan is to reduce the use of non-renewable resources and minimize the negative impact on the environment by using recycled materials (e.g., glass and aluminum).

Source: Author's own elaboration based on General Motors de México (2022).

Remarks: GM is committed to preserving the environment through natural resource efficiency; its future projects are focused on the use of returnable, reused, or recycled materials for the packaging and manufacturing of its products; its CE projects in Mexico are aligned with the objectives of the company in developed countries. It has four main projects: efficient use of water and protection of aquifers, energy efficiency, waste management, and preservation of biodiversity.

Table 3. Coding of CE approaches for automotive companies: Ford.

Extending resource loops, setting goals and measures	Reducing material and natural resources	Closing resource loops	Substitution with renewables and natural process
-Extension of batteries' life cycle by repairing. -Reduce non-recycled water consumption to zero by 2025.	-All Mexican Ford plants use LED lighting. -Reduction of water in all production processes (100% of the water used by the Chihuahua plant and 45% of water consumed by the Hermosillo plant is recycled). -Cuautitlán and Irapuato joined the rainwater harvesting projects aimed to use 1900 m^3 of rainwater per day and 5000 m^3 per month. -Hydraulic oil from refrigerant oil production lines is separated resulting in savings of 326 000 L of water, 18 000 L of refrigerant oils, a production line stoppage of 32 hours/year, and about 194 000 USD/year.	-Components of Ford vehicles are made from used batteries, bottles, tires, cardboard packaging, and natural fibers, among others. -Globally, Ford recycles an average of 1.2 billion plastic bottles for auto parts each year.	-Ford's 2035 goal is that 100% of the energy used in plants be renewable. -The 2025 goal is zero use of raw water. -Irapuato plant has 100% of dry urinals that save water and avoid waste pollution.

Source: Author's own elaboration based on Ford (2022).

Remarks: Ford is committed to preserving the environment through the proper use of natural resources, manufacturing products through second-hand inputs to extend the life of usable materials, aligning local projects with global projects; its main actions in Mexico have resulted on a considerable reduction in water use in several plants.

Table 4. Coding of CE approaches for manufacturers of FMCGs: Heineken

Extending resource loops, setting goals and measures	Reducing material and natural resources	Closing resource loops	Substituting with renewables and natural process
-The 2030 goal is "zero emissions." -Use of the ReSOLVE framework in all functional areas to perform an auto evaluation of the CE actions. -Treatment of water used before discharging to the environment. -The 2025 goal is to reduce in 160 ton the number of packages. -Production process of bottles and cans modified to reduce their weight by 36% and then CO_2 emissions. -Sustainability advances supervised by top management. -Alliances with critical business partners.	-A global reduction of 3.1 hL in water consumption/hL of produced beer implies a 96% advance in the 2020 goal set in 3.5 L water/L beer. -The water reduction is the lowest in the plants located in Monterrey, NL. and Orizaba, Ver. This last plant reports the lowest water consumption, 2.38 L water beer. -Restitute 2.4 m^3 million of the water from the plants of Monterrey, Toluca, Guadalajara, and Tecate and to regions with limited water resources. -"Cultivating a Better Mexico" program, a water balancing project in 883 ha of the Lerma-Basin Chapala basin in Guanajuato, supports conservation agriculture by saving water and reducing the environmental impact of bare production (57% of barely is sustainable).	-The industrial plant of Meoqui operates under the CE paradigm and is the greenest plant in Latin America. -CE reducing resources approaches in 2019 included a 17% reduction in water consumption, a 16.5% reduction in energy, and an 11% reduction in thermic energy. -The 2021 sustainability report declares 100% of waste is recycled, 60% of water is reused, and 100% of electricity comes from renewable sources. -Recycling packing materials and transitioning to HiCone Virgen package to recycled HiCone. -Third of the bottles are recycled, 70.7% of the cans, 56% of boxes, and 50% of the plastic rings.	-"Drop the C" initiative proposed a global reduction of 45% in CO_2 emissions in main operations and the increased use of renewable sources of energy; currently, it reports 51% of the energy used in the production area in all facilities came from renewable sources and a 98% fulfillment of the 2020 goal. -Objectives for Mexico are a 40% reduction in emissions in production through increasing the process's efficiency. -20% reduction in emissions during distribution via optimization of vehicle capacity and routes, use of cleaner technologies (e.g., biodiesel), and intermodal transportation. -50% reduction in cooling by using 100% Green Fridges equipment. -Biogas for boilers is produced from the treatment of residual water. -Meoqui plant reduced an extra 16.5% of its use of electricity and 11% of its use of thermic energy. -2% increase in the use of renewable thermic energy in Mexican breweries.

Source: Author's own elaboration based on Unilever (2021, 2022a, 2022b, 2022c).

Remarks: Reduction of CO_2 emissions through several projects such as the use of green fridges, production of low-weight cans, optimization of vehicle utilization during distribution, and substitution to renewable energies. Meoqui plant is an internal benchmark of eco-efficiency. It has measurable objectives for the reduction of water and CO_2 emissions.

Table 5. Coding of CE approaches for Manufacturers of FMCGs: Unilever.

Extending resource loops, setting goals and measures	Reducing material and natural resources	Closing resource loops	Substituting with renewables and natural process
-Use at least 25% recycled plastic by 2025. -Recovery and recycling of containers of personal care products thru recollection in main Mexican cities, points of sale, collaboration with small recyclers, and creation of a collection center. -Use of stamps to distinguish between recyclable and non-recyclable products and reuse of at least 20% of recycled materials by 2025.	-Suppliers' and partners' innovations to reduce the use of raw materials intensive in greenhouse emissions (GHG) such as phosphates of laundry products. -Reduction of volume water in manufacturing since 2008, goal is 49% per ton of production. -1 billion € Climate Nature Fund and Lighthouse Projects promote regenerative agriculture by training suppliers and smallholders to recuperate 1.5 million ha of land and forests by 2030. 100% sustainable sourcing of key crops. -"Future Foods" program's goal is to increase annual sales of plant-based products designed to look, taste, or cook like animal-derived proteins. -Most of the ingredients in beauty and personal care products are natural and the division is committed to protecting and regenerating 1.5 million ha of land, forests, and oceans by 2030. -Halve food waste in operations by 2020 and 96% reduction waste per ton of production in 2022. -40% upgrade in CO_2 efficiency of the global logistics network by reducing the distance traveled, improving truck utilization, reduction of the total number of trucks used, and 100% replacement of car fleet by EVs or hybrids by 2030. -Fundamental chemistry innovations to remove and reduce inorganics and surfactants, and compact products.	-Move to 100% renewable or recycled ingredients by 2030. The 7th generation of cleaning and laundry products (e.g., the OMO liquid laundry capsule is biodegradable and made from renewable and captured industrial emissions (gray carbon). -Value recuperation of manufacturing waste of biological sources for animal feed, recovery, and recycling to capture biogas via anaerobic digestion or agriculture composting. -The 2025 objective is an absolute reduction of 100 000 tons of virgin plastic by recycling 25% of plastic and the 100% long-term substitution of plastic packing by reusable, recyclable, or compostable plastic. -Zero non-hazardous waste to landfills from factories since 2015. 4486 tons of hazardous waste were safely disposed of in 2021. Extension to distribution centers and warehouses.	-Climate Transition Action Plan states a long-term 2039 goal of net zero GHG emissions of raw materials, manufactured products, logistics, and distribution including freezers at points of sales. -The Mexican plant of aerosols is the first Latin American plant to achieve zero emissions through the substitution of natural gas for solar energy, saving more than 330 tons of CO_2 per year. -100% renewable grid electricity in 2020 and transition to renewable heat by 2030. -The 2030 Chain Emissions Reduction target is to halve the full chain emissions on a per-consumer use basis thru neutralization and compensation.

Source: Author's own elaboration based on Unilever (2021, 2022a, 2022b, 2022c).

Remarks: Recycling of containers; alliances with suppliers to innovate in environmentally friendly materials; recovery of biological waste; gradual substitution of hazardous materials and substitution to renewable or recyclable ingredients; a Climate Transition Action Plan to reach zero GHG emissions.

Table 6. Coding of CE approaches for Manufacturers of FMCGs: Danone.

Extending resource loops, setting goals and measures	Reducing material and natural resources	Closing resource loops	Substituting with renewables and natural process
-100% of packages are designed for reuse, recycling, or composting. -Water jugs last 4 years and can be reused multiple times and recycled. -Goal is to recycle 100% of PET bottles and 73% of dairy products packages. Volvic Germany completed its switch to 100% rPET for its full range of water bottles. -84% of the package was reusable, recyclable, or compostable in 2021.	-Design new distribution models to reduce energy use and emissions. -Reduction of 27.25% of total food waste since 2016. -55% of facilities operate under a 4R action plan (Reduce, Reuse, Recycle, Reclaim). -Increased use of electronic and hybrid vehicles for last-mile distribution. -Reduce unnecessary packing. -Blue operations environmental management program promotes the incorporation of sustainable actions into operating processes. -Campaigns to promote preference towards healthy, nutritious, and sustainable products that fulfill local consumer diets. -Sustainable agriculture program in Aguascalientes to recover and protect water resources and soil while increasing productivity (35.5% savings in water). -Goal is to save 9 million m^3 of water per year by training farmers and implementing drip irrigation systems. -The Margarita project, a collaborative project supported by Danone, international associations, the Regional Cattle Union of Jalisco, and the Autonomous National University of Mexico supports family milk producers located in Central Mexico to adopt more sustainable production practices. 50% of Danone's milk supply is sourced by these local producers. -Regenerate 8000 ha of palm oil in degraded areas and 3500 ha of global diversity.	-Ecodesign to eliminate components that complicate recycling -Close the loop of bottles and containers.. -Close the water cycle by treating the water.	-Reduce emissions of CO2 by 50% in 2030. Reduction of 48.3% emissions since 2015. -68.5% of renewable energy purchased in 2021. -100% of the dairy products in the plant of Irapuato use energy generated from wind power. -Adding more low-carbon and plant-based products into Danone's portfolio. -62% of net sales were covered by the B Corp certification that expresses Danone's long-time commitment to sustainable business. -Traceability of key ingredients (palm oil, soy, paper, fruit, cocoa, and sugar cane) through certifications such as RSPO, Proterra, FSC, Rainforest Alliance, Organic, Fair Trade, Bonsucro, or RTRS to guarantee security.

Source: Author's own elaboration based on Danone (2020a, 2020b, 2021).

Remarks: 100% of packages are recycled, reused, or compostable; about 50% of facilities operate under a 4R action plan (reduce, reuse, recycle, reclaim). Sustainable agriculture plan and adoption of sustainable production practices in collaboration with local communities; traceability of key materials to guarantee security; steady reduction of CO2 emissions and water usage since 2015.

Discussion

The comparison across cases indicates that the reduction of water and energy are the main CE practices. The establishment of alliances with the industry, the public and private companies, the support of top management, and the establishment of long-term measurable goals are also common actions for all companies. No alliances with research institutions and innovative start-ups to close the product and materials cycles were identified despite their relevance as observed by authors such as Golay (2021) regarding the use of recycled and environmentally friendly fibers by the Scandinavian fashion industry.

Extending the resource loop through the innovation of long-lasting products is the less utilized CE approach. In the case of the FMCG manufacturer sector, slowing the life of the products could be difficult because of their characteristics: short shelf life, nondurable, and consumed rapidly. Extending the packages' life cycle by promoting refillable products such as Tetra Pak, which is easier to transport and requires less energy to produce, could contribute to slowing the package life cycle provided a significant percentage of packages be recycled. The automotive industry has more opportunities to extend the life cycle of their products by encouraging reparation, reselling by certified dealers that guarantee the quality of second-hand vehicles, and the regulated reuse of automotive parts.

As previously noted by Munoz-Melendez *et al.* (2021), there are limited efforts to close the supply chain by redesigning products or reusing raw materials. Closing the packing cycle is the most common approach among wholesale manufacturers of FMCG, meanwhile automakers are focused on the eco-efficiency of their production processes. The reduction of natural resources (water, energy, and materials), zero emissions initiatives, the use of recycled water, and the awareness of the importance of increasing the efficiency of reverse logistics operations (recovery, reuse, refurbishing, and recycling) are the prevailing CE approaches among automakers. For example, Toyota put into operation its biological wastewater treatment plant in 2015 to avoid the discharge of more than 100 000 m^3 of wastewater, and in 2018 it opened a reverse osmosis treatment plant with an annual capacity to recycle 320 000 m^3 of water. Additionally, Toyota set a goal of zero CO_2 emissions for new vehicles. Volkswagen's plant in Puebla reduced its environmental indicators by more than 40% (energy use, CO_2 emissions, and waste disposal) from 2010 to 2021, and its Guanajuato plant reports a 37% progress in environmental efficiency from 2014 to 2021.

Reusing water and waste, either in the production process or performing additional activities (e.g., animal feed and biogas generation reported by Unilever), are CE actions to close the water cycle, resulting in environmental and social benefits. The reduction of emissions is on the agenda of all companies with clear long-term goals that consider the use of renewable resources.

The initial diagnosis of the Instituto Nacional de Ecología y Cambio Climático (INECC, 2020) agrees with the conclusion of this work, the degree of advancement of CE in Mexico is low, except for specific companies, as shown in the case studies analyzed in this work (e.g., Heineken) and other published studies (e.g., Natura). The INECC intended to develop a strategic roadmap to advance CE in Mexico by performing a series of interviews with members of the Confederation of Mexican Industrial Chambers (Concamin), which comprises key economic sectors that contribute to 35% of the GNP, four national industrial chambers, public research centers associated with the Council of Science and Technology, and independent consultants. The INECC, previous studies, and the present study concur with the need for multisectoral coordination because CE actions correspond to a bottom-up approach led by MN companies that set targets for their subsidiaries and industrial sector. The identification of strategies to transit from linear to circular models, given the weakness of Mexican regulations that refrain from closing loops for other materials besides plastic, paper, and metal, deserves special attention (Dieleman & Martínez-Rodríguez, 2019). Several projects such as the creation of a national market of materials to recover their value at different stages of their cycle use (e.g., steel recycling after classification of scratch), the development of a knowledge network where large corporations support the implementation of the CE among small and medium-sized enterprises (SMEs), and the introduction of technologies 4.0 to benefit from the efficiency of Industry 4.0 were proposed by the INECC.

The INECC report also identifies projects that represent benchmarks such as Nestle's reuse of water and the innovation for extracting water from raw materials. Other benchmark projects identified in this work include the 100% production of dairy products manufactured by Danone using wind power and the programs to switch to 100% renewable energy in all manufacturing plants of the automotive companies analyzed. Finally, a set of key performance indicators (KPI) is developed by the INECC, based on international experiences to track CE advances at different levels. These KPI could be the basis of a standardized evaluation of the CE progress of Mexican subsidiaries, allowing comparison among companies, because at present each company sets its indicators. While Heineken reports CE initiatives already implemented in Mexico and prescribed by its headquarters, other MN such as Unilever seem to establish a global CE roadmap and guidelines to subsidiaries so they can advance circularity.

Conclusions

The Agenda of Work Groups 2020, a joint initiative between the Business Coordinator Council and the Mexico Mundial Pact, acknowledges private and public organizations, the academy, and civil society play a critical role to support sustainability. The Circular Economy group, one of the working groups created to define programs to achieve the SDG, published the EC Good Practices manual that provides tools and experiences to switch from a linear to a circular model. The guidelines are based on the analysis of six cases performed by a research group led by enterprises and in partnership with international and governmental organizations (Grupo de Trabajo Agenda 2030, Economía Circular, 2022). This work adds to the documentation of the CE approaches of enterprises located in Mexico by analyzing the cases of six subsidiaries of MN that provide reports and some quantitative evidence of the extent of their actions and environmental impact. Thus, the research enhances the identification of opportunities (e.g., promotion of eco-innovation) and difficulties (e.g., non-regulated informal recycling) for the implementation of CE models in developing countries.

Three of the case studies are companies in the automotive industry, a sector that has not been previously examined to the extent of other sectors. The additional cases analyzed in this study -the Heineken case is fully analyzed in contrast with the cited report that focuses only on the Meoqui plant- confirm leading companies have the potential to implement CE models and achieve economic savings by improving the efficiency of their manufacturing processes and by closing the resources (energy and water), materials (including package), and product cycles.

However, the CE actions of studied companies are mainly based on a systemic approach for identifying and reducing water and fuel energy in manufacturing and operative processes; based on the restitution of solid waste to the industrial sector if the cost of secondary raw materials from recycling (e.g., package) is feasible; and marginally based on the innovation of products that are environmentally-friendly, recyclable, and with a maximum use in longer life cycles. The CE concept is a fragmented collection of activities mostly driven by the concepts of eco-efficiency, cleaner production, and adoption of renewable energy than the cradle-to-cradle principle and the concept of closed supply chains. Therefore, large MN are still in a transition stage to a circular production system.

Although it was not explicitly described in the secondary sources revised, the development of reverse logistics capabilities, a limited innovation of long-life products, and the lack of a shared system that may evolve into an ecological cluster seem to be major barriers to closing materials and product loops and undeveloped organizational capabilities (e.g., limited absorptive capabilities to internalize and exploit the CE experiences of other industries). The secondary data also suggested cultural (e.g., unlimited desire for next-generation technology), market (e.g., lack of a well-developed secondary market for refurbished products), and technological issues (e.g., high costs of technologies for the recycling of electronics' screens and plastics) as main barriers to the implementation of CE models. All these subjects agree with the trends and research venues identified by Ahmad *et al.* (2023) in their bibliographic study.

CE is a necessary concept to advance sustainability, but currently the main actors in the transition process toward circularity are private companies. Top management has a critical role in translating CE into practice, as noted in all cases where the guidelines and projects outlined by the headquarters define the advance of the CE efforts among subsidiaries. A complementary top-down strategy including mandatory management of waste, water, and energy, the backing of eco-parks, and the emergence of new legislation and its adoption by the industry are required for CE to progress (Cortinas & Rosillo, 2022). The Mexican National Development Plan 2019-2024 recognizes the importance of sustainable development, but it does not develop an action plan (Dieleman & Martínez-Rodríguez, 2019). The 2019 initiative of a General Law of CE aims to provide a normative framework for the recycling and value recuperation of waste, particularly packages and containers. However, these exogenous actions are far from promoting a bottom-up collaborative approach that facilitates the transition to circularity attained by European companies (Córdova *et al.*, 2021).

Among the limitations of this research is the reduced number of case studies analyzed, thus, an extension of this work is to conduct more cases in other critical manufacturing and commerce sectors to generalize and contrast results. Furthermore, the analysis of additional cases would amend a potential bias in case selection as they were selected based on extensive online research and the judgment of the authors (Yin, 2014). The use of information from other qualified sources (e.g., international environmental groups) is another extension of this work, because the content of the sustainability reports analyzed comes from the companies themselves, which may not be an objective source. Apart from conducting research that overcomes the potential limitations of this work, a longitudinal study that tracks the CE projects of the companies studied and links their advancement with the three dimensions of sustainability (environmental, social, and economic) is another theme for future research.

Conflict of interests

The authors declare no conflicts of interest.

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