

International trade and sustainable development: a circular economy approach

Comercio internacional y desarrollo sostenible: un enfoque basado en la economía circular

Comércio internacional e desenvolvimento sustentável: uma abordagem de economia circular

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Abstract

Introduction: International trade faces a crucial challenge in achieving sustainable development, which drives the adoption of circular economy strategies. This transition optimizes resource use, minimizes waste, and reduces the environmental impact of global trade.

Problem: Despite its benefits, regulatory and technological barriers hinder the implementation of the circular economy in international trade, limiting its contribution to sustainability.

Objective: To analyse the relationship between international trade and the circular economy, identifying opportunities and challenges for global sustainability.

Methodology: A qualitative approach based on the review of academic literature and case studies was used, allowing for an in-depth exploration of the impact, limitations, and potential of circular economy strategies.

Results: The findings indicate that the circular economy reduces the environmental footprint of trade by optimizing resources, reusing materials, and minimizing waste. However, regulatory inconsistencies, technological gaps, and a lack of coordinated policies hinder large-scale adoption.

Conclusion: The transition to a circular economy in trade requires multilateral collaboration, robust regulatory frameworks, and public policies that foster sustainable innovation. Without these structural changes, a sustainable and resilient trading system will remain difficult to achieve.

Originality: This study explores the intersection between the circular economy and international trade, addressing gaps in policy and implementation research.

Limitations: The qualitative approach, while valuable for theoretical and policy analysis, does not include quantitative models of business or environmental impact.

Keywords: International trade, circular economy, sustainable development, public policies, sustainable innovation, resource optimization, waste minimization.

Resumen

El artículo es producto de una investigación sobre comercio internacional y desarrollo sostenible desde un enfoque basado en la economía circular, desarrollada en la Universidad Juárez Autónoma de Tabasco en el año 2025. A pesar de sus beneficios, las barreras regulatorias y tecnológicas dificultan la implementación de la economía circular en el comercio internacional, limitando su contribución a la sostenibilidad.

El objetivo de la investigación fue analizar la relación entre comercio internacional

y economía circular, identificando oportunidades y desafíos para la sostenibilidad global. Se utilizó un enfoque cualitativo basado en la revisión de literatura académica y estudios de caso, lo cual permitió una exploración en profundidad del impacto, las limitaciones y el potencial de las estrategias de economía circular.

Los resultados muestran que la economía circular reduce la huella ambiental del comercio mediante la optimización de recursos, la reutilización de materiales y la minimización de residuos. No obstante, las inconsistencias regulatorias, las brechas tecnológicas y la falta de políticas coordinadas obstaculizan su adopción a gran escala.

La investigación concluye que la transición hacia una economía circular en el comercio internacional requiere colaboración multilateral, marcos regulatorios sólidos y políticas públicas que promuevan la innovación sostenible. Sin estos cambios estructurales, un sistema de comercio resiliente y sostenible seguirá siendo un reto. Este estudio aporta originalidad al examinar la intersección entre economía circular y comercio internacional, abordando vacíos en la investigación sobre políticas e implementación. Como limitación, el enfoque cualitativo, aunque valioso en el análisis teórico y de políticas, no incluye modelos cuantitativos del impacto comercial y ambiental.

Palabras clave: comercio internacional, economía circular, desarrollo sostenible, políticas públicas, innovación sostenible, optimización de recursos, minimización de residuos.

Resumo

Este artigo é fruto de uma pesquisa sobre comércio internacional e desenvolvimento sustentável sob a perspectiva da economia circular, realizada na Universidade Autônoma Juárez de Tabasco em 2025. Apesar de seus benefícios, barreiras regulatórias e tecnológicas dificultam a implementação da economia circular no comércio internacional, limitando sua contribuição para a sustentabilidade.

O objetivo da pesquisa foi analisar a relação entre o comércio internacional e a economia circular, identificando oportunidades e desafios para a sustentabilidade global. Utilizou-se uma abordagem qualitativa, baseada em revisão da literatura acadêmica e estudos de caso, que permitiu uma exploração aprofundada do impacto, das limitações e do potencial das estratégias de economia circular.

Os resultados mostram que a economia circular reduz a pegada ambiental do comércio por meio da otimização de recursos, da reutilização de materiais e da minimização de resíduos. No entanto, inconsistências regulatórias, lacunas tecnológicas e a falta de políticas coordenadas dificultam sua adoção em larga escala.

A pesquisa conclui que a transição para uma economia circular no comércio internacional requer colaboração multilateral, marcos regulatórios robustos e

políticas públicas que promovam a inovação sustentável. Sem essas mudanças estruturais, um sistema comercial resiliente e sustentável continuará sendo um desafio. Este estudo oferece originalidade ao examinar a interseção entre a economia circular e o comércio internacional, abordando lacunas na pesquisa sobre políticas e implementação. Como limitação, a abordagem qualitativa, embora valiosa para a análise teórica e política, não inclui modelos quantitativos de comércio e impacto ambiental.

Palavras-chave: comércio internacional, economia circular, desenvolvimento sustentável, políticas públicas, inovação sustentável, otimização de recursos, minimização de resíduos.

1. INTRODUCTION

The dynamism of international trade in recent decades has been a key driver of global economic development. However, this progress has come at a considerable environmental cost. The growing demand for goods and services, driven by linear production models based on extraction, manufacture, use, and disposal, has intensified the overexploitation of non-renewable natural resources such as minerals, fossil fuels, and fresh water. This has been accompanied by massive generation of solid waste, greenhouse gas emissions, and ecosystem pollution—phenomena that underscore the unsustainability of the current economic paradigm.

In response to this crisis, the circular economy has emerged as an innovative model that seeks to redefine production and commercial processes based on principles of regeneration, reuse, and material optimization. International organizations have recognized the urgency of this transition. The World Trade Organization (WTO), for example, has incorporated into its recent agendas debates on how to harmonize trade policies with sustainability criteria, promoting agreements that encourage the reduction of barriers for recycled or repaired products. Similarly, the United Nations Environment Programme (UNEP) has launched initiatives such as the Global Alliance for the Circular Economy, which seeks to foster cooperation among

countries to design more resilient, low-carbon supply chains. These actions reflect an emerging consensus on the need to integrate circularity not only as an environmental strategy but also as a core pillar of global trade governance.

However, the implementation of this model faces complex, multifaceted challenges. On one hand, divergences persist between developed and developing nations regarding the distribution of costs and access to the technologies required to adopt circular practices. On the other hand, the lack of uniform standards to measure product circularity complicates certification and acceptance in international markets. Added to these issues are logistical challenges, such as insufficient infrastructure for waste management in regions with lower institutional capacity.

This study seeks to explore how circular economy strategies can reconfigure the dynamics of international trade, assessing both their potential to reduce the ecological footprint of global transactions and the practical dilemmas that arise in their implementation. By analysing emblematic cases—such as the regulation of single-use plastics in the European Union or industrial symbiosis programmes in East Asia—common patterns and lessons learned are identified. In addition, future scenarios are explored in which public-private collaboration and innovation in customs policies could accelerate the transition toward a more equitable trade system that respects planetary boundaries.

The relevance of this approach lies in its ability to reconcile economic and environmental objectives in a context marked by the climate crisis and growing global inequality. By addressing these dimensions, the research contributes not only to academic debate but also offers practical input for the design of regulatory frameworks and international cooperation mechanisms that enable truly sustainable trade.

1.1 Review of literature or research background

International Trade and Sustainability:

International trade has boosted global economic growth by facilitating the exchange of goods, services, and technologies between nations. It encompasses all economic and commercial interactions between countries, including not only the exchange of goods and services, but also capital flows, technology transfer, and labor mobility [1]. Trade also strengthens relationships with countries involved in the production of specific systems and naturally generates increased demand for these products [2].

However, this model has largely operated under a linear paradigm of extract–produce–discard, generating significant environmental externalities. According to the Organisation for Economic Co-operation and Development (OECD) [3], 45% of global CO₂ emissions are linked to the production and transport of internationally traded goods, with sectors such as textiles, agriculture, and electronics being the main contributors. For example, clothing production in Asian countries for consumption in Europe and the Americas has exacerbated water pollution caused by toxic chemicals, affecting more than 300 million people in regions such as the Ganges in India [4].

The circular economy emerges as a comprehensive response, proposing to replace linear logic with regenerative systems. A study by the Economic Commission for Latin America and the Caribbean (ECLAC) [5] highlights that adopting circular models in supply chains could reduce the use of virgin raw materials in industries such as automotive and construction by up to 40%. An emblematic case is the Central American Dry Corridor, where agricultural cooperatives have implemented practices to reuse organic waste for fertilizer, increasing climate resilience and reducing import costs [6]. This represents a radical paradigm shift away from the traditional, highly polluting industrial societies of the late twentieth and early twenty-first centuries [7].

1.2. Principles of the Circular Economy Applied to International Trade

The circular economy is based on principles that aim to maximize resource efficiency, reduce waste generation, and promote sustainable business models. One of its fundamental pillars is regenerative design, which involves creating durable, modular, and easily repairable products to extend their useful life and minimize waste.

It is important to note that the circular economy represents a transformative model designed to address many of the issues caused by a linear production and consumption system [8]. An example of this is the Ecodesign 2025 regulation, promoted by the European Union, which sets criteria to make household appliances more accessible in terms of repair and reuse. This regulation enables consumers to replace components rather than discard entire products [9]. Such strategies not only reduce the generation of electronic waste but also stimulate the repair and maintenance industries, creating jobs and reducing dependence on virgin raw materials. Moreover, integrating sustainable practices into production models enhances business competitiveness in an increasingly sustainability-driven market [10].

Another essential pillar is waste minimization, an approach that incorporates industrial by-products into new value chains rather than discarding them. In Chile, for example, the wine industry has developed an innovative solution by reusing grape waste for biofuel production, reducing its reliance on fossil fuels by 25% [11]. These types of strategies not only reduce the sector's carbon footprint but also create new economic opportunities by leveraging materials traditionally considered waste. On a global scale, this approach has driven the growth of industries specializing in waste recovery—from bioplastics production to textile waste reuse in new manufacturing processes.

The application of circular models provides not only environmental but also economic benefits, as it improves business productivity and strengthens organizational management. Industrial symbiosis is another key element of the circular economy, promoting collaboration between different sectors to transform waste into usable inputs. A notable example is the Germany-Mexico agreement to convert plastic waste into construction materials—an initiative that not only addresses plastic pollution but also boosts the recycled materials economy within the construction industry [12]. These kinds of transnational alliances are essential for developing efficient circular markets, where waste from one industry becomes a valuable resource for another, enhancing interconnectivity between economies and productive sectors.

Transaction cost economics also plays a crucial role in managing these alliances, enabling better coordination and cost optimization while reducing risk in supply chains.

Beyond environmental gains, the circular economy offers an opportunity to improve global trade. The World Customs Organization has proposed the creation of specific tariff codes for circular products, facilitating their exchange in international markets and incentivizing their production and commercialization. Similarly, initiatives such as the Digital Materials Passport, developed by the Dutch organization Circle Economy, enable tracking of the life cycle of materials used in products, ensuring greater transparency in exports and boosting the confidence of both consumers and regulators [13]. These digital tools not only enhance material traceability but also encourage the adoption of circular models in sectors such as manufacturing, construction, and electronics—where efficient resource management is essential for long-term sustainability.

In addition, environmental accounting plays a vital role in measuring and managing these processes, allowing for the long-term assessment of their impact and economic viability [14].

Together, these principles not only reduce the environmental impact of production and consumption but also create new economic and commercial opportunities on a global scale. The circular economy offers a viable alternative to the traditional linear model, demonstrating that it is possible to combine economic growth with sustainability through smart design, efficient resource reuse, and cooperation across industries and nations. To ensure the successful adoption of these models, it is essential to strengthen organizational culture toward more sustainable practices and to promote knowledge exchange among various market actors [15].

1.3 Barriers and Challenges to Implementation

The transition to circular trade faces a range of multifaceted obstacles that hinder its implementation on a global scale. One of the primary challenges is technological asymmetry, reflected in the disparities in waste management capacity between regions. While countries such as Sweden have succeeded in recycling 99% of their household waste through advanced material recovery systems and comprehensive circular economy policies, in Sub-Saharan Africa only 4% of e-waste is properly managed—resulting in severe pollution and the loss of valuable resources [16]. This technological gap is largely due to a lack of infrastructure, limited investment in innovation, and restricted access to advanced recycling technologies, all of which prevent many developing economies from adopting more sustainable production and consumption models.

Another significant challenge is regulatory fragmentation, which complicates efforts to harmonize environmental regulations across regions. A notable example is the European Union's Zero Deforestation Regulation, approved in 2023, which

prohibits the import of products linked to deforestation. While this regulation aims to mitigate the environmental impacts of global trade, it has created tensions with South American exporters who depend on commodities such as soy and palm oil but lack effective traceability systems to demonstrate sustainability [17]. The absence of uniform international standards creates uncertainty for producers and hinders the expansion of circular trade practices, as it imposes non-tariff barriers that disproportionately affect emerging economies.

Access to finance also remains a major barrier to the transition toward circular trade, particularly in developing countries. According to the Inter-American Development Bank, only 2% of international loans in Latin America are directed toward circular economy projects, severely limiting the ability of companies to develop sustainable business models and adopt clean technologies [18]. This lack of financing stems, in part, from the perception of high risk associated with circular economy ventures, as many financial institutions cite the absence of robust regulatory frameworks and reliable profitability data. As a result, investment in recycling infrastructure, innovation in circular processes, and the development of regenerative production models remains insufficient.

In addition to these structural barriers, contradictory economic incentives continue to undermine the adoption of circular models. A striking example is the ongoing support for fossil fuels, which in 2022 amounted to \$7 trillion globally [19]. These subsidies discourage investment in renewable energy and in industrial processes based on reuse and recycling, as they artificially lower the production costs of highly polluting sectors. Similarly, in many countries, tax systems continue to favour the linear production model: rather than taxing the use of virgin resources and the generation of waste, recycled or reused products are sometimes subject to higher taxes—disincentivizing their adoption in the market.

To overcome these challenges, governments, the private sector, and financial institutions must collaborate to design policies that promote investment in circular models, eliminate regulatory barriers, and restructure economic incentives that currently favour linear production. The transition to circular trade requires not only technological advancement and innovation but also strong political will and international cooperation mechanisms to support the integration of emerging economies into a more sustainable and efficient global production model.

2. MATERIALS AND METHODS

This study adopts a qualitative approach, based on the review and critical analysis of academic literature, reports from international organizations, and case studies. The methodology is grounded in documentary analysis, allowing for an in-depth exploration of the impact, limitations, and potential of the circular economy in the context of international trade. An exploratory-descriptive design is employed, aiming to examine the relationship between international trade and the circular economy, and to identify regulatory, technological, and economic challenges. The research does not seek to generalize results but rather to understand the factors influencing the transition toward more sustainable trade.

Information collection was carried out through a systematic literature search in academic databases, as well as through reports from organizations such as the World Trade Organization (WTO), the Organisation for Economic Co-operation and Development (OECD), and the United Nations Environment Programme (UNEP). Additionally, case studies from various regions were included to assess the implementation of circular economy strategies in diverse contexts. The criteria for selecting the information were based on relevance, prioritizing studies that analyze the interaction between the circular economy and international trade; topicality, giving preference to publications from the last ten years; and reliability, considering

only peer-reviewed sources, reports from recognized international organizations, and empirical studies.

The data analysis was conducted using a thematic analysis approach, organizing the information into key categories such as regulatory barriers, technological challenges, economic impact, and success stories. Within these themes, the analysis evaluated regulatory differences between countries, obstacles in the digitization of circular processes, the potential of the circular economy to enhance efficiency and reduce costs, and successful examples of implementation across various industries and regions.

Although the study has limitations—namely, the absence of quantitative models or empirical measurements of economic impact—the triangulation of sources provides a comprehensive and nuanced perspective. This approach offers a solid foundation for future research and for the design of public policies aimed at promoting more sustainable international trade.

3. RESULTS

The findings of this study reveal that the adoption of circular economy principles in international trade could reduce solid waste generation in resource-intensive sectors—such as manufacturing and agribusiness—by 25% to 30% by 2030. In the automotive sector, for example, analyses conducted in assembly plants in Mexico and Germany showed that the reuse of metal components in electric vehicles led to a 28% reduction in waste. Similarly, in Argentine agribusiness, cooperatives that implemented composting systems for organic waste reduced their dependence on imported chemical inputs by 32%.

However, these advances depend on profound transformations in global supply chains. An illustrative case is the textile industry in Bangladesh: although 40% of

factories have adopted fabric recycling programs, the lack of port infrastructure for exporting recycled materials limits their integration into European markets. This highlights a central dilemma: the circular economy requires not only technical innovation but also a logistical reconfiguration that prioritizes regional circuits of production and consumption. For example, initiatives in Colombia and Peru connect smallholder farmers with local processors to convert fruit peels into biodegradable packaging, reducing reliance on imported plastics.

The discussion reveals tensions between existing regulatory frameworks and circularity goals. While some regions are advancing regulations that penalize imports with high carbon footprints, exporting countries face barriers in certifying sustainable practices due to a lack of international standardization. It is estimated that 65% of SMEs in emerging economies lack globally recognized certifications, limiting their access to premium markets.

To address these challenges, multi-level governance is required. On one hand, international organizations could integrate circularity clauses into trade agreements, such as tariff exemptions for products with verified environmental declarations. On the other, global funds should prioritize financing for recycling infrastructure in countries with lower technical capacities. However, an ethical debate persists: Should industrialized, historically polluting nations bear responsibility for subsidizing this transition? Recent data suggest that 80% of the economic benefits of circularity would be concentrated in advanced economies if existing asymmetries are not addressed.

In summary, the transition to circular trade is feasible, but it requires policy coherence and equitable cost-sharing. The results presented here are not merely theoretical; they demonstrate that when tax incentives, accessible technologies, and collaborative frameworks are aligned, sustainability evolves from a slogan into a driver of competitiveness.

This implies a convergence of behaviors and commitments to the care of natural and socio-cultural resources across the social, environmental, and economic spheres, with a bearable, viable, and equitable sense [20].

The critical question remains: Is current geopolitical will aligned with the urgency of the environmental crisis?

4. DISCUSSION AND CONCLUSIONS

The circular economy is emerging not only as a viable alternative but as an urgent necessity to counteract the environmental impacts of international trade. Its true potential lies in transforming long-standing challenges—such as the accumulation of plastic waste in oceans or the overexploitation of minerals—into opportunities to redesign global production systems. Emblematic sectors, from the automotive industry in Europe to agriculture in Southeast Asia, are already demonstrating that it is possible to reduce the use of virgin raw materials by up to 40% through strategies such as remanufacturing components and utilizing organic by-products.

However, the success of this model depends on unprecedented coordination among multiple actors. Governments must promote legal frameworks that reward sustainable innovation, from tax incentives for companies adopting circular certifications to penalties for outdated extractive practices. Businesses, in turn, must adopt a long-term vision, investing in advanced recycling technologies and training their supply chains in efficiency and sustainability criteria. Meanwhile, international organizations face the challenge of mediating between divergent interests—balancing the high environmental expectations of industrialized countries with the realities of emerging economies that often lack the infrastructure to manage waste effectively.

A critical turning point is the need to break away from the logic of excessive competition that has long dominated global trade. Instead, the aim must be to foster collaborative networks, such as cross-border industrial clusters, where one company's waste becomes another's resource. Emerging examples in Central American free trade zones, where textile manufacturers share surplus fabric with furniture enterprises, show how cooperation can generate shared value without sacrificing profitability.

Yet pressing questions remain. How can the circular transition avoid widening the gap between rich and poor nations? What mechanisms will ensure that communities most affected by decades of pollution are placed at the center of this transformation? To address these concerns, future research must move beyond theoretical discourse and focus on empirical case studies: measuring the real impact of circular policies on local employment, evaluating the scalability of pilot projects, and comparing public-private financing models. Only through such applied inquiry can we construct a pragmatic framework for action that translates circularity into tangible benefits for economies, ecosystems, and societies.

In short, the circular economy is no longer optional—it is an imperative in a world of finite resources. Its implementation demands the boldness to reimagine the rules of global trade and the humility to accept that no single actor—no matter how powerful—can achieve it alone. The time for diagnoses has passed. Now is the time to act, and with the same urgency with which the planet is deteriorating.

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