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Sustainability as a strategic driver in business decision-making

Sostenibilidad como eje estratégico en la toma de decisiones empresariales

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Circular economy and eco-innovation practices: a sustainable development approach

Prácticas de economía circular y eco-innovación: un enfoque del desarrollo sustentable

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Abstract: the academic literature establishes that the integration and application of circular economic strategies encourage industrial enterprises to enhance their eco-innovation practices and sustainable performance, which helps drive the transition to a more sustainable economic system. However, the body of knowledge and evidence presented in the current academic literature on the effects of circular economic practices on eco-innovation and sustainable development presents fragmented and, in some cases, contradictory evidence and results. Therefore, this study seeks to fill this gap and contribute to addressing this deficiency by analyzing and discussing the effects of circular economic practices on eco-innovation and sustainable development practices of industrial enterprises. To this end, a paper survey was distributed to a sample of 410 industrial enterprises in Mexico, analyzing the data obtained through PLS-SEM. The findings suggest that circular economic practices have a notable beneficial influence on both eco-innovation practices and sustainable development activities, while eco-innovation practices do not exert a significant positive influence on sustainable development activities. In this context, the results led to the final inference that Mexican industrial enterprises are in an incipient stage of transition from a traditional linear model to a circular economic model, which is improving eco-innovation practices and sustainable development.

Keywords: circular economy, circularity, innovation, eco-innovation, sustainability, sustainable development, manufacturing firms, manufacturing industry.

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Resumen: la literatura académica establece que la integración y aplicación de estrategias de economía circular incentiva a las empresas industriales a mejorar sus prácticas de eco-innovación y su desempeño sustentable, lo cual ayuda a impulsar la transición hacia un sistema económico más sustentable. Sin embargo, el conjunto de conocimientos y evidencia presentados en la literatura académica actual sobre los efectos de las prácticas de la economía circular en la eco-innovación y el desarrollo sustentable presenta evidencia y resultados fragmentados y, en algunos casos, contradictorios. Por ello, este estudio busca llenar este vacío y contribuir a abordar esta deficiencia mediante el análisis y la discusión de los efectos de las prácticas de la economía circular en la eco-innovación y el desarrollo sustentable de las empresas industriales. Para este fin, se distribuyó una encuesta en papel a una muestra de 410 empresas industriales en México, analizando los datos obtenidos a través de PLS-SEM. Los hallazgos derivados sugieren que las prácticas de la economía circular tienen una notable influencia beneficiosa tanto en las prácticas de eco-innovación como en las actividades del desarrollo sustentable, mientras que las prácticas de eco-innovación no ejercen una influencia positiva significativa en las actividades del desarrollo sustentable. En este contexto, los resultados llevaron a la inferencia final de que las empresas industriales mexicanas se encuentran en una etapa incipiente de transición de un modelo lineal tradicional a un modelo económico circular, que está mejorando las prácticas de eco-innovación y el desarrollo sustentable.

Palabras clave: economía circular, circularidad, innovación, eco-innovación, sustentabilidad, desarrollo sustentable, empresas manufactureras, industria manufacturera.

Introduction

The rise in environmental problems, such as water and air pollution, the depletion of natural resources, and ecological imbalance, is leading to greater consumer awareness and an increase in demand for environmentally friendly products (Le *et al.*, 2023). Furthermore, from a business perspective, the constant uncertainty regarding the availability of natural resources, coupled with the strong social pressure industrial companies are facing, is raising awareness within the business sector about the need to adopt and implement sustainable initiatives to minimize negative impacts on the environment (Le *et al.*, 2023). Therefore, industrial companies are seeking strategies that balance economic, social, and environmental benefits (Skalli *et al.*, 2024). However, most industrial companies worldwide continue to prioritize economic objectives over social and environmental benefits, rather than balancing the triple bottom line (Le *et al.*, 2023).

From this perspective, circular economy (CE) practices and eco-innovation (EI) practices are two of the most widely adopted strategies by industrial companies to address sustainability challenges. Wuyts *et al.* (2020) suggested that CE acts as a driver of innovation and sustainability, and thus CE and EI play an essential role in enhancing sustainable development (SD) activities in industrial firms. However, the current academic literature remains limited and lacks robust empirical evidence on the adoption of CE and EI that generates economic benefits while simultaneously respecting social and environmental standards (Skalli *et al.*, 2024), therefore, it is recommended to obtain future empirical evidence on the effects of CE and EI and their implications for the economic, social, and environmental performance of the manufacturing industry (Skalli *et al.*, 2024).

There are differences in the findings. For example, Cheng *et al.* (2021) did not observe significant effects of CE on sustainability performance, while Saha *et al.* (2021) found negative effects, and other studies have identified notable beneficial influences (e.g., Susanty *et al.*, 2020). Furthermore, the relationship between CE and EI requires further empirical testing in the manufacturing industry (Triguero *et al.*, 2023), especially since it remains unclear in the academic literature what types of EI practices should be promoted to support the adoption and implementation of CE in the industry, enabling not only the creation of competitive advantages for organizations but also an improvement in SD (Mora-Contreras *et al.*, 2025), such that these practices do not harm their reputation, image, credibility, and competitive advantage.

From this perspective, the objective of this research is to analyze and discuss the effects that CE has on EI and SD. To achieve this objective, an empirical study was conducted in Mexican industrial firms, using a sample of 410 observations and estimating the research model using the *P*artial Least Squares Structural Equation Modeling *(*PLS-SEM) statistical technique, with the support of SmartPLS 4.0 software (Ringle *et al.*, 2024). The manufacturing industry in

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Mexico is essential for two basic reasons: first, because it is the industry least compatible with environmental protection and sustainability (Scur *et al.*, 2019); and second, because it is the industry that contributes the most to the national GDP (INEGI, 2020).

Finally, in line with the recommendations of Mora-Contreras *et al*. (2025) and Mora-Contreras and Carrillo-Hermosilla (2025), to conduct future studies that provide solid empirical evidence on the relationship between CE and EI that contribute to generating improvements in the economic, social, and environmental aspects of industrial companies, the main contribution of this study is to provide cutting-edge information on CE practices that impact EI practices and to integrate them into a coherent SD framework in industrial firms. Therefore, the effects of CE on EI and SD can be considered inconclusive and open to debate; thus, to complement and expand the limited existing knowledge in the academic literature, this study poses the following research question: *What are the effects of CE practices on EI practices and SD activities in industrial firms?*

Circular Economy and Sustainable Development

The current environmental crisis facing the planet, known as the planetary emergency, demands a significant socioeconomic transformation of global society (De Angelis and Ianulardo, 2024), especially within companies, as they play a fundamental role in driving the transition toward sustainability (Schaltegger *et al.*, 2023). However, "to transform companies toward true sustainability and well-being for all, it is necessary to change the system itself" (Waddock, 2020, p. 9). This serious environmental crisis demands a profound restructuring of the intellectual frameworks through which sustainability is understood in the field of management (De Angelis and Ianulardo, 2024), hence the field of management studies, and more specifically that of corporate sustainability, is criticized in the academic literature for its inability to contribute effectively to SD and its management practices (Schaltegger *et al.*, 2023).

To address this issue, the CE emerges in the academic literature as one of the most effective and efficient strategies (De Angelis and Ianulardo, 2024); therefore, this study defines CE as "a transformative and systemic vision for a more ecologically effective economic system that operates within planetary boundaries and, consequently, maintains and rebuilds natural capital" (De Angelis and Ianulardo, 2024, p. 4862). Essentially, because recent studies have demonstrated in theory the relationship between CE and SD (e.g., Mora-Contreras and Carrillo-Hermosilla, 2025), and because CE is considered the most operational concept compared to others proposed in the academic literature for achieving a more sustainable economy (Mora-Contreras *et al.*, 2023).

However, although there are studies published in the academic literature that have demonstrated that CE significantly improves SD performance (e.g., Mora-Contreras *et al.*, 2023; Piyathanavong *et al.*, 2024), their results cannot be considered conclusive (Khan *et al.*, 2021). In particular, because some studies have found a positive influence between CE and economic and environmental performance, but not on social performance (e.g., Mora-Contreras *et al.*, 2025), while other studies have found a positive influence between CE and social and environmental performance (e.g., Khan *et al.*, 2021), and yet another study has found a positive influence between CE and economic, social, and environmental performance (e.g., Khan and Kabir, 2020), further studies are needed to provide robust empirical evidence on the relationship between CE and SD (Mora-Contreras and Carrillo-Hermosilla, 2025).

In order to provide empirical evidence supporting the relationship between CE and SD, recent studies such as that by Khan and Kabir (2020) have found that CE significantly increases SD, while the study by Priyadarshini and Abhilash (2020) has demonstrated the existence of a positive relationship between CE and SD. Similar results were obtained in the study by Sebestová and Sroka (2020), who found that small industrial firms that adopted and implemented CE practices significantly improved their SD activities. Therefore, it can be concluded that the application of CE helps industrial firms reduce negative environmental impacts and improve their SD through reduction, reuse, recycling (3Rs), recovery (4Rs), redesign, and remanufacturing (6Rs) of materials and raw materials in production processes (Mora-Contreras *et al.*, 2023). Thus, considering the information presented above, the following research hypothesis can be proposed.

H1: The higher the level of the circular economy, the higher the level of sustainable development.

Circular Economy and Eco-Innovation

The concept of the CE has received significant attention from the scientific, academic, and business communities, as well as from policymakers and governments seeking to replace the current linear “take, make, and dispose” model of production and consumption with a more sustainable circular model (Al Halbusi *et al.*, 2025). The adoption and implementation of CE requires industrial companies to incorporate EI into their production and management systems, in order to achieve a shift that prevents the depletion of natural resources, closes energy cycles, and improves long-term economic, social, and environmental performance (Mora-Contreras *et al.*, 2025), to which end CE will help industrial companies repair, reuse, remanufacture, refurbish, and recycle materials, with EI playing an essential role (Mora-Contreras *et al.*, 2025).

From a business perspective, researchers and academics have recently focused their studies on analyzing the effects of CE on EI (e.g., Al Halbusi *et al.*, 2025), particularly from a SD perspective in the manufacturing industry (Mora-Contreras *et al.*, 2023; Mora-Contreras and Carrillo-Hermosilla, 2025). From this perspective, the effective adoption and implementation of CE in industrial firms depend, to a large extent, on systemic cooperation and integration among multiple stakeholders (Ramírez-Rodríguez *et al.*, 2024), with EI serving as a means to facilitate this transition (Schultz and Reinhardt, 2022), as it has been demonstrated in the academic literature that CE substantially improves EI in industrial firms, enabling them to enhance both sustainable performance and competitive advantages (Piyathanavong *et al.*, 2024; Mora-Contreras *et al.*, 2025).

Furthermore, it has been demonstrated in the academic literature that EI is consistent with CE (e.g., Kiefer *et al.*, 2021), especially if EI is defined as:

> The production, assimilation, or exploitation of a product, production process, service, management practice, or business method that is new to the organization and that results, throughout its life cycle, in a reduction of environmental risk, pollution, and other negative impacts of resource use (including energy use) compared to relevant alternatives. (Kemp and Pearson, 2007, p. 3)

Therefore, CE has a notable beneficial influence on EI, primarily because EI refers to any type of innovation implemented in industrial companies to reduce negative impacts on the environment (from changing conditions in supply, demand, or market regulation), whereas CE refers to the adoption and implementation of a set of EI explicitly designed to promote a more circular innovation system (Triguero *et al.*, 2023).

In this context, the adoption and application of CE demonstrate industrial firms’ commitment to environmental sustainability, leading to improved SD (Le *et al.*, 2023). Therefore, all business practices of industrial firms revolve around improving resource efficiency and reducing raw material consumption to minimize environmental damage (Kiefer *et al.*, 2021). Thus, CE provides the ecological resource base necessary to promote the adoption of EI in companies and to enable them to address sustainability challenges by transitioning from a traditional linear model to a more sustainable one (Cherrafi *et al.*, 2022). According to Kiefer *et al.* (2021), the CE contributes to an increase in EI in a systematic way, as the relationship between the CE and EI is too close (Schultz and Reinhardt, 2022). Thus, considering the infor-

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mation presented above, it is possible to propose the following research hypothesis.

H2: The higher the level of circular economy, the higher the level of eco-innovation.

Eco-innovation and sustainable development

Innovation is considered in the academic literature as one of the essential elements that increase business performance, improve people's standard of living, and have a strong influence on the development of economies. This idea is presented by Dima *et al.* (2020), who argue that innovation is a critical factor determining the development potential of industrial enterprises, national economies, and society in general. It demonstrates that innovation can be used to introduce environmentally friendly products, known as EI, which substantially reduce negative impacts on the environment and sustainability (Chien *et al.,* 2023). However, the positive effects of EI, both on industrial firms and on sustainability, are not immediate, as a prolonged period is required to achieve better business and sustainable development outcomes (Chen *et al.*, 2023).

Nevertheless, there is no doubt that EI significantly improves SD (Chien *et al.,* 2023), especially in the last two decades, during which environmental concerns related to natural resources have increased, requiring measures that lead to the achievement of ecological and long-term sustainability (Ahmad *et al.*, 2024). From this perspective, Chen *et al.* (2023) analyzed the influence of EI on green growth in BRICS countries during the 1993–2019 period and found that EI stimulates green growth and SD, while Suki *et al.* (2022) found that EI can significantly reduce both greenhouse gas and CO2 emissions and optimize resource utilization, which has a positive impact on both the green growth of countries and firms as well as on sustainable development.

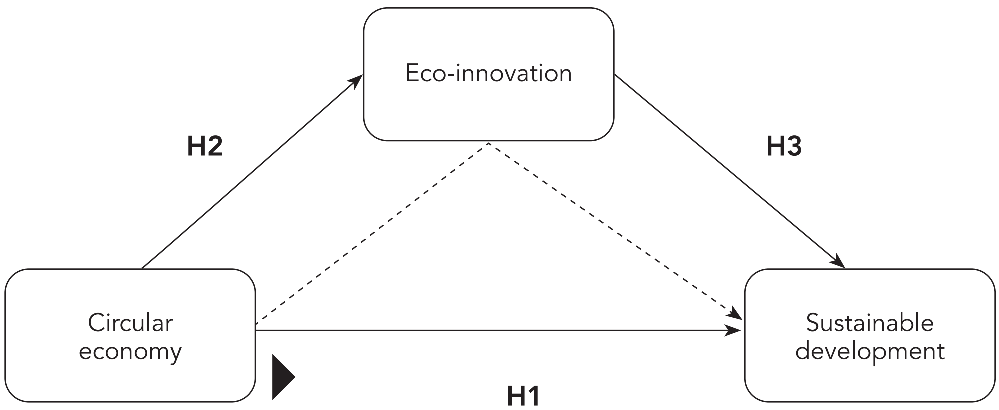
Mahmood *et al.* (2022) analyzed the effects of EI on corporate green growth and found that EI contributes positively to corporate green growth, primarily because EI contributes to the promotion and development of environmentally friendly products and technologies, which not only reduces levels of environmental pollution but also enables sustainable economic growth. Koseoglu *et al.* (2022) suggested that countries should transition toward green EI, as it is vital for enhancing sustainable development, given that EI is one of the fundamental ways to increase levels of sustainable development, while Sun *et al.* (2023) argued that EI can significantly improve resource efficiency by enhancing product design and production processes to make them more environmentally friendly, reducing industrial waste, and promoting the adoption of circular economy practices, thereby reducing the depletion of natural resources.

Furthermore, EI can help industrial companies develop environmentally friendly products and technologies, thereby reducing pollution levels, promoting the use of renewable energy, and lowering emissions of pollutants (Chien *et al.*, 2023). In this context, EI can help organizations increase their economic performance while minimizing the adverse effects of pollution and achieving social and environmental goals (Sun *et al.*, 2023). Consequently, an increasing number of countries worldwide are incorporating EI into their policies and programs, with the aim of significantly reducing greenhouse gas emissions in light of the catastrophic climate change caused by industrialization and the exponential demand for consumer goods (Chien *et al.*, 2023). Therefore, considering the information presented above, it is possible to propose the following research hypothesis.

H3: The higher the level of eco-innovation, the higher the level of sustainable development

In Figure 1 below, the three hypotheses proposed in the research model can be seen.

Figure 1
Research Model



Materials and methods

To answer the questions established in the research model, an empirical study was conducted among industrial firms in Mexico, using the National Directory of Economic Units (DENUE), which, as of January 30, 2023, contained a registry of 32,541 industrial firms with more than ten employees (INEGI, 2023). It is important to note that industrial firms belong to various regional, national, and international chambers of commerce and business organizations; therefore, the study was not oriented toward any particular chamber or business organization. Additionally, a "Business Panel" was conducted, involving five business owners from industrial firms, two representatives from government agencies involved in financial support for businesses, and three academics in the field of innovation, who were provided with the survey to be used for analysis and discussion.

The results obtained from this Business Panel enabled the design of a survey to collect information, which was administered to a pilot sample of ten business leaders from industrial companies to verify that the questions were appropriate and that there were no incorrect responses from the executives of the surveyed manufacturing firms, with only minor adjustments made to the wording. Pilot studies are essential to ensure validity when questionnaires are self-administered or contain self-developed scales (Bryman, 2016; Hair *et al.*, 2016). The selection of industrial companies was carried out using simple random sampling, considering a margin of error of ±4% and a 95% confidence level, which resulted in a sample of 410 companies; the survey was sent to 600 industrial companies, and a total of 410 surveys were received. The paper survey was administered from February to June 2023 and distributed to executives at the industrial companies, who identified individuals within the organization with the appropriate experience and knowledge to answer the different sets of questions.

As a preliminary step to the reliability and validity analysis, a comprehensive review of the academic literature was conducted to identify the most appropriate measurement scales for the study. To measure CE, the scale developed by Ormazabal *et al.* (2018), consisting of eight items, was used. EI was assessed using the scale by Segarra-Oña *et al.* (2014), consisting of seven items. Finally, SD was measured using the scale proposed by D'Amato *et al.* (2019), consisting of nine items. All items on the three scales were assessed using a five-point Likert scale (1 = strongly disagree; 5 = strongly agree). Table 1 presents the items of the scales used in this study and shows that all exceed the recommended value of 0.6 according to Hair *et al.* (2019).

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Table 1
Evaluation of the measurement model

Indicators	Constructs	Factor loadings (p-value)
Circular economy (CE) **Cronbach's alpha: 0.947; Dijkstra-Henseler's rho (ϱA): 0.949; CRI (ϱc): 0.955; AVE: 0.728**		
CE1	There is an environmental commitment on the part of senior management	0.818 (0.000)
CE2	There is support for environmental management from middle management.	0.859 (0.000)
CE3	There is cooperation among different departments or functional areas to improve the organization's environmental practices.	0.874 (0.000)
CE4	There is a training program for the organization's employees and workers on environmental topics.	0.874 (0.000)
CE5	There is a comprehensive environmental quality management program.	0.842 (0.000)
CE6	There are ongoing environmental audit programs for the organization, such as the ISO 14000 standard.	0.873 (0.000)
CE7	Eco-labels are used on most of the products produced by the organization.	0.866 (0.000)
CE8	There is a program to prevent pollution from waste generated by the organization, such as clean production.	0.818 (0.000)
Eco-innovation (EI) **Cronbach's alpha: 0.936; Dijkstra-Henseler's Rho (ϱA): 0.946; CRI (ϱc): 0.948; AVE: 0.723**		
EI1	Focuses its investment primarily on eco-innovation activities.	0.858 (0.000)
EI2	Raises awareness about eco-innovation	0.869 (0.000)
EI3	Distributes information on eco-innovation	0.887 (0.000)
EI4	Offers ongoing training in eco-innovation.	0.858 (0.000)
EI5	Participates in or develops research and development projects in eco-innovation.	0.838 (0.000)
EI6	Consistently supports the adoption and implementation of environmental standards.	0.833 (0.000)
EI7	Supports investments to improve the eco-innovation of its suppliers.	0.804 (0.000)
Sustainable Development (SD) **Cronbach's alpha: 0.935; Dijkstra-Henseler's rho (ϱA): 0.937; CRI (ϱc): 0.945; AVE: 0.659**		
SD1	Expands the economy's productive potential.	0.815 (0.000)
SD2	Promotes economic growth to facilitate the satisfaction of basic needs	0.834 (0.000)
SD3	Decouples economic growth from material consumption.	0.829 (0.000)
SD4	Stabilizes the economy's productive potential	0.848 (0.000)
SD5	Stabilizes economic growth to safeguard ecological thresholds and redistribute access.	0.854 (0.000)
SD6	Decouples economic growth from material consumption, taking rebound effects into account.	0.837 (0.000)

SD7	Limits and transforms the economy's productive potential.	0.768 (0.000)
SD8	Reduces economic growth while simultaneously reducing inequalities and exploitation	0.758 (0.000)
SD9	It dematerializes society and the economy by emphasizing the role of self-sufficiency, happiness, and equity.	0.755 (0.000)

The analysis of the data derived from the survey of industrial firms was conducted using the PLS-SEM statistical technique with the support of SmartPLS 4.0 software (Ringle *et al.*, 2024), particularly because this study employs a composite indicator model, which is considered in the academic literature as the operational definition of the emerging construct that mediates all model effects, and concepts measured through composite indicators typically do not have an error term (Hair *et al.*, 2019).

The reliability and validity of the CE, EI, and SS measurement scales were assessed using Cronbach's Alpha, CRI, Dijkstra-Henseler rho, and AVE (Hair *et al.*, 2019). The Cronbach's Alpha, CRI, and Dijkstra-Henseler rho values exceed the recommended value of 0.70 (Hair *et al.*, 2019); while the AVE values are higher than the recommended value of 0.50 (Hair *et al.*, 2019), indicating, on the one hand, that the items effectively measure each of their variables and, on the other, the reliability of the data obtained. Regarding discriminant validity, it was assessed using the Fornell and Larcker criterion and the heterotrait-monotrait ratio (HTMT).

The results are shown in Table 2 and indicate that Cronbach's alpha ranges from 0.935 to 0.947, Dijkstra-Henseler's rho ranges from 0.937 to 0.949, and the CRI ranges from 0.945 to 0.955, indicating that these are good values and exceed the threshold of 0.70, while the AVE ranges from 0.659 to 0.728, which is higher than the 0.50 value recommended by Hair *et al.* (2019). The results obtained in this study show that the HTMT values range from 0.115 to 0.399, which are higher than the recommended value of 0.08, indicating the existence of discriminant validity for the CE, EI, and SD measurement scales.

Table 2

Reliability, Validity, and Discriminant Validity

PANEL A. Reliability and Validity					
Variables	**Cronbach's Alpha**	**CRI**	**Dijkstra-Henseler Rho**	**AVE**	
Circular economy	0.947	0.949	0.955	0.728	
Eco-innovation	0.936	0.946	0.948	0.723	
Sustainable development	0.935	0.937	0.945	0.659	

PANEL B. Fornell-Larcker criterion				**Relación heterotrait-monotrait (HTMT)**		
Variables	**1**	**2**	**3**	**1**	**2**	**3**
1. Circular economy	**0.853**					
2. Eco-innovation	0.144	**0.850**		0.148		
3. Sustainable development	0.381	0.114	**0.812**	0.399	0.115	

Note. CRI: Composite Reliability Index; AVE: Average Variance Extracted. PANEL B: Fornell-Larcker criterion: The diagonal elements (in bold) are the square root of the variance shared between the constructs and their measures (AVE). For discriminant validity, the diagonal elements must be greater than the non-diagonal elements.

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Results and Discussion

Results

To test the hypotheses proposed in the research model, the PLS-SEM statistical technique was used with the SmartPLS software (Ringle *et al.*, 2024), particularly because PLS-SEM is generally used in underdeveloped theories across various disciplines (Hair *et al.*, 2019). Furthermore, the use of PLS-SEM is essential, not only because it facilitates the explanation of measurement error in the variables—which gives this method greater potential than multiple linear regression (Hair *et al.*, 2019)—but also when the objective pursued through the application of the structural equation model is the prediction and explanation of the key constructs of the research model. Table 3 shows the results obtained from the application of PLS-SEM.

Table 3

Structural Model

Paths	Path (t-value; p-value)	95% confidence interval	f^2	Support
EC → DS (H1)	0.379 (7.498; 0.000)	[0.267 - 0.475]	0.171	Yes
EC → EI (H2)	0.149 (2.843; 0.004)	[0.054 - 0.251]	0.026	Yes
EI → SD (H3)	0.062 (1.283; 0.200)	[-0.032-0.151]	0.007	No
Indirect effects				
EC → EI → DS	0.323 (8.828; 0.000)	[0.251 - 0.395]	0.182	Sí
Endogenous variable	**Adjusted R^2**	**Model fit**	**Value**	**HI99**
		SRMR	0.034	0.040
EI	0.122	dULS	0.342	0.477
DS	0.154	dG	0.177	0.238

Note. CE: Circular Economy; EI: Eco-innovation; SD: Sustainable Development. One-tailed t-values and p-values in parentheses; 95% confidence intervals via bootstrapping (based on n = 10,000 subsamples); SRMR: standardized mean residual; dULS: unweighted least squares difference; dG: geodesic difference; NFI: normal fit index; HI99: 99% percentiles based on bootstrapping.

Table 3 shows the results obtained and indicates that they have acceptable statistical levels, with adjusted R^2 values greater than the recommended value of 0.10, an SRMR value (0.034) lower than the recommended value of 0.08 (Hair *et al.*, 2019), and unweighted least squares difference (dULS) (0.342), and geodesic difference (dG) values (0.177) lower than the HI99 values (Hair *et al.*, 2019), which allows for the verification of the research model's significance. In general terms, the results derived from the application of PLS-SEM allow us to establish that EC has significant beneficial influences on the SD of industrial firms (0.379; p-value 0.000), which provides empirical evidence in favor of hypothesis H1. Similarly, the results obtained also allow us to verify that EC has a significant positive influence on the IE of industrial firms (0.149; p-value 0.004), providing empirical evidence in favor of hypothesis H2. However, the results obtained establish that there is no positive relationship between IE and DS in industrial firms (0.062; p-value 0.200), which allows us to reject Hypothesis 3.

Discussion

The results obtained support our argument that CE has a significant positive influence on SD in industrial firms, which is consistent with the findings of Khan and Kabir (2020), Priyadarshini and Abhilash (2020), and Sebestová and Sroka (2020). One possible explanation for this positive effect may be that a significant number of industrial firms in Mexico are transitioning from a traditional linear model to a circular economic model, which, through practices of recycling, reusing, and remanufacturing materials, is not only increasing firms' economic performance but also significantly reducing the level of industrial waste, greenhouse gas and CO2 emissions, leading to a substantial improvement in sustainable development.

Furthermore, the results also show the existence of a notable beneficial influence of CE on EI, which is similar to those found by Schultz and Reinhardt (2022), Mora-Contreras *et al.* (2023), and Mora-Contreras and Carrillo-Hermosilla (2025). One of the key reasons that could explain this result is that the adoption and application of CE promote the implementation of EI, since industrial companies, by incorporating recycled materials into new products, are manufacturing more environmentally friendly products. This not only generates a significant increase in their economic and financial performance but also substantially improves social and environmental performance levels—i.e., they are improving their level of SD.

However, the results obtained do not support our argument regarding the existence of a notable beneficial influence between EI and SD, which contradicts the evidence presented in the academic literature. Possible reasons for this result include, on the one hand, that industrial firms are in an early stage of adopting EI and, as established in the academic literature, results in organizations are long-term rather than immediate. On the other hand, industrial firms may be more focused on implementing CE than on EI, since organizations in Mexico, as in any other country with an emerging economy, are characterized by a scarcity of financial resources.

Practical implications

The findings of our study are relevant to executives, policymakers, business professionals, and public administration officials. First, company executives who wish to adopt and implement CE that enhances their EI and SD activities can achieve substantial long-term improvements in their competitive advantages if they consider collaboration beyond their supply chain and proactively address legal, institutional, employee, and stakeholder pressures regarding environmental concerns for CE. According to the findings, CE helps companies foster a culture of environmental protection by promoting ecological values, disseminating EI practices, and favoring environmentally friendly products and eco-friendly circular packaging.

Second, company executives must align the adoption and implementation of CE practices with their business strategy, as this will enable them to achieve higher levels of circularity and sustainability. Therefore, business leaders must recognize that planning more in line with the realities of the business world and with the challenges and opportunities posed by the adoption and implementation of CE and CE practices in a globalized and highly competitive market generates greater chances of success. In this regard, policymakers should promote public initiatives aimed at expanding the use of recyclable materials across all industrial companies, as this will enable them to foster circularity that is viable from technical, economic, environmental, and social perspectives, in line with the guidelines of the Sustainable Development Goals.

Third, the results of this study suggest that to generalize the scope of its conclusions to all industrial firms, policymakers and public administrations should apply policies and tax incentives to industrial firms that adopt and implement CE and EI practices, since, as demonstrated in the literature, firms may require additional financial support to ensure their economic viability (e.g., Ranta *et al.*, 2018; Kirchherr *et al.*, 2018). This support is necessary in emerging economies, where resource and knowledge constraints are common among industrial firms (Rodríguez-Espíndola *et al.*, 2022), as they tend to be more sensitive to the additional financial costs arising from the adoption and implementation of CE and EI practices in a SD context (Triguero *et al.*, 2022).

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Conclusions

It is possible to conclude, on the one hand, that although the research model offers a holistic view of CE, EI, and sustainable development—which includes the three most frequently cited activities in the academic literature (economic, social, and environmental)— the model does not exhibit high statistical consistency; therefore, it can be concluded that the adoption and implementation of CE, EI, and SD are in a starting phase in Mexico's industrial companies, and are in the initial phase of the transition from a linear production model to a circular production model, and require further work on the adoption and implementation of these types of practices across all production and marketing activities of the organizations.

On the other hand, it can also be concluded that the relationship between CE, EI, and SD remains a subject of active academic debate in the academic literature, therefore, it is necessary for researchers, academics, and industry professionals to direct their future studies toward providing solid empirical evidence, demonstrating a positive relationship between these three constructs, especially in emerging and developing economies in order to corroborate the results obtained and advance knowledge of EC, EI, and SD practices.

This study has several limitations that should be considered in future research. The first limitation concerns the generalizability of the results, particularly because the study focused solely on industrial firms in Mexico, which poses challenges for applying the findings to a broader group of firms in other sectors or countries. Therefore, to address this limitation, future research in other industries and countries could use this same survey to verify whether the results are similar. A second limitation is that this study adopted a research model analyzed using the PLS-SEM statistical technique; however, the use of other types of statistical techniques could broaden our understanding of the link between CE, EI, and SD. Therefore, it would be advisable for future studies to use neural networks or logistic regression to corroborate the results obtained.

A third limitation is that the literature has analyzed and discussed the various sustainable benefits that the joint adoption of CE and EI generates for industrial firms. However, further studies are needed to provide robust empirical evidence to better understand the implementation of CE practices by industrial firms, particularly in developing countries, as these countries generate the highest levels of pollution due to the lack of environmental policies and programs. Therefore, it would be advisable to conduct future studies in such countries to compare the results obtained.

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Declaration of Authorship - CRediT Taxonomy

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Gonzalo Maldonado-Guzmán	Conceptualization, formal analysis, research, methodology, supervision, writing, and original draft.
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Vianney Judith Robledo-Herrera	Data analysis, formal analysis, research, writing, and editing.

Statement on the use of artificial intelligence

The authors **DECLARE** that in the preparation of the article titled: "Circular Economy Practices and Eco-Innovation: An Approach to Sustainable Development," artificial intelligence (AI) was not used at any stage of the process.

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Women and sustainable consumption in emerging markets: implications for management

Mujeres y consumo sostenible en mercados emergentes: implicancias para la gestión

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Abstract: sustainability and marketing literature identifies women as a segment with consistent patterns of environmental sensitivity, enabling the examination of ecological orientations in emerging contexts. This study analyzes attitudes, practices, and consumption preferences toward eco-friendly products among Chilean women, identifying sociodemographic factors associated with ecological self-perception and willingness to pay for sustainable alternatives. Using a non-experimental, cross-sectional quantitative design, a survey was administered to 391 women residing in a strategic urban center in Chile (Coquimbo). The analysis integrated descriptive statistics, binary logistic regression, and cluster segmentation. Results reveal an identity legitimacy gap, as only one in four women self-identifies as "green" despite reporting favorable attitudes, alongside an attitude–behavior gap in higher-effort actions. Regression indicates increased ecological self-perception among young women (OR=2.05, p=.017) and those in larger households (OR=1.62, p=.047). Cluster segmentation identifies three groups: Green Core (9,7 %), Economical (23,0 %), and a dominant Pragmatic segment (67,3 %), with a willingness-to-pay threshold between 10 % and 25 %. It is concluded that, in emerging contexts, the expansion of sustainable consumption requires strategies that overcome identity and economic gaps, engaging the majority pragmatic segment through offerings that balance sustainability, quality, and price, consolidating the adoption of ecological practices beyond the core of environmentally committed consumers.

Keywords: sustainability, consumption, gender, attitudes, behavior, segmentation, preferences, identity.

Resumen: la literatura en sostenibilidad y marketing identifica a las mujeres como un segmento con patrones consistentes de sensibilidad ambiental, lo que permite examinar orientaciones ecológicas en contextos emergentes. Este estudio analiza las actitudes, prácticas y preferencias de consumo hacia productos ecológicos en mujeres chilenas, identificando factores sociodemográficos asociados a la autopercepción ecológica y a la disposición a pagar por alternativas sostenibles. Bajo un diseño cuantitativo no experimental y transeccional, se aplicó una encuesta a 391 mujeres residentes en un centro urbano estratégico de Chile (Coquimbo). El análisis combinó estadística descriptiva, regresión logística binaria y segmentación por conglomerados. Los resultados revelan una discrepancia en la legitimación identitaria, ya que solo una de cada cuatro mujeres se autodefine como "verde" pese a reportar actitudes favorables, sumado a una brecha actitud-conducta en acciones de alto esfuerzo. La regresión indica mayor autopercepción ecológica en mujeres jóvenes (OR=2.05, p=.017) y de hogares numerosos (OR=1.62, p=.047). La segmentación identifica tres perfiles: Núcleo Verde (9,7 %), Económicas (23,0 %) y un segmento Pragmático dominante (67,3 %), cuyo umbral de disposición a pagar se sitúa entre el 10 % y el 25 %. Se concluye que, en contextos emergentes, la expansión del consumo sostenible requiere estrategias que superen las fracturas identitaria y económica, conectando con el segmento pragmático mayoritario mediante ofertas que equilibren sostenibilidad, calidad y precio, y que consoliden la adopción de prácticas ecológicas más allá del núcleo de consumidoras ecológicamente comprometidas.

Palabras clave: sostenibilidad, consumo, género, actitudes, conducta, segmentación, preferencias, identidad.

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Introduction

The environmental crisis has intensified interest in sustainability, making it a key factor in purchasing decisions and in frameworks that promote responsible behavior (White *et al*., 2019; Yusoff *et al*., 2023). Consequently, the market for eco-friendly products has grown steadily, driven by consumers seeking to align their habits with environmental values (Testa *et al*., 2021). However, as noted by Bechler *et al*. (2021) and Kollmuss and Agyeman (2002), the transition toward genuinely sustainable consumption is hindered by the attitude-behavior gap, i.e., the difference between pro-environmental intentions and actual actions, where priorities, purchasing habits, convenience, and perceived costs act as critical barriers (Carrington *et al*., 2014; Kollmuss and Agyeman, 2002).

To explain this gap, consumer behavior research has shifted from mainly sociodemographic approaches (Diamantopoulos *et al*., 2003) toward studies that incorporate psychographic variables such as identity, values, and social norms. In this line, Barbarossa and De Pelsmacker (2016) highlight the role of these factors in sustainable behavior, systematized in recent meta-analyses that synthesize individual, contextual, and experiential predictors (Neves *et al*., 2025). Likewise, market segmentation through cluster analysis has been shown to capture consumer heterogeneity; as demonstrated by Jaiswal *et al*. (2021), this approach allows identifying profiles based on real trade-offs between attributes, where environmental considerations compete with price, quality, and brand (Dinh *et al*., 2021). In parallel, Whitmarsh and O'Neill (2010) argue that ecological identity constitutes a key predictor of pro-environmental behavior by internalizing environmental values into the self-concept (Bouman *et al*., 2020; Lou and Li, 2021).

However, favorable attitudes or isolated behaviors rarely suffice to consolidate a stable environmental identity. Although aggregate studies confirm a general positive relationship between identity and climate action (Vesely *et al*., 2021), the literature suggests the existence of a representative subgroup that engages in pro-environmental behaviors without identifying as "green." A phenomenon conceptualized in this study as the "identity legitimation gap," based on a more nuanced understanding derived from the integration of quantitative and qualitative findings on the identity-action relationship and the role of self-identity (White *et al*., 2019). This paradox poses a substantial obstacle, as the lack of identification with the "green" category can weaken consumer loyalty and the consistency of their purchasing choices in the long term (Wild and Schulze, 2024). As Gatersleben *et al*. (2014) warn, the relationship between identity and action is complex and mediated by personal values and situational factors, highlighting the need to align identity, values, and communication to foster sustainable behaviors (Wang and Udall, 2023).

In Chile, research on eco-friendly consumption has progressed from models focused on attitudes and intentions (Araya-Pizarro and Rojas-Escobar, 2020; Palavecinos *et al*., 2016) toward more sophisticated psychometric models (Araya-Pizarro, 2025; Sandoval-Díaz and Neumann, 2023). However, a critical gap persists in the local literature: integrating the identity construct—and, specifically, the legitimation gap—with revealed preferences and the identification of market segments using multivariate analysis. This approach, common in developed contexts (Sánchez *et al*., 2016), has been scarcely explored in emerging markets, where economic constraints complicate the adoption of sustainable consumption.

This gap is relevant for women, a group that, as documented by McCright and Xiao (2014) and Zhao *et al*. (2021), tends to show a greater willingness toward sustainability, but whose processes of self-perception and identity legitimation under economic constraints have not been examined in depth in Chile.

Therefore, this study aims to analyze the attitudes, practices, and consumption preferences toward eco-friendly products among Chilean women, identifying the sociodemographic factors associated with ecological self-perception and willingness to pay (WTP) for sustainable alternatives. The specific objectives are: (1) to characterize environmental practices and attitudes,

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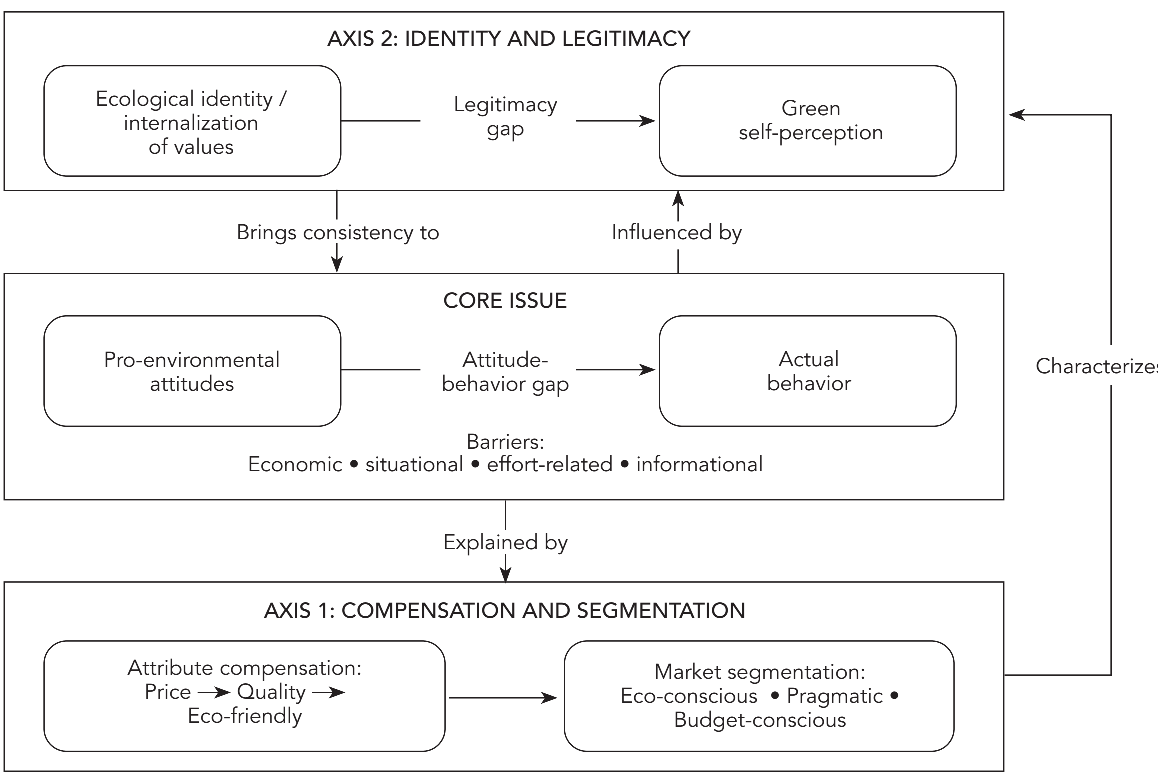
assessing the attitude-behavior and identity legitimation gaps; (2) to determine the preference structure and trade-offs between ecological attributes, quality, and price through cluster analysis; (3) to establish willingness-to-pay thresholds for eco-friendly products; and (4) to identify the sociodemographic factors associated with self-identification as a green consumer. The findings sought to provide empirical evidence for the green consumer theory in Latin America and offer practical guidance for marketing and public policy, focusing on overcoming economic and identity-related barriers.

Attitude-Behavior Gap and Barriers to Sustainable Consumption

The study of eco-consumer behavior is grounded in various theoretical approaches that explain the divergence between stated pro-environmental attitudes and the actual adoption of sustainable practices. This study proposes an integrative model with three conceptual axes: the attitude-behavior gap as the central problem, attribute trade-offs and segmentation as explanatory mechanisms for market heterogeneity, and ecological identity as psychosocial support that provides long-term coherence (Figure 1).

Figure 1

Theoretical model of the gap in eco-friendly consumption



Note. Model developed based on the conceptual integration of the attitude-behavior gap, ecological identity, and the mechanisms of attribute compensation and segmentation.

The starting point is the attitude-behavior gap (Bechler *et al*., 2021; Kollmuss and Agyeman, 2002), understood as the discrepancy between favorable attitudes toward sustainability and their translation into actual purchasing behaviors (Carrington *et al*., 2014). This disassociation is conditioned by barriers that filter intention into action (White *et al*., 2019), including economic factors (premium pricing, low purchasing power), situational factors (availability), effort factors (time, convenience), and informational factors (mistrust, greenwashing) (Isac *et al*., 2025). In this context, the trade-off between ecological attributes and other decision-making criteria explains varied responses to sustainable consumption (Dinh *et al*., 2021; Dolnicar *et al*., 2018), while ecological identity provides greater behavioral consistency over time (Whitmarsh and O'Neill, 2010).

Decision-Making and Heterogeneity in the Green Market

To understand actual decision-making, research has moved toward models based on attribute trade-offs. According to Dinh *et al*. (2021) and Tsaabitah *et al*. (2025), choice arises from a multi-criteria evaluation that simultaneously weighs environmental impact, perceived quality, and price. Experiments show that these trade-offs are strongly conditioned by price sensitivity, limiting the premiums actually paid for green attributes.

This decision-making process, together with attitudinal factors, generates marked heterogeneity in the market. As Dolnicar *et al*. (2018) highlight, such variability can be captured empirically through segmentation techniques such as cluster analysis, which allows identifying distinct consumer profiles. The literature on market segmentation commonly reveals a typology ranging from a Green Core or *Early Adopters* (enthusiastic greens, with high environmental concern and purchase intent), through Pragmatic groups (moderate greens), to Economic groups (reluctant greens, with low levels of commitment), as demonstrated in studies based on cognitive and behavioral variables (Jaiswal *et al*., 2021).

Ecological identity and the legitimization of sustainable behavior

To address long-term behavioral consistency, it is necessary to examine ecological identity. Drawing on Tajfel and Turner's (1979) social identity theory and Bem's (1972) self-perception theory ; this construct represents the degree to which individuals integrate environmental values into their self-concept (Whitmarsh and O'Neill, 2010). Ecological identity offers a more stable predictor of sustainable behavior than general attitudes, as actions tend to align with the self-image that people seek to maintain and validate socially (Bouman *et al*., 2020). This internalization occurs in interaction with the social environment, where perceived norms and values reinforce environmental commitment (Lou and Li, 2021).

Contemporary literature introduces a key complexity: the identity legitimation gap. This phenomenon occurs when consumers, despite holding favorable attitudes and engaging in pro-environmental behaviors, do not identify themselves as "green." Based on Higgins' (1987) self-discrepancy theory, this can be explained by the perception of a gap between the "actual self" (behaviors exhibited) and the "ideal self" (the perfect eco-conscious consumer), creating an identity barrier that inhibits internalization (White *et al*., 2019). In turn, Wild and Schulze (2024) describe this mechanism as a form of environmental modesty in which individuals underestimate their achievements by assuming they do not meet the socially constructed standard of what it means to be "green."

The articulation of these three axes (attribute compensation, market segmentation, and ecological identity) allows for a more comprehensive view of sustainable consumption. While attribute compensation explains specific decisions, segmentation identifies stable patterns, and ecological identity provides the psychological foundation that gives temporal coherence to choices.

Based on this review, it is hypothesized that women will exhibit a triple dissociation: (1) an attitude-behavior gap mediated primarily by economic and effort barriers; (2) an identity

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legitimation gap where environmental practices do not correspond to a high level of green self-identification; and (3) a heterogeneous preference structure manifested in distinct segments dominated by a pragmatic profile that balances sustainability, quality, and price.

Materials and Methods

Study Design and Sample

This study adopted a quantitative approach with a non-experimental cross-sectional design, integrating descriptive, analytical-classificatory techniques, and inferential models. The design allowed for the characterization of attitudes and preferences, the identification of natural consumer segments through cluster analysis, and the determination of factors associated with ecological self-perception using logistic regression.

The target population consisted of women aged 18 to 65 residing in Chile's fourth most populous metropolitan area: La Serena-Coquimbo metropolitan area (Coquimbo Region). The sample size was determined using the formula for infinite populations, with a 95% confidence level, 5% margin of error, and maximum variance (p = .50), resulting in minimum of 384 participants.

Given the absence of an exhaustive sampling frame and the exploratory nature of the study—focused on validating emerging theoretical constructs rather than estimating population parameters—non-probabilistic network (snowball) sampling was implemented. This technique is useful for accessing hard-to-reach populations or those for which no defined sampling frame exists, and is particularly appropriate for exploratory and qualitative research, or in the initial phases of quantitative studies (Etikan *et al*., 2016). Although this type of sampling does not allow for statistical generalization, its strength lies in the identification and recruitment of cases with representative characteristics.

Of a total of 401 questionnaires received, 391 valid cases that met the inclusion criteria were retained. The final sample profile showed diversity in age, educational level, and employment status, thus capturing the structural heterogeneity of the analyzed population.

Data Collection

Data collection was conducted using a self-administered structured questionnaire, administered between May and June 2021, and distributed via email and digital platforms (Instagram, Facebook, X). Participants were informed about the study's objectives, the voluntary nature of their participation, and the academic use of the data, with anonymity and confidentiality safeguarded in accordance with current ethical principles. The instrument underwent content validation by a panel of four experts in management, sustainability, and methodology, and demonstrated adequate internal consistency on the scale of ecological attitudes and practices ($\alpha = .82$), exceeding the recommended threshold of .70.

The questionnaire was organized into three sections. The first collected sociodemographic information through categorical questions (age, educational level, marital status, employment status, monthly household income, number of children, and household size). The second section assessed ecological attitudes and practices using a five-point Likert scale (1 = never; 5 = always) comprising twelve items, distributed across two dimensions: pro-environmental attitudes (awareness and interest in environmental protection) and ecological behavioral practices (consumption behaviors requiring varying levels of effort).

The third section operationalized the constructs of ecological self-perception, preferences, and willingness to pay. Self-perception was measured using a direct self-identification question, while preferences were captured through a revealed-preference task designed to observe the actual trade-offs in the purchasing decision. To do so, each participant ranked four prototypes of a cosmetic product (A, B, C, and D), combining three attributes: eco-certification (yes/no), quality (fair/good), and price (low/medium/high), presented as visual representations that emulated real-world choice contexts

(Figure 2). Finally, the DAP was assessed using a categorical question regarding the maximum acceptable price premium for products with ecological attributes. This approach minimized social desirability bias by relying on observed trade-offs rather than stated intentions.

Figure 2

Choice prototypes based on ecological, quality, and price attributes

Product A:	**Product B:**	**Product C:**	**Product D:**
eco-friendly, high quality and high price (USD 21)	not eco-friendly, regular quality and low price (USD 5.5)	not eco-friendly, high quality and medium price (USD 10.5)	eco-friendly, regular quality and medium price (USD 10.5)

Note: 1 USD = 950 CLP.

Data Analysis

The analysis was conducted in a three-phase methodological sequence. In Phase 1, a univariate descriptive analysis was performed to characterize the sociodemographic profile of the sample and describe the frequency distributions of attitudes, practices, and ecological self-perception.

Phase 2 consisted of cluster segmentation, carried out in two stages. Initially, a hierarchical method using Ward's criterion was applied to determine the optimal number of clusters, evaluated by inspecting the dendrogram. Next, a k-means analysis was performed, which generated a three-group solution based on the Z-scores of preferences for the attributes of quality, environmental friendliness, and price. Finally, the clusters were validated using a one-way analysis of variance (ANOVA).

In Phase 3, a binary logistic regression model was used to identify the sociodemographic predictors of ecological self-perception, coded based on self-identification as a green consumer (1 = yes; 0 = no). Predictor variables included age (<25 years), marital status (single), household size (>3 members), presence of children (yes), educational level (higher education), and income (>USD 1,052). WTP thresholds were derived from the direct question regarding the maximum acceptable amount for eco-friendly products.

Model evaluation included goodness of fit (Hosmer-Lemeshow test), explanatory power (Nagelkerke, Cox & Snell, and McFadden pseudo R^2), as well as discriminatory power (AUC-ROC). In addition, multicollinearity was assessed using the Variance Inflation Factor (VIF). All analyses were performed using IBM SPSS Statistics v.24 software, with a significance level of $\alpha = .05$.

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Results and discussion

Sociodemographic characteristics of the sample

The sample consisted mainly on young women (76.2% under 35 years of age). The educational level was relatively high, with 50.4% of participants reporting a college education. Most reported being single (68.3%) and childless (56.0%), and living in households with 1 to 5 members (91.8%). The employment distribution showed a predominance of employed workers (45.8%) and unemployed individuals (36.0%). Monthly household income was concentrated in the low and lower-middle income brackets, with the majority of households reporting incomes below USD 738 (51.1%). This sociodemographic pattern reveals a profile of young women with outstanding educational capital but evident economic constraints (Table 1).

Table 1

Sociodemographic Characteristics of Participants (n=391)

Variable	Segment	Percentage
Age	Between 18 and 25 years	33.5
	Ages 26–35	42.7
	Between 36 and 45 years old	14.6
	Over 45	9.2
Educational level	High school or lower	26.1
	Vocational (CFT or IP)	23.5
	University (undergraduate)	44.3
	Graduate	6.1
Marital status	Single	68.3
	Married	15.3
	Living with a partner	11.5
	Other	4.9
Children	None	56.0
	One	19.2
	Two	17.9
	More than two	6.9
Household size	1 to 3 members	50.6
	4 to 5 members	41.2
	More than 5 members	8.2
Employment status	Employed	45.8
	Self-employed	17.9
	Unemployed	36.0
	Retiree	0.30
Monthly household income	Less than USD 369	19.7
	Between USD 369 and 737	31.4
	Between USD 738 and 1,052	17.9
	Between $1,053 and $1,579	16.4
	More than USD 1,579	14.6

Note. 1 USD = 950 CLP.

Environmental attitudes and practices

The analysis of environmental practices and attitudes revealed consistent differences between statements and actual behaviors. In the attitudinal dimension, high percentages of favorable responses were observed: 89.8% reported a high commitment to environmental protection, 88.5% acknowledged the impact of their consumption, 81.8% expressed concern for future generations, and 75.4% experienced emotional well-being when purchasing eco-friendly products.

Environmental practices varied substantially depending on the effort required. Low-cost actions, such as turning off lights, showed nearly universal adoption (90.0%), while behaviors requiring greater commitment, such as sorting waste (25.6%) or repairing electronic devices (36.1%), were markedly less frequent. Intermediate engagement behaviors, such as researching eco-friendly products (55.3%) or discussing climate change (56.5%), showed moderate levels of adoption (Table 2).

Table 2

Frequency of eco-friendly attitudes and practices (n=391), in %

Statements	Low	Medium	High
Q1. I turn off the lights when I am not using them	4.4	5.6	90.0
Q2. I buy products with recyclable packaging	14.4	32.4	53.2
Q3. I separate organic and inorganic waste	54.5	19.9	25.6
Q4. I recycle or reuse paper and cardboard	31.2	27.6	41.2
Q5. I repair damaged electronic devices	37.0	26.9	36.1
Q6. I usually buy secondhand clothes	38.6	20.7	40.7
Q7. I look into eco-friendly products when I see them advertised	18.9	25.8	55.3
Q8. I talk about climate change with family and friends	23.3	20.2	56.5
Q9. I am interested in protecting the environment	4.8	5.4	89.8
Q10. I feel good about buying eco-friendly products	11.3	13.3	75.4
Q11. I care for the environment for future generations	6.9	11.3	81.8
Q12. I am aware that my consumption affects others	5.1	6.4	88.5

Note. Low = Never or almost never, Medium = Sometimes, High = Always or almost always.

The results confirmed the attitude-behavior gap (Bechler *et al.*, 2021; Kollmuss and Agyeman, 2002), reflected in an adoption gradient inversely proportional to the effort required and consistent with situational barriers (White *et al.*, 2019). However, the study showed that, among Chilean women, the adoption of pro-environmental practices does not imply the internalization of an ecological identity. When asked how they view themselves, only 25.6% self-identify as "green," revealing a gap in identity legitimation—understood as the distance between acting and feeling entitled to assume that identity.

This finding suggested the operation of a "perceived sufficiency" threshold that consumers do not reach, possibly exacerbated by multiple social demands traditionally managed by women, where the pro-environmental role competes with other priority responsibilities (caregiver, homemaker). Based on Higgins' (1987) self-discrepancy theory, the aspiration toward the "ideal self" of a sustainable consumer—the "perfectly green consumer"—constitutes a difficult-to-achieve standard, creating a barrier in self-perception (White *et al.*, 2019).

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Although participants engage in pro-environmental actions, they do not fully internalize them, possibly out of fear of being perceived as inconsistent. This reveals that self-efficacy and subjective norms, components of Ajzen's (1991) Theory of Planned Behavior, mediate both behavior and identity construction (Whitmarsh and O'Neill, 2010).

Preference Structure and Market Segmentation

Choice patterns became evident after examining revealed preferences. Product D (eco-friendly, average quality, medium price) obtained the most favorable average ranking (1.92), being selected in first or second position by 76.7% of the participants. Product A (organic, good quality, high price) showed a polarized pattern, with 23.0% of first preferences but 45.6% of last choices. Product B (non-organic, average quality, low price) captured 28.1% of first choices, while Product C (non-organic, good quality, medium price) was predominantly ranked as the third choice (49.9%) (Table 3).

Table 3

Choice patterns and trade-offs between attributes (n=391)

Product	1st Place (%)	2nd Place (%)	3rd Place (%)	4th Place (%)	Ranking*
A	90 (23.0)	61 (15.6)	62 (15.9)	178 (45.6)	2.92
B	110 (28.1)	45 (11.5)	64 (16.4)	172 (44.0)	2.82
C	38 (9.7)	138 (35.3)	195 (49.9)	20 (5.1)	2.45
D	153 (39.1)	147 (37.6)	70 (17.9)	21 (5.4)	1.92

Note. *Ranking: weighted average calculated using positions (1–4), where a lower value indicates higher preference.

Cluster analysis (k-means) confirmed the existence of three statistically distinct consumer segments with clear commercial implications. The ANOVA showed that all variables contribute significantly to the variability between groups (Quality: $F = 195.00$, $p < .001$; Organic: $F = 84.85$, $p < .001$; Price: $F = 195.00$, $p < .001$). The distances between cluster centers were significant (2.44–3.30), indicating adequate separation between them (Table 4).

Table 4

Profiles of consumer segments identified through cluster analysis

Segment	n (%)	Quality	Organic	Price	Dominant profile
Green Core	38 (9,7 %)	+1.43	+1.28	+0.55	Premium and organic
Economy	90 (23,0 %)	+1.43	-0.78	-1.83	Quality at a low price
Pragmatic	263 (67,3 %)	-0.70	+0.08	+0.55	Value-price-ecology balance

Note: Values represent standardized Z-scores. Positive = above-average preference, Negative = below-average preference.

The identified clusters are characterized as:

- **Green Core (9.7%):** high quality rating (Z = +1.43) and strong preference for ecological attributes (Z = +1.28), showing a willingness to accept premium prices (Z = +0.55).
- **Economy (23.0%):** value high quality (Z = +1.43), but show low interest in ecological attributes (Z = -0.78) and a strong preference for low prices (Z = -1.83).
- **Pragmatists (67.3%):** represent the largest segment, exhibiting a balanced profile with acceptance of average quality (Z = -0.70), a slight preference for organic products (Z = +0.08), and tolerance for higher prices (Z = +0.55).

The segmentation highlighted the heterogeneity of the organic market, identifying three statistically distinct segments (Green Core, Pragmatists, and Economists) that replicate and quantify, within the Chilean context, typologies empirically identified in other emerging markets (Jaiswal *et al*., 2021). The most decisive finding was the predominance of the pragmatic segment, which reflects the practical rationality that many women apply in household management, where sustainability is valued as an attribute integrated into a broader value equation that includes family well-being and budget constraints, rather than as an absolute purchasing principle.

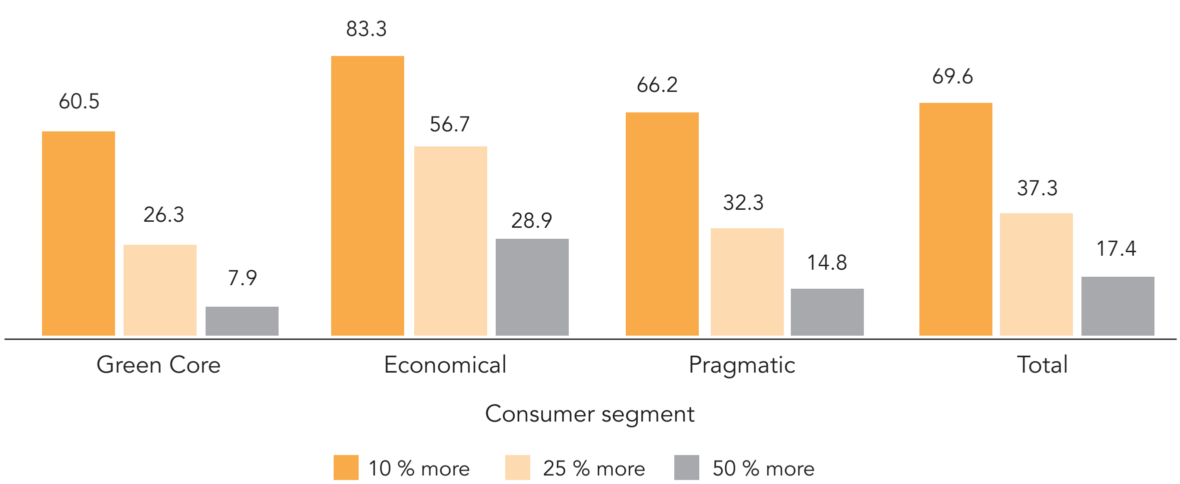
The analysis of revealed preferences validated the theory of attribute trade-offs (Dinh *et al*., 2021; Tsaabitah *et al*., 2025). The preference for Product D (eco-friendly, medium price, average quality) over Product A (eco-friendly, high price, good quality) demonstrates that, in situations of economic constraint, sustainability is valued but subordinated to considerations of affordability. The WTP inflection point between 10% and 25% establishes a critical mass threshold for organic products, consistent with studies reporting high price elasticity for green goods (Dinh *et al*., 2021).

Willingness to pay for eco-friendly products

The results identified a critical price threshold for the mass adoption of organic products: while 69.6% accept 10% premiums, this acceptance drops significantly to 37.3% for 25% premiums, identifying a critical price range between 10% and 25% premiums, which provides key guidance for the pricing strategy of sustainable products (Figure 3).

Figure 3

Willingness to pay for organic products (%)



Note: The percentages represent the sum of the "Agree" and "Strongly Agree" categories.

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Association analysis using chi-square tests showed that the relationship between segments and WTP intensifies and becomes statistically significant as the required premium increases (WTP 10%: $\chi^2 = 14.67$, p = .066; WTP 25%: $\chi^2 = 22.14$, p = .005; WTP 50%: $\chi^2 = 24.55$, p = .002). This gradient indicates that for low premiums (10%), DAP operates as a relatively cross-cutting phenomenon, where sustainability begins to be perceived as an expected attribute that does not substantially increase the product's price—a trend documented in mature markets (White *et al*., 2019). However, as the premium increases, the latent preference structure defining each segment emerges strongly, triggering mechanisms for compensating for differential attributes (Dinh *et al*., 2021).

The disaggregated frequency analysis confirmed this behavior. The Green Core demonstrates consistency with its profile, maintaining the highest DAP across all three levels, reflecting the internalization of sustainability as a core value of its identity (Whitmarsh and O'Neill, 2010). For this segment, price is a secondary attribute compared to quality and ecological benefits. In contrast, the Economical segment shows a sharp drop in DAP beyond 10%, prioritizing the price attribute almost exclusively, even above quality, reflecting budget constraints as *the* main decision-making *driver* (Carrington *et al*., 2014).

The managerial relevance lay in the behavior of the Pragmatics segment (67.3% of the sample). This group exhibits a consistently moderate DAP profile, with high acceptance at 10% (66.2%), which experiences a sharp drop at 25% (32.3%), falling to nearly half, and plummets at 50% (14.8%). This pattern validates its characterization as the segment that makes rational *trade-offs* between sustainability, price, and quality (Jaiswal *et al*., 2021). Its tolerance threshold, between 25% and 50%, establishes the critical price limit for the widespread adoption of sustainable consumption in this context. Exceeding this point would restrict the market to a limited niche, concentrated in the Green Core.

Ecological self-perception and sociodemographic profile

As a key finding, the study identified a wide gap in identity legitimation. While the majority report favorable pro-environmental attitudes and engage in low-effort sustainable practices, only 25.6% self-identify as "green," indicating that the implementation of environmental actions does not necessarily translate into an integrated ecological identity.

Logistic regression analysis found that women under 25 (OR=2.05, p=.017) and those living in households with more than three members (OR=1.62, p=.047) were more likely to self-identify as "green." These data indicate that younger women and those belonging to larger households are approximately twice and 1.6 times more likely, respectively, to adopt this ecological identity, although the magnitude of these associations was modest (OR < 3.47). Single marital status showed a positive association, although it remained at a statistically trend-level (OR=1.73, p=.08).

Model evaluation revealed adequate overall fit (Hosmer-Lemeshow test, p = .767), moderate discriminatory power (AUC-ROC = .64), and a classification accuracy of 74.4%, albeit with limited explanatory power (Nagelkerke R^2 = .067). The multicollinearity analysis confirmed the independence among the predictors, with variance inflation factor (VIF) values below 2.5 (Table 5).

Table 5

Binary logistic regression model (n = 391)

Item	B	Error	Wald	Sig.	VIF	OR	I.C. 95 % OR
Marital status (single)	0.55	.31	3.03	.082*	1.32	1.72	0.93 – 3.19
Education (higher education)	0.19	.28	0.45	.501	1.09	1.21	0.70 – 2.08
Household size (> 3)	0.48	.24	3.95	.047**	1.05	1.62	1.01 – 2.61
Age (< 25 years)	0.72	.30	5.70	.017**	1.50	2.05	1.14 – 3.68

Income (> 1,000,000)	0.20	.27	0.59	.444	1.08	1.23	0.73 – 2.07
Children (with children)	0.19	.31	0.39	.530	1.59	1.21	0.66 – 2.22
Constant	-2.27	.48	22.0	.000***		0.10	
Hosmer and Lemeshow test	.564	χ^2 =6.75					
Cox and Snell R^2	.045						
Nagelkerke's R^2	.067						
McFadden's pseudo-R^2	.041						
Overall percentage	.744						
AUC-ROC curve	.642						

Note. Dependent variable: ecological self-perception (1 = Yes, 0 = No). * p < .10; ** p < .05; *** p < .01. Effect size of the ORs: negligible (OR < 1.68), small (1.68 < OR < 3.47), moderate (3.47 < OR < 6.71), and large (OR > 6.7).

The results reinforced recent trends in the literature but also reveal its limitations. The association with large households suggests that the family acts as a microenvironment that reinforces ecological norms, where women's role as educators and transmitters of values facilitates identity internalization through social validation (Bouman *et al.*, 2020). However, the coexistence of educational capital with economic constraints creates a paradox of actionable knowledge, where high environmental awareness does not always translate into the ability to act when the budget is limited. In these contexts, abstract or long-term environmental benefits do not offset economic barriers, and immediate attributes such as price carry greater weight in purchasing decisions (Carrington *et al.*, 2014; White *et al.*, 2019).

Although youth and large households largely predict green self-perception, the model explains only a fraction of the variance. Neves *et al.* (2025) highlight that sociodemographic factors operate as incomplete approximations of underlying psychological constructs.

Strategic implications

This research offers an integrative view of women's sustainable consumption in emerging markets, identifying three interrelated gaps that explain its complexity: the attitude-behavior gap (Carrington *et al.*, 2014; Kollmuss and Agyeman, 2002), an economic gap marked by high price sensitivity, and an identity legitimation gap. The findings show that although environmental awareness exists, its practical expression is mediated by contextual and identity-related factors, challenging linear models of pro-environmental behavior (Syed *et al.*, 2024). Although the data were collected in 2021, the observed patterns reflect structural dynamics that remain relevant today. The attitude-behavior gap and economic barriers continue to condition the willingness to pay considerable premiums, results that agree with recent studies in emerging economies (Adialita *et al.*, 2025; Alenazi, 2025) and align with theoretical syntheses on environmentally responsible practices (Neves, 2025). Simultaneously, ecological identity plays a central role in legitimizing conscious consumption habits (Wild and Schulze, 2024), confirming the analytical relevance of these findings for understanding the persistent tensions in women's behavior committed to environmental care.

Theoretically, the findings suggest expanding explanatory frameworks of consumer behavior. Ajzen's Theory of Planned Behavior (1991) could be enriched by incorporating ecological identity not only as a predictor but as an outcome mediated by "perceived sufficiency" (Vesely *et al.*, 2021), in line with Tajfel and Turner's (1979) theories of social identity and Bem's (1972) theory of self-perception. Furthermore, evidence suggests that economic constraints act as a double barrier in emerging markets, limiting both action (Carrington *et al.*, 2014) and identity construction by hindering the behaviors necessary to legitimize oneself as "eco-friendly" (Lou and Li, 2021). DAP is thus structured from the consumer's segmental

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position, combining price sensitivity, attribute compensation, and identity willingness. The growing statistical significance of this relationship shows that as price increases, the segmental profile gains greater predictive weight, linking segmentation theory with the literature on DAP. Finally, we propose shifting the analytical focus from "why they do not act" (Kollmuss and Agyeman, 2002) to "why those who act do not feel legitimized," positioning the identity gap as a strategic component of sustainable behavior (Wild and Schulze, 2024).

From a practical perspective, the results offer useful guidelines for business strategy and public policy. It is recommended to develop narratives that legitimize progress rather than perfection; to abandon the archetype of the "perfect green consumer" and normalize partial behaviors to reduce the identity barrier and engage the pragmatic majority (White *et al*., 2019). At the same time, innovation in business models is required through "accessible eco-friendly offerings" that ensure profitability even with minor concessions on environmental attributes, supported by supply chain efficiencies to achieve critical levels of accessibility. This aligns with evidence that perceived behavioral control, influenced by price, determines adoption (Paul *et al*., 2016). The effectiveness of these strategies depends on precise segmentation, targeting pragmatic consumers through messages that highlight tangible benefits and align sustainability with economic rationality, reinforcing the coherence between identity, environmental values, and communication (Wang and Udall, 2023).

In short, moving toward sustainable consumption in emerging markets requires transforming the dominant narrative, replacing the pressure for ecological perfection with the legitimization of imperfect but consistent action. Only when consumers feel empowered to call themselves "green"—even if only partially—can an identity foundation be established that supports deeper, more lasting, and strategically manageable behavioral changes.

Conclusions

This study showed that the transition toward sustainable consumption in emerging markets requires overcoming three interconnected critical points: economic, behavioral, and, centrally, identity-related. In scenarios of economic constraint such as Chile's, sustainability operates as a negotiated value within decision-making equations where price, quality, and functionality compete with environmental attributes.

The identification of a pragmatic majority segment suggests redefining competitive opportunities. While traditional strategies focus on the core green niche, the potential for mass adoption lies with consumers seeking to balance sustainability with other benefits. The critical price threshold (10%–25%) clearly defines the commercial viability of sustainable offerings in these markets. While acknowledging that price and functionality influence the adoption of sustainable products, the identity legitimation gap revealed that action alone does not guarantee the internalization of a green identity. Despite high levels of stated commitment, only one in four women identifies as "green," demonstrating that the sustainable transition requires not only facilitating actions but also reinforcing the associated identity. Thus, we propose shifting the focus from "why they do not act" to "why those who act do not feel legitimized." The strategic imperative is not limited to overcoming barriers of price or availability, but to building narratives that enable identification with sustainability without demanding ecological perfection.

These findings have implications for the theory of sustainable behavior and for the implementation of business strategies and public policies. At the academic level, it is necessary to integrate identity into explanatory models of pro-environmental behavior. For businesses and public policies, this implies promoting narratives that value progress and designing offerings that balance sustainability and accessibility.

This study has certain limitations that open opportunities for future research. First, the cross-sectional nature of the data collected in 2021 prevents the establishment of causal relationships and the observation of the temporal evolution of identity and behavioral gaps. Longitudinal studies could examine how these dynamics change in response to economic fluctuations or new environmental policies. Second, the use of non-probabilistic sampling restricts the statistical generalizability of the results, although it allows for a valuable initial exploration of the constructs in the analyzed context. It is recommended to replicate the study with probabilistic and representative samples, as well as to extend it geographically to assess the cross-cultural consistency of the findings. Finally, future work could experimentally validate the marketing strategies derived from segmentation, or explore through mixed methods the narrative construction of "perceived sufficiency" as a mechanism to address the identity legitimation gap.

Based on these results, three complementary areas of focus are identified: (1) experimental evaluation of marketing and communication strategies centered on the pragmatic segment, articulating sustainability, tangible value, and economic rationality; (2) analysis of business models and pricing schemes within the critical premium threshold identified for emerging markets; and (3) studies on the construction of "perceived sufficiency" in the ecological identity of women as household managers under economic constraints.

In conclusion, the competitiveness of sustainable businesses in Latin America will depend on developing models and strategies adapted to the reality of emerging economies, recognizing both the persistence of economic constraints and the presence of a large pragmatic segment willing to adopt sustainable options since they offer tangible value, accessibility, and an identity with which they can identify.

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Statement on the use of artificial intelligence

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Models for sustainability communications: a comparative study in Chile, Colombia and Ecuador

Modelos de comunicación para la sostenibilidad: un estudio comparativo en Chile, Colombia y Ecuador

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Abstract: this study analyzes the communication contexts in which large organizations in Chile, Colombia, and Ecuador manage their sustainability communications, as well as their main characteristics, strategic orientations, and structural differences within the Latin American organizational landscape. A non-experimental, quantitative methodology was adopted through a survey of 75 organizations in the three countries. The instrument was adapted from the Communication and Sustainability Convergence Model, which evaluates the level of integration between sustainable practices within organizations, their communication formats, and relationships with society. The results show a general recognition of the strategic value of sustainability, but with variations in implementation and impact in each country. Chilean and Colombian organizations mainly execute symmetrical and participatory communication models in which sustainability is aligned with the institutional purpose and reflected through dialogue with stakeholders. In contrast, Ecuadorian organizations show a more instrumental orientation in their practices, with one-way dialogues focused primarily on strengthening corporate reputation and achieving business objectives. These differences stem from contextual factors such as the maturity of regulatory frameworks, social pressure, and the organizations' track record in sustainability. The study concludes that sustainability communications can reach its transformative potential when it is integrated into organizational culture through two-way communication practices.

Keywords: sustainability communication, organizational communication, strategic management, stakeholders, Latin America.

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Resumen: este estudio analiza los contextos comunicacionales en los que grandes organizaciones de Chile, Colombia y Ecuador gestionan su comunicación para la sostenibilidad, así como sus principales características, orientaciones estratégicas y diferencias estructurales en el ámbito organizacional latinoamericano. Se adoptó una metodología cuantitativa de tipo no experimental mediante la aplicación de un cuestionario a 75 organizaciones de los tres países. El instrumento se basó en el Modelo de Convergencia de Comunicación y Sostenibilidad, el cual evalúa el nivel de integración de las prácticas sostenibles de las organizaciones, sus formatos comunicacionales y relaciones con los públicos. Los resultados muestran un reconocimiento general sobre el valor estratégico de la sostenibilidad, pero con variaciones en su implementación e impacto en cada país. Las organizaciones chilenas y colombianas ejecutan principalmente modelos comunicativos simétricos y participativos en los que la sostenibilidad se alinea con el propósito institucional mediante diálogos con los públicos. En contraste, las organizaciones ecuatorianas muestran una orientación más instrumental en sus prácticas con diálogos unidireccionales centradas en el fortalecimiento de la reputación corporativa y cumplimiento de objetivos comerciales. Estas diferencias se deben a factores como la madurez de los marcos regulatorios, la presión social y la trayectoria institucional en materia de sostenibilidad. El estudio concluye que la comunicación para la sostenibilidad alcanza su potencial transformador cuando es integrada a la cultura organizacional junto con prácticas de comunicación bidireccionales.

Palabras clave: comunicación para la sostenibilidad, comunicación organizacional, gestión estratégica, stakeholders, Latinoamérica.

Introduction

Communication and sustainability aim to establish strong, lasting bonds between an organization and its various stakeholders, ensuring the achievement of its objectives and even its survival. Therefore, it is essential that communication management fosters a direct relationship characterized by constant interaction and genuine understanding of the people within the involved groups, thereby strengthening the link between sustainability processes and the strategies implemented by organizations (Miller *et al.*, 2018; Schmeltz, 2017).

Although communication and sustainability have traditionally been studied as complementary fields (Bartlett *et al.*, 2007; Roper, 2012), in recent years there has been an increase in research addressing their strategic convergence (Orozco-Toro *et al.*, 2023). As a result of this approach, conceptual frameworks have been developed, such as the Model of Sustainability and Communication Contexts proposed by Durán and Mosquera (2016), grounded in public relations theories by Grunig and Hunt (2000), corporate social responsibility by Garriga and Melé (2004), and strategic collaboration by Austin *et al.* (2005). The following sections will address the preeminence and cross-cutting nature of communication and sustainability in organizations.

Communication for Sustainability

In organizations, communication is understood as a key and relevant process for achieving proposed goals and guiding stakeholders toward objectives, thereby facilitating the fulfillment of organizational commitments (Carvajal-Ordoñez *et al.*, 2025; Heredia and Sulca-Tapia, 2022). According to Weder (2024), the relationships between organizations and their environment are unique in terms of the direction of communication, its function, and its participatory nature. Consequently, information and communication are the primary foundations for disseminating knowledge about environmental issues and encouraging behavioral changes toward more sustainable practices within organizations (Pinzón-Castro and Maldonado-Guzmán, 2023; Wedayanti *et al.*, 2024), which generate an impact on society.

Thus, it is necessary to distinguish three dimensions to understand the core of communication and sustainability in organizations: communication on sustainability issues as part of public discourse (i.e., deliberative; ensuring open discourse, transparency, and the construction of meaning), communication as a one-way transmission of a specific sustainability issue or policy to achieve a specific effect or objective (instrumental), and finally, communication for sustainability, understood as "a call to action" (Weder *et al.*, 2021).

According to Porter and Kramer (2006), organizations can develop specific communication strategies that convey their commitment to sustainability with the aim of communicating their social commitment to stakeholders. These strategies also allow organizations to demonstrate their performance in comparison to competitors and to various stakeholders

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(Bettiol *et al.,* 2024). Consequently, an organization's legitimacy will depend on whether its audiences perceive it to operate ethically, legally, and appropriately within society's system of norms and values (Overton *et al*., 2022). Organizations committed to sustainability need to provide concrete evidence of their sustainable practices and communicate their commitment effectively (Kim *et al.,* 2024). Therefore, it is important that those responsible for developing and executing sustainability communication plans take into account organizational objectives, including economic, social, and environmental issues, as well as alignment with the corporate purpose.

The creation of relevant and accurate sustainability messages targeted at different stakeholders is fundamental to sustainability communication, as it generates a "call to action" that not only raises awareness but also drives behavioral change toward more responsible practices aligned with sustainable development goals (Mendoza-Solis *et al.,* 2025). Consequently, an effective message (content, channel, target audience) and a coherent organizational discourse (saying and doing) build strong and lasting relationships that reinforce the commitment established with different stakeholders, based on transparent, two-way communication with an emphasis on dialogue with stakeholders (Estanyol *et al*., 2025; Oliver-González and Martín-Herrero, 2025).

Sustainability

The growing importance of sustainability is evident in the agendas of countries and private and governmental organizations, under global frameworks such as the 2030 Agenda. In this regard, sustainability has also permeated business discourse, particularly in large companies, which develop policies and actions that impact environmental management as well as social and economic aspects (Costa-Sánchez and Peñafiel-Saiz, 2024). Unfortunately, the relevance of sustainability increased, in part, due to the environmental crisis facing the planet and the various social and economic factors that impact sustainable development.

Debates surrounding sustainability have emerged from various perspectives, including epistemological discussions in Spanish regarding whether the term should be spelled "sostenibilidad" or "sustentabilidad." Ambivalence regarding which term to use is frequently encountered, especially in the Latin American business context. When addressing the topic of development linked to environmental, social, and economic aspects (triple bottom line), authors tend to favor the term "sostenibilidad" (Aguado *et al*., 2009), while other researchers lean toward the concept of "sustentable" (Foladori and Tommasino, 2000), and finally, there are those who use them interchangeably in their research (Leff, 2004).

From the perspective of organizations, the issue of sustainability has become essential for their own future, and in some sectors it is common for them to also implement or launch other initiatives such as social marketing, corporate social marketing, and Corporate Social Responsibility (CSR), among others (Barrio-Fraile *et al.,* 2024).

Given this context of sustainability, it is crucial to understand that responsibility for the planet's problems must be assumed by all its inhabitants (Leff, 2004), and is not solely the duty of governments or large companies. However, from a business perspective, the greatest responsibility should fall on large companies, as they should be encouraged to work toward the planet's sustainability, since, after all, they are the ones capable of taking on the challenge of addressing economic, social, and environmental challenges (Ibáñez-Hernández *et al.,* 2025).

Likewise, it can be observed that the current environmental crisis is due to a variety of factors, such as politics and culture (Aguado *et al.,* 2009), globalization, and consumerism (Bauman, 2010). There are even authors who consider large global corporations to be the primary causes of this environmental crisis (Cortina, 2005).

Both public and private sector companies, non-governmental organizations, and citizens have an obligation to embrace sustainability as a daily commitment, and no effort should be spared in this regard (Acevedo-Duque *et al.,* 2023; Bondi and Turnbull, 2025; Eljadue, 2024; Fernández, 2023; Quiles-Soler *et al.*, 2025). Beyond the debate on global warming, the future of the planet is determined by what has been termed "planetary boundaries," where the Earth has exceeded the limits necessary to sustain life, and it is everyone's responsibility to reverse this condition (Sachs, 2016).

The objective of this study is to comparatively analyze the communication contexts in which large organizations in Chile, Colombia, and Ecuador manage communication for sustainability, in order to identify strategic orientations, levels of integration, and structural differences between countries. To this end, the following research questions are formulated to guide the study:

1. In what communication contexts for sustainability do the Chilean, Colombian, and Ecuadorian organizations under study operate?
2. What are the differences and similarities between the sustainability communication contexts of the Chilean, Colombian, and Ecuadorian organizations under study?

Materials and methods

Design and Participants

This study followed a non-experimental quantitative design. It included 75 large organizations from Chile (n=27), Colombia (n=33), and Ecuador (n=15), selected through a non-probabilistic convenience sampling process. The selection of countries was based on academic and contextual criteria, as they correspond to the researchers' institutional and professional environments, which facilitated access to organizational networks and ensured the study's relevance to specific Latin American contexts.

For the selection process, the researchers developed their own database by compiling the 500 largest organizations in Latin America, using rankings published by leading economic and financial journals in Chile, Colombia, and Ecuador as a reference. Based on this database, organizations with at least 200 employees were identified, based on the assumption that large organizations have greater economic, human, and structural resources to establish sustainable development practices in their management (Sedovs *et al.*, 2025).

This database was cross-referenced with the researchers' professional and academic networks to identify key contacts—primarily professionals with experience in communications and/or sustainability—who were most likely to respond. In total, 245 invitations were sent by mail across the three countries. After making follow-up calls and sending institutional reminders, and taking into account the data collection period established by the study's sponsoring entity, a final sample of 75 organizations that completed the survey by May 2024 was obtained (response rate: 30.6%). Although respondents agreed to provide their organizations' names for categorization purposes, this information was kept confidential.

Development and updating of the instrument

The instrument was a questionnaire based on the Convergence and Sustainability Model by Durán González and Mosquera López (2016), which establishes four contexts or orientations in which an organization may be situated based on its communication and sustainability practices. It is important to note that the model proposed by these authors has an evolutionary nature marked by the continuum of collaboration by Austin *et al.* (2005), meaning that the contexts do not develop sequentially, i.e., they can evolve over time according to the changing environment and the direction of the organizations (see Table 1).

The original questionnaire, developed by Durán, Mosquera, and Vega (2017) and administered to 16 Ecuadorian organizations, features a constant-sum mechanism and underwent two updates by the researchers of this study. The first update took place in 2019 and

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involved revising and updating the original questions to adapt them to a new research context. Subsequently, in 2024, a second update was carried out, which included the demographic items and adjustments to the wording of some statements, with the aim of increasing their precision and comprehensibility.

Table 1

Communication and sustainability contexts

Context/ Orientation (Code)	Approach	Perspective on Social Responsibility	Type of Business
Business (N)	Achievement of business objectives.	Competitive advantage Collaboration: philanthropic	Press agent with one-way communication; communication integrated into marketing and advertising.
Accountability (AC)	Strengthening of corporate image and reputation.	Political-institutional instrument Collaboration: transactional, aligned with organizational interests.	Information for the public through one-way communication for transparency.
Stakeholder interests (SI)	Interest in the needs of stakeholders.	Management that prevents a crisis. Collaboration: transactional.	Two-way asymmetric information with communication practices that seek feedback from the public.
Common good (CG)	Satisfaction of social needs.	Guided by organizational values and recognition of the impact of actions on society. Collaboration: integrative with dialogue.	Symmetrical, two-way communication to foster dialogue with audiences.

Note. Adapted from Durán González and Mosquera López (2016).

The final version of the 2024 questionnaire consisted of 17 questions, seven of which pertained to demographic information and 10 addressed the same sustainability and communication items as the original questionnaire, with adjustments to the wording. To optimize the processing and analysis of the information, a specific code was assigned to each item (see Table 2).

Table 2

Items and codes for the communication and sustainability contexts sections of the instrument

Communication (code)	Sustainability (code)
Information flow within the organization. **(C_IF)**	Perception of sustainability. **(PS)**
Communication objectives. **(C_CO)**	Type of collaboration within the organization. **(TC)**
Communication strategies. **(C_CS)**	Planning and resources for SR **(PRS)**
Ideal profile of the professional communicator. **(C_PC)**	Planning for environmental preservation **(PEP)**
Organizational discourse on sustainability. **(C_OD)**	Respect for human rights. **(RHR)**

Note. Adapted from Durán González and Mosquera López (2016).

As seen in Table 2, the areas of communication and sustainability each have five items (variables), and each item presents the respondent with four statements corresponding to one of the four contexts or orientations proposed in the model by Durán González and Mosquera López (2016). The survey followed a scoring design called "constant sum," meaning participants had to distribute up to a maximum of 10 points among the four statements. It should be noted that respondents had the option to assign most or all 10 points to a single statement if it best described the practices used in their organization. In other words, it was possible to assign zero points to one of the statements representing a context or orientation.

A pilot test was conducted to evaluate the items included in the questionnaire and obtain constructive feedback. In November 2024, the researchers sent the survey via Survio to six of their professional and academic contacts, including journalists, communications managers, and sustainability engineers. The selection criteria were based on having experience in the areas of strategic communication and/or sustainable management, considering that in some organizations these areas are not necessarily integrated into the same department. The feedback received focused on two main aspects: (1) the format and functionality of the survey on the Survio platform and (2) the wording of certain titles and statements. Regarding the format, it was recommended to expand the instructions on how to allocate the 10 points among the four statements, in order to avoid confusion and explicitly specify that it was possible to assign zero points to any of them. Likewise, it was suggested to incorporate an "accept" button to reinforce informed consent and the confidentiality of the responses. Regarding the wording, the reviewers pointed out the need to clarify certain terms used in the question titles. Consequently, the title "conceptual framework" was replaced by "conception of sustainability," and "public relations" by "communication," as these were considered broader and more understandable concepts. In addition, certain expressions were adjusted to improve semantic clarity; for example, the phrase "we usually do" was replaced by "frequently." After incorporating these observations, the average response time was reduced from 14 to 12 minutes on average. It should be noted that the researchers did not change the constant summing mechanism established by the authors of the original questionnaire.

The survey was emailed to the participant database between November 2024 and May 2025. During this period, which was set to meet the deadlines specified by the study's sponsoring institution, the researchers made follow-up calls to encourage participation and reinforce the confidentiality of the information provided. Finally, the participants' responses were aggregated and averaged to enable the analysis of each of the variables in the areas of communication and sustainability.

Validation process

The instrument employs the constant sum mechanism for each question, as originally designed by Durán, Mosquera, and Vega (2017), with the aim of identifying the relative importance assigned to the presented statements. It was decided to retain this format in order to maintain methodological fidelity to the theoretical reference model. By allowing for the capture of internal priority configurations rather than absolute levels of agreement, the mechanism does not meet the necessary conditions for conducting an internal consistency validation using Cronbach's Alpha (Clow and James, 2014). This is primarily because the assignment of points among four possible statements creates a forced dependency among them, even though they represent different characteristics of the communication and sustainability contexts. Due to these characteristics, the researchers used the Entropy and Gini indices to detect possible automatic or random responses across the two dimensions of the instrument (n=10) and thus assess the instrument's validity.

Entropy has been used in several studies on organizational information management (Morillo Sánchez, 2024; Tchupo and Macht, 2023) to measure the degree of dispersion or uncertainty in a set of survey responses. A high entropy index reflects a balance among the responses

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given to the presented options—i.e., the surveys do not show a preference for any particular option (index close to 1)—while a low entropy index reflects a concentration of responses on one or two options, indicating a clear preference (index close to 0).

On the other hand, the Gini index measures the level of inequality in a distribution of responses and has been used in surveys that assess preferences among participants (Wagner *et al*., 2025). A low Gini index (close to 0) indicates a balanced distribution of responses; a high index (close to 1) indicates that responses lean toward a single category or preference. The statistical software R was used to calculate these indices.

Data Analysis

To compare variations in the responses collected from each country, the nonparametric Mann-Whitney U test was used, which is suitable for small, independent samples without a normal distribution. The calculations were performed in Jamovi, an open-source statistical software, setting a significance level at $p<0.05$; i.e., there is statistical significance when the p-value is less than 0.05. The following hypotheses were formulated:

1. **Null hypothesis (Ho):** There are no statistically significant differences between the communication and sustainability practices reported by the organizations in the study.
2. **Alternative hypothesis (Ha):** There are significant differences between the communication and sustainability practices reported by the organizations in the study.

Results and discussion

Validation results

In the Sustainability (S) dimension, the results of the responses showed a solid and consistent distribution across the four possible contexts and, in turn, revealed clear differences in intensity. In the Communication (C) dimension, the responses exhibited a balanced distribution with moderate and well-defined ranges across the four contexts. Overall, the questions generated consistent Gini and Entropy patterns (no percentages were found at the high extremes of Gini >0.80, and there were few percentages near the extreme range of entropy <0.25), i.e., respondents understood and answered the instrument's questions without generating automatic responses or anomalies, which is considered a good indicator of validity.

Organizational profile

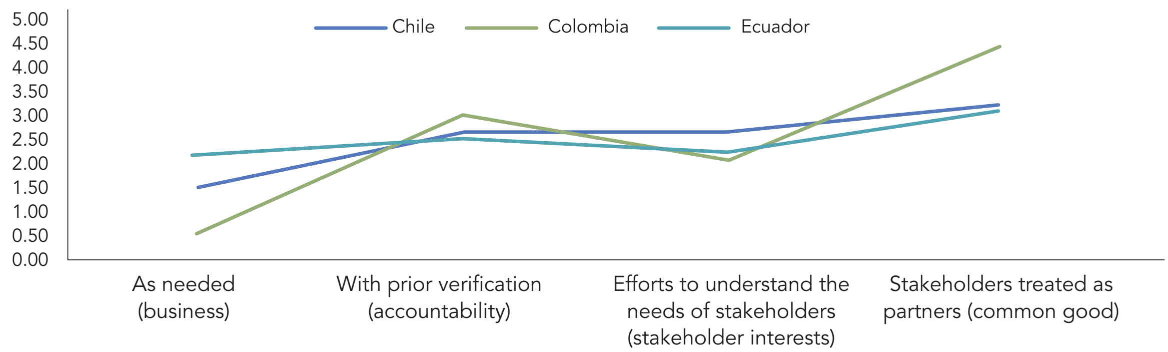
The most representative economic activities in the sample were education (17.33%), industry (12%) (textiles, wood, metals, plastics, etc.), communications and technology (9.33%), food and beverages (8%), logistics and transportation (6.67%), commerce (6.67%), energy (5.33%), government and public service organizations (6.67%), construction (4%), mining and/or oil (4%), fishing and agriculture (4%), healthcare (4%), brokerage (1.33%), consulting (4%), cosmetics (1.33%), funeral services (1.33%), insurance (1.33%), vehicle sales and rentals (1.33%), and tourism (1.33%).

Results in the field of communication

Variable: Information processes and flows (C_IF)

Although there was no statistical significance for this variable, the graph shows that information flows in organizations across the three countries trend toward the Common Good context, particularly in Colombia. On the other hand, Ecuadorian organizations showed the strongest orientation toward Business (Figure 1).

Figure 1
Information Flow



Note: Prepared by the authors based on data from the 2025 survey.

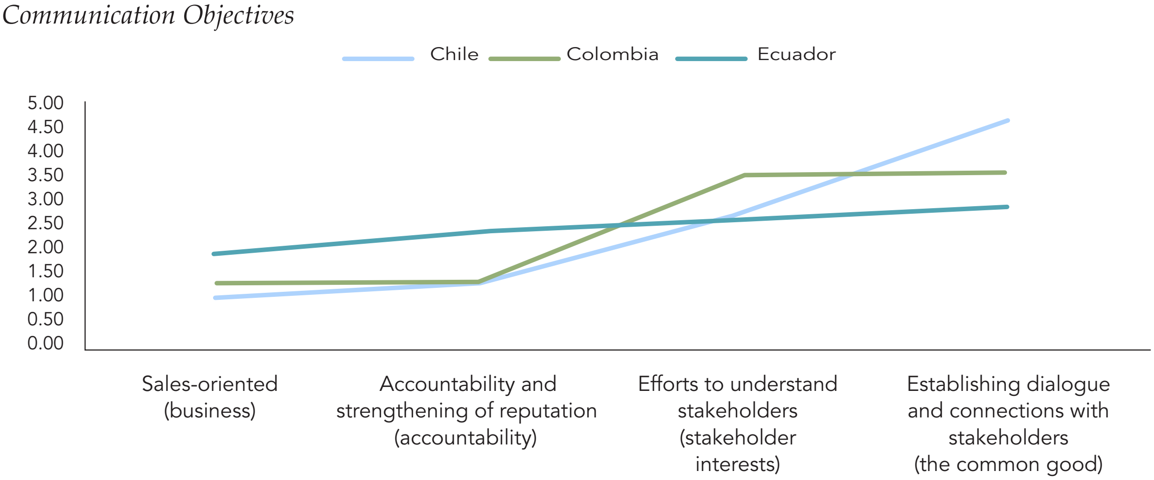
Some of the respondents from the participating organizations offered the following comments, which reflect certain variations among the three countries:

- They should improve in the areas of communication, human relations, and other matters so that they can succeed with their employees, who are the ones driving the company forward. (Respondent 61 from an Ecuadorian organization).
- The company seeks to continuously communicate strategic objectives across all areas to promote clarity in processes, motivate quality in their roles, and enable them to be key players in everyone's growth. (Respondent 39 from a Colombian organization).
- Communication should aim to convey the organization's purpose and the shared value creation initiatives it undertakes. (Informant 2 from a Chilean organization).

Variable: Communication Objectives (C_CO)

Figure 2 shows that Ecuadorian organizations exhibit a stronger sales orientation regarding communication objectives, i.e., a business-oriented context. In Chile, there is a greater inclination toward the common good. Despite these variations, these differences were not statistically significant.

Figure 2
Communication Objectives



Note: Prepared by the authors based on data from the 2025 survey.

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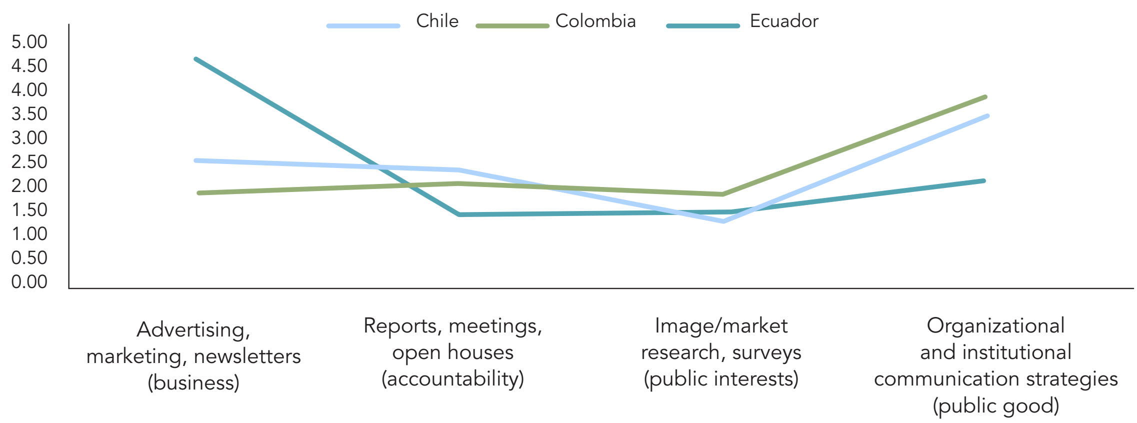
Variable: Communication Strategies (C_CS)

Figure 3 shows that respondents' answers in the three countries point toward the more evolved context—i.e., the Common Good context—especially in Colombia and Chile. On the other hand, in Ecuadorian organizations, an orientation toward the Business context is observed. These differences regarding the Business context are statistically significant (p=0.014).

Figure 3

Communication Strategies



Note. Prepared by the authors based on data from the 2025 survey.

Respondent comment:

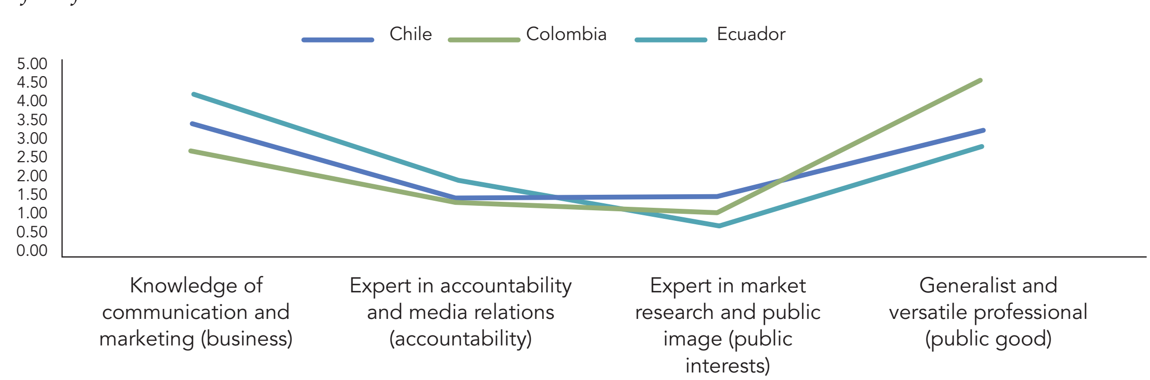
The sustainability policy in my organization is very well integrated with strategic communication, both at the corporate level and in advertising messages, as well as at different levels such as internal and external communication. (Respondent 26 from a Chilean organization).

Variable: Profile of the Ideal Communicator (C_PC)

Figure 4 shows a preference for two main profiles situated in two opposing contexts: Business and Common Good. The results of the statistical calculations show no significant differences among the three countries, meaning they all follow the same trend.

Figure 4

Profile of the ideal communicator



Note. Prepared by the author based on data from the 2025 survey.

Variable: Organizational Discourse (C_OD)

Organizations in Chile and Colombia lean primarily toward the Common Good context (Figure 5). In contrast, in Ecuador, a greater tendency toward the Business context is observed. In this regard, the difference between Ecuador and the other countries is significant (p=0.037).

Figure 5

Organizational discourse

Note. Prepared by the author based on data from the 2025 survey.

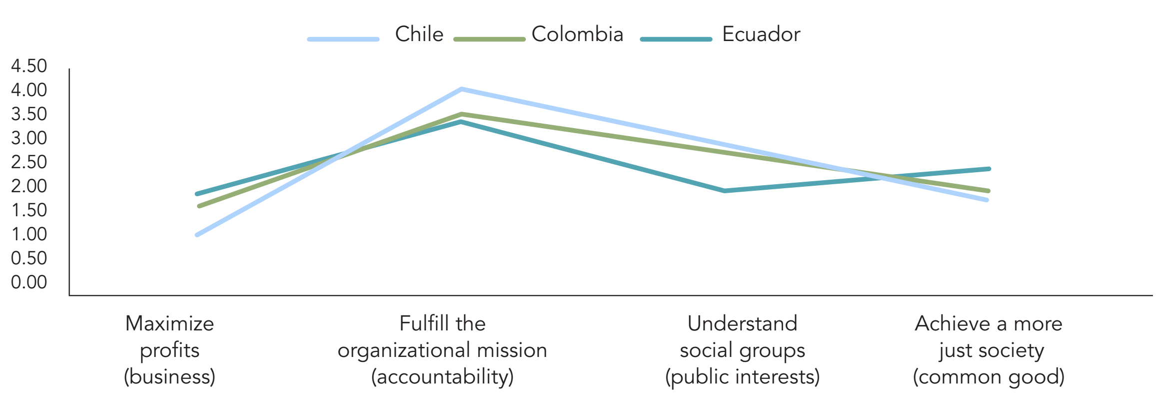
Results in the area of sustainability

Variable: Perspective on sustainability (PS)

The responses reflect insignificant differences between countries, as all demonstrate an orientation toward the accountability context in terms of their conception of sustainability (see Figure 6).

Figure 6

Conception of sustainability



Note. Prepared by the author based on data from the 2025 survey.

Respondent comment:

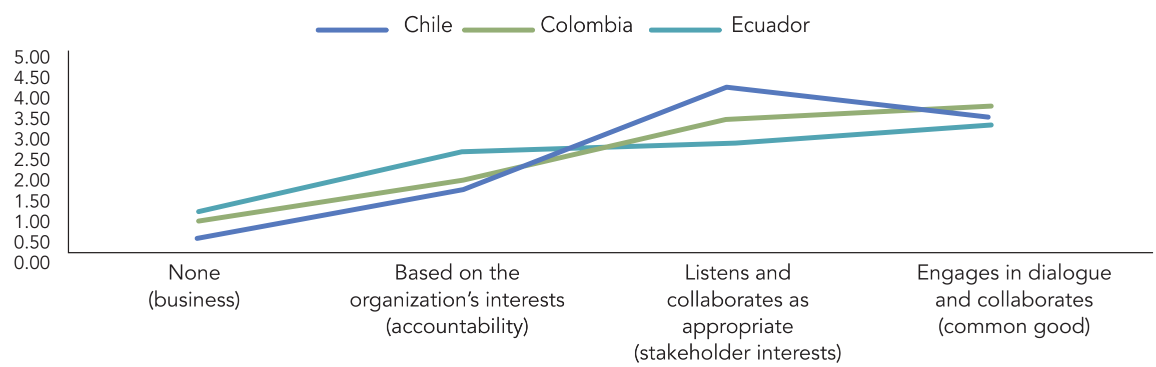
(...) it is a company that has truly demonstrated its interest in working on sustainability and implementing it, being very consistent with its value of integrity and putting into practice what it promotes. (Respondent 45 from a Colombian organization).

Variable: Type of collaboration (TC)

The responses reflect non-significant differences between countries, as they point toward the context of Stakeholder Interests, i.e., they listen to requests for collaboration to decide whether they can be addressed without losing sight of the organization's needs (Figure 7).

Figure 7

Type of collaboration



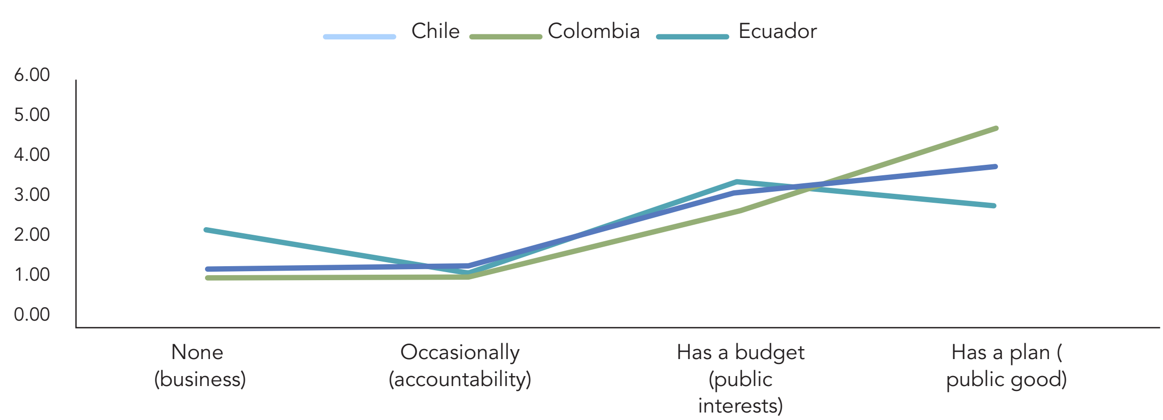
Note. Prepared by the author based on data from the 2025 survey.

Variable: Planning and Resources for Sustainability (PRS)

Organizations in Chile and Colombia appear to be oriented toward the Common Good, while in Ecuador an orientation toward the Public Interests context is observed. However, these differences are not significant (see Figure 8).

Figure 8

Planning and resources for social responsibility



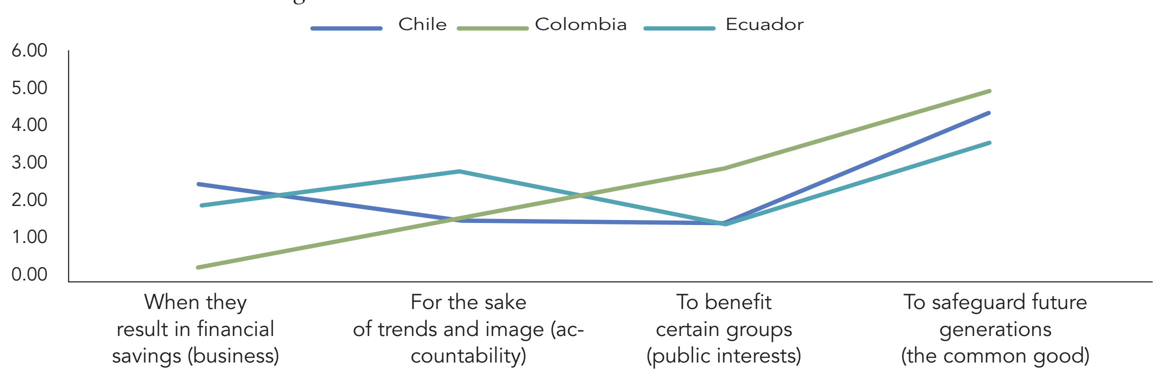
Note. Prepared by the author based on data from the 2025 survey.

Variable: Environmental Care Planning (PEP)

Regarding actions to protect the environment, there are no significant differences among the three countries, as all demonstrate an orientation toward the Common Good (Figure 9).

Figure 9

Environmental Care Planning



Note. Prepared by the author based on data from the 2025 survey.

Respondent comment:

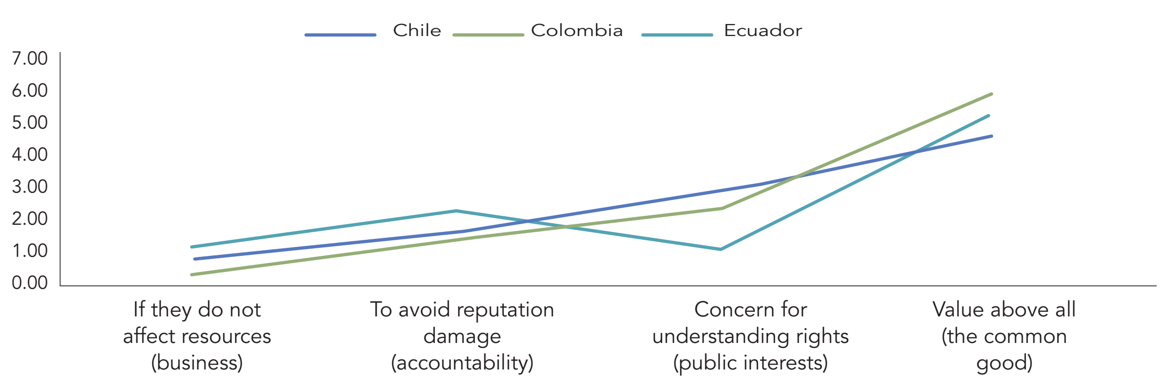
Sustainability is part of the organization's DNA; it is considered a strategic process, has an ESG plan, and aligns with the 2030 Agenda, the 2050 goals, and the SDGs. It is vital to understand that this is not just one aspect but is at the core of how we operate as an industry, caring for people, the business, and the planet so we can be here for another 100 years. (Respondent 66 from an Ecuadorian organization).

Variable: Respect for the rights of others (RHR)

The responses from the three countries in Figure 10 show a general inclination toward the Common Good context, i.e., they view respect for the rights of others as a value above all others. In Ecuadorian organizations, however, a shift toward the Stakeholder Interests context is observed. This result approaches statistical significance (p=0.05).

Figure 10

Respect for the rights of others



Note. Prepared by the author based on data from the 2025 survey.

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Discussion

This comparative study analyzed how communication practices for sustainability are shaped in organizations across three Latin American countries, based on the perspectives of communication and/or sustainability professionals who participated in the survey. By applying an empirical approach, patterns were identified that reveal that according to respondents' answers, organizations appear to be making progress in integrating sustainability and communication into their strategies and practices, albeit with certain differences in their orientations. With this analysis, we will proceed to answer the research questions posed at the beginning of the study.

Q1: Communication contexts for sustainability in which the organizations operate

The first question sought to identify the communication contexts for sustainability in which the organizations under study operate. The data suggest that in Chile and Colombia, the participating organizations have achieved greater alignment with the context of the Common Good in terms of their communication practices (information communication processes, objectives, strategies, and discourse) and sustainability (resource planning, environmental preservation, and respect for the rights of others). This is reflected in those responses indicating the use of more symmetrical and two-way communication models. The actions in these two countries incorporate diverse strategic communication tools to achieve both internal and external objectives, consistent with the findings of Estanyol *et al.* (2025) regarding the importance of dialogue with stakeholders. In these dialogues, sustainability is conceived as part of corporate strategy and not merely as a reputational tool.

In contrast, the perceptions of professionals in Ecuadorian organizations show a more pronounced business orientation, reflecting a less evolved context characterized by patterns of limited information dissemination—or only that which is convenient for the organization. Communication management in these organizations shows significant signs of stagnation in this context, where the focus is on traditional strategies such as press releases, advertising, and cause-related marketing that serve reputational objectives. According to Porter and Kramer (2006), this type of action limits innovation and the transformative capacity of communication for sustainability.

At the same time, the responses from Ecuadorian participants show signs of slight progress toward the context of Stakeholder Interests. This finding stems from the emphasis on business objectives in communication through more traditional strategies, and from conceiving sustainability primarily as a tool to enhance image and reputation within the context of Corporate Social Responsibility. While a moderate approach is observed regarding environmental planning and the type of collaboration provided to other entities, an instrumental logic persists that delays the transition toward the Common Good. This observation aligns with the findings of authors such as Schmeltz (2017) and Weder *et al.* (2021), who assert that once organizations transition to more two-way dialogue models, they are able to move beyond a marketing mindset to create genuine commitments to society.

Differences and similarities between organizational communication contexts for sustainability

The second question addresses the differences and similarities among the countries under study. It was found that the main similarity is the recognition of sustainability as part of the strategic agenda and as a commitment to fulfilling the organizational mission in society (Costa-Sánchez and Peñafiel-Saiz, 2024). It is also observed among the participating organizations a preference for two ideal profiles for a professional communicator: on the one hand, experts with knowledge in the area of advertising and communications integrated into marketing are valued, and on the other, professionals with a holistic view of the organization's objectives—i.e., communicators who seek consistency between what is said and what is done (Oliver-González and Martín-Herrero, 2025).

However, while organizations in Chile and Colombia appear to be oriented toward collaborative models that prioritize dialogue for the Common Good, in Ecuador a predominantly instrumental, business-oriented approach is observed, particularly regarding communication strategies and organizational discourse. This contrast can be explained by contextual factors such as the maturity of regulatory frameworks, pressure from stakeholders, and differing Corporate Social Responsibility practices in each country (Bondi and Turnbull, 2025; Overton *et al.*, 2022). While there are signs of nascent environmental planning and collaboration with the public in this country, an instrumental orientation persists, in which actions to protect the environment arise because they are trendy and because they help strengthen organizational reputation. This orientation aligns with what several authors have proposed regarding the potential of Corporate Social Responsibility as a competitive differentiator (Bettiol *et al.*, 2024).

In this context, many of the actions carried out under the umbrella of sustainability are symbolic and superficial, as they align more closely with the logic of greenwashing. As Porter and Kramer (2006) warn, these practices do little to earn public trust and hinder the transformative potential of communication for the common good.

Conclusions

This article, which examines models for communicating sustainability through a comparative study of three Latin American countries (Chile, Colombia, and Ecuador), has identified differences and similarities, offering valuable insights for companies in any business sector.

The study reveals a tension between two approaches: one focused on dialogue and the transformation of stakeholder interests, and the other on market logic and reputation—i.e., on business. The Ecuadorian case highlights the limitations inherent in viewing sustainability as an instrumental resource. Communication follows traditional formats and one-way communication flows to maintain control over shared information. In certain contexts, some stakeholders are approached from an instrumental logic that emphasizes their status as consumers, which limits the recognition of their diversity and capacity for dialogue during the organizational analysis and decision-making process. To overcome this, it is necessary to review communication channels and power structures to redistribute them and pave the way for a more authentic social dialogue.

Although the study did not aim to analyze the contextual factors behind organizational behavior, these are important variables to consider. In contexts where environmental regulation is weak and the tradition of Corporate Social Responsibility is in its initial phase, as in the case of Ecuador, organizations tend to have more conservative and one-way communication practices. In contrast, in more mature cases such as those observed in Chile and Colombia, sustainability is part of the organization's mission and objectives; they use more open communication channels and strategies that go beyond simply enhancing reputational positioning. Therefore, it can be concluded that it is not enough to incorporate sustainable discourse into corporate media; rather, it is necessary to transform communication into a structural practice, permeating internal culture and strategic decisions. It is advisable to critically review the communicative use of sustainability, as well as to develop better ethical and regulatory frameworks to generate greater coherence in decision-making.

From a theoretical perspective, these findings strengthen the Convergence Model between sustainability and strategic communication by demonstrating that the transition toward contexts oriented toward the Common Good does not respond solely to communicational decisions, but to institutional, regulatory, and cultural conditions that shape the type of dialogue possible. This broadens our understanding of bidirectional models by showing that their implementation depends on the maturity of the environment and the effective recognition of stakeholders as dialogue partners rather than merely as strategic audiences.

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In practical terms, the research suggests that organizations that remain stuck in instrumental approaches limit their ability to generate sustained legitimacy. It is necessary to strengthen internal structures that promote dialogue, integrate sustainability into strategic planning, and align communication plans with the evolving environment, so that the entire organization acts coherently toward achieving its objectives and the triple bottom line.

The main practical implication of this study is the need for organizations to continue joining forces to improve dialogue with their audiences, better organize their communication and media plans, understand how the environment is evolving to align communication plans, and ensure that the entire organization works toward achieving its objectives and the triple bottom line.

Among the main limitations of the study is its non-experimental, cross-sectional quantitative design. While this allows for the description of trends and differences among the countries studied, it does not aim to establish causal relationships since it does not analyze the temporal evolution of organizational practices. Furthermore, while the study sample is relevant for including large Latin American organizations, it exhibits an uneven distribution across the analyzed countries (Chile n=27, Colombia n=33, and Ecuador n=15), which limits the identification of significant differences in some variables—particularly in the case of Ecuador—as well as the generalizability of the results. Additionally, since the data is self-reported by key informants, the results are based on individual perceptions of organizational practices and not necessarily on their actual implementation.

Future research could expand the sample sizes and incorporate contextual variables such as regulatory frameworks and leadership styles to further explain the differences and identify causal relationships across the various dimensions of communication for sustainability.

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Jaime Alberto Orozco-Toro	Writing, review, and editing: literature review, introduction, theoretical framework.
Caroline Ávila	Writing, review, and editing: discussion, conclusions.

Statement on the use of artificial intelligence

The authors **DECLARE** that, in the preparation of the article titled: "Communication Models for Sustainability: A Comparative Study in Chile, Colombia, and Ecuador," artificial intelligence (AI) was not used at any stage of the process.

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Strategic drivers of green employment in firms: environmental awareness, resilience, and technology

Conciencia ambiental, resiliencia y tecnología: estrategias clave para impulsar el empleo verde empresarial

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Abstract: this study investigates the associations between individual factors and organizational outcomes related to sustainability, with a focus on the implementation of green jobs and green behaviors. Specifically, the analysis examines (a) the relationship between green awareness and green jobs, (b) the association between resilience and green awareness, and (c) the mediating role of technology acceptance in the relationship between green awareness and green jobs. A sample of 302 workers in Spain was analyzed using a PLS-SEM model (SmartPLS) with validated scales for technology acceptance, green awareness, green jobs/skills, and resilience (Likert 1–7). The results indicate that green awareness is positively associated with green job and behavior performance, resilience is positively related to green awareness, and technology acceptance partially mediates the effect of green awareness on green jobs. Among the control variables, education level does not show a significant effect, while job category is negatively associated with green jobs, possibly due to limited opportunities for action at lower hierarchical levels. Due to the cross-sectional design, these findings should be interpreted as associative rather than causal. Overall, the results highlight that integrating pro-environmental behavior and technology adoption provides insight into the attitude–behavior gap in the green transition and underscores the importance of selecting and developing resilient employees with ecological values, as well as designing user-centered green tools, training, and working conditions that support the translation of attitudes into environmental performance.

Keywords: green awareness, resilience, technology, green jobs, pro-environmental.

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Resumen: este estudio examina cómo factores individuales se asocian con resultados organizativos vinculados a la sostenibilidad, con foco en la realización de empleos y conductas verdes. Se evalúan (a) la relación entre conciencia verde y empleos verdes, (b) la asociación entre resiliencia y conciencia verde y (c) el papel mediador de la aceptación tecnológica en el vínculo entre conciencia y empleos verdes. Con una muestra de 302 trabajadores en España, se estimó un modelo PLS-SEM (SmartPLS) utilizando escalas validadas de aceptación tecnológica, conciencia verde, empleos/habilidades verdes y resiliencia (Likert 1-7). Los hallazgos muestran asociaciones coherentes con las hipótesis: la conciencia verde se relaciona positivamente con el desempeño de empleos/conductas verdes; la resiliencia se asocia positivamente con la conciencia verde; y la aceptación tecnológica presenta una mediación parcial y significativa, atenuando el efecto directo de la conciencia sobre los empleos verdes. En las variables de control, el nivel educativo no muestra un efecto significativo, mientras que la categoría laboral se relaciona negativamente con los empleos verdes, lo que podría reflejar menor margen de actuación en niveles jerárquicos inferiores. Dado el diseño transversal, estos resultados deben interpretarse como relaciones asociativas y no como evidencia causal. A la luz de los resultados, se sugiere que integrar el comportamiento proambiental y la aceptación tecnológica ayuda a comprender la brecha actitud-comportamiento en la transición verde y apuntan a la conveniencia de seleccionar y desarrollar talento resiliente y con valores ecológicos, así como de diseñar herramientas y formación verdes centradas en el usuario y condiciones de trabajo que faciliten transformar actitudes en desempeño ambienta..

Palabras clave: conciencia verde, resiliencia, tecnología, empleos verdes, proambiental.

Introduction

Sustainability is no longer considered a secondary issue but has become a strategic pillar of decision-making (García-Salirrosas, 2023; Hermundsdottir and Aspelund, 2022). The climate crisis, along with social and institutional pressure, is driving organizations to integrate environmental criteria into their strategy (Daddi *et al*., 2016). This shift is reflected in the rise of green jobs, which provide the skills and practices needed to operate and compete with a smaller environmental footprint, facilitating the adoption of low-carbon and circular models based on resource efficiency. From a microfoundations perspective, the focus is on the individual, cognitive, motivational, and behavioral mechanisms that enable the effective implementation of sustainability. The aim is to identify which environmental beliefs and knowledge—such as green awareness; which psychological willingness—such as the resilience to sustain decisions under cost and time pressures; and which tool-adoption capabilities—such as technological acceptance—drive strategic guidelines to translate into daily routines, operational decisions, and green behaviors in everyday work.

Green jobs are defined as those jobs that, across various sectors (agriculture, industry, services, R&D, administration), contribute substantially to preserving or restoring environmental quality (Bohnenberger, 2022). At the organizational level, this involves incorporating practices, routines, and standards that align performance with environmental objectives and integrate environmental management into competitive strategy (Hart, 1995).

In this process, the role of employees and their attitudes is decisive, because environmental policies only have an impact when they translate into habits, decisions, and operational standards in the workplace (Norton *et al.*, 2015). Likewise, many pro-environmental behaviors are discretionary, such as energy conservation, waste separation, or eco-improvement proposals; therefore, they depend largely on values and motivations in addition to formal rules. In fact, a significant number of sustainability failures can be due to difficulties in implementation and adherence, rather than strategic design.

In this context, employee green consciousness—understood as the degree of sensitivity, knowledge, and personal commitment to environmental protection in the workplace—is associated with a higher likelihood of engaging in pro-environmental behaviors at work (Dumont *et al*., 2017; Paillé and Boiral, 2013; Katz *et al*., 2022; Alherimi *et al*., 2024). Consequently, the first objective is to analyze the relationship between employee green consciousness and the performance of green jobs/behaviors (Paillé *et al*., 2014; Alt *et al*., 2016).

Another individual variable of interest is employee resilience, defined as the ability to adapt, learn, and overcome adverse situations or changes (Connor and Davidson, 2003). Since the implementation of sustainable practices often requires adjustments to routines and work methods, more resilient employees tend to cope better with these challenges and may show a

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greater willingness toward eco-friendly behaviors (Norton *et al*., 2015; Paillé and Boiral, 2013; Avey *et al*., 2008). From this perspective the second objective arises: to analyze the relationship between employee resilience and their green consciousness.

However, even if an employee holds strong environmental values, this does not in itself guarantee that such awareness will translate into observable results at work. This difference is related to the well-known attitude–behavior gap, which has been extensively documented in environmental research (An *et al*., 2022; Blake, 1999; Gifford, 2011; Kollmuss and Agyeman, 2002). In the organizational context, it could be argued that technology acceptance acts as an enabling mechanism that facilitates this translation: when employees perceive technologies as useful and easy to use, the likelihood of incorporating sustainable practices into their daily routines and decisions increases, in line with classic models of technology acceptance (Davis, 1989; Venkatesh *et al*., 2003) and with evidence on "green" information systems that promote pro-environmental behaviors at work (Chen and Tung, 2014). When green practices depend on digital tools or clean technologies, their acceptance determines whether awareness translates into observable actions. Therefore, the third objective is to analyze the mediating effect of technology acceptance on the relationship between green awareness and green jobs/behaviors.

Regarding the research gap and originality, although the literature has separately analyzed the relationship between environmental awareness and pro-environmental behaviors and has developed robust models of technology adoption, it is still limited the evidence that integrates within a single explanatory framework the micro-foundations, enabling the conversion of a "green" orientation into operational outcomes within the organization. This study aims to bridge that gap by proposing and testing a model that connects (i) a relevant individual psychological resource (resilience) as a precursor to (ii) green consciousness, and explains its translation into (iii) green practices/behaviors through a conversion mechanism based on technology acceptance.

Thus, the study does not merely replicate known relationships in a new context but explicitly addresses the "how" of implementation: why environmental motivation does not always translate into action and under what instrumental conditions it can do so, addressing critiques regarding the accumulation of constructs without enough detaila of the micro-mechanisms underpinning the day-to-day implementation of sustainability (Aguinis and Glavas, 2012). In summary, the article explicitly links individual drivers (green awareness and resilience) with organizational outcomes (green practices/behaviors) and incorporates technological acceptance as a mechanism that converts attitudes into environmental performance.

The theoretical framework underpinning the hypotheses and the proposed research model is developed below.

Relationship between green c onsciousness and green jobs

We understand green consciousness as the degree to which a person is aware of environmental problems, is sensitive to them, and makes a personal commitment to protect the environment (Kim and Lee, 2023); it can be understood as a cognitive and motivational antecedent. According to the Theory of Planned Behavior and the Value-Belief-Norm model, this willingness translates into pro-environmental intentions and behaviors when the individual perceives that they can act (perceived control) and that they should do so (moral obligation) (Ajzen, 1991; Bamberg and Möser, 2007).

In the organizational context, greater green awareness increases the relevance of ecological goals and the alignment between personal values and the company's environmental practices. This encourages employees to seek out or take on positions with a greater environmental component or, alternatively, to redesign their own work by incorporating tasks aimed at reducing impacts, such as resource conservation, waste prevention, or process improvement (Boiral, 2009; Norton *et al*., 2015). From the

Motivation-Opportunity-Ability perspective, green consciousness acts as an internal motivation that drives the search for opportunities and the adoption of sustainable routines; even when opportunities are limited, it manifests in everyday behaviors (energy conservation, recycling, proposals for environmental improvements, among others) that progressively "green" the workplace (Paillé and Boiral, 2013).

Green consciousness reinforces self-determination because it fosters the internalization of ecological values: when a person integrates environmental protection into their value system and identity, acting sustainably ceases to be perceived as an external demand and comes to be experienced as a personal choice. In terms of Self-Determination Theory, this internalization increases autonomous regulation (greater value coherence and sense of purpose) and, therefore, enhances persistence even when green behaviors involve effort or costs (Deci and Ryan, 2000; Gifford, 2011).

For its part, empirical evidence consistently shows that both attitudes and environmental awareness are positively associated with sustainable behaviors at work, such as environmental citizenship, eco-initiatives, and job-specific behaviors oriented toward sustainability. Furthermore, it has been documented that these behaviors enhance the environmental component of jobs (Paillé *et al*., 2014). Thus, it can be observed how theory and accumulated findings support the notion that greater green awareness translates, through intention, personal norms, and value congruence, into a higher probability of holding and performing green jobs.

Consequently, Hypothesis 1 is proposed.

H1: Employee green consciousness is positively related to green jobs.

Relationship between resilience and green consciousness

Resilience provides psychological resources—such as self-efficacy, hope, and optimism—that broaden cognitive openness and the willingness to explore alternatives, fostering sustained attention, learning, and reflection on environmental impacts and solutions, in line with resource conservation theory and the theory of positive emotion expansion and construction (Hobfoll, 1989; Fredrickson, 2001). In the workplace, this "reserve" of resources makes it easier to reframe sustainability initiatives as manageable challenges rather than threats, which increases sensitivity toward ecological goals and promotes the internalization of pro-environmental values and norms (Bakker and Demerouti, 2007).

Likewise, resilience is considered a component of psychological capital, understood as a higher-order positive resource composed of developable personal capacities that support well-being and performance. In its classical formulation, psychological capital integrates self-efficacy, hope, optimism, and resilience. Specifically, resilience provides the capacity to recover and adapt in the face of adversity, maintaining effort and learning in the face of demands and setbacks (Luthans *et al*., 2006; Avey *et al*., 2011). Based on these approaches, it is argued that more resilient employees tend to exhibit greater green consciousness, as they have more resources to sustain focus, reinterpret obstacles, and consolidate frameworks for action aligned with sustainability (Avey *et al*., 2011). Based on these arguments, the following hypothesis is proposed.

H2: Employee resilience is positively related to their green consciousness.

The mediating role of technology acceptance

Employees' willingness to accept and implement innovative technologies amplifies the effect of their environmental awareness on sustainable work practices. Several recent empirical studies indicate that technological innovations can promote sustainability by facilitating new forms of environmental participation and making green behavior more accessible (An *et al*., 2022; Leesakul *et al*., 2022). In this regard, in the consumer sector, it has been noted that cer-

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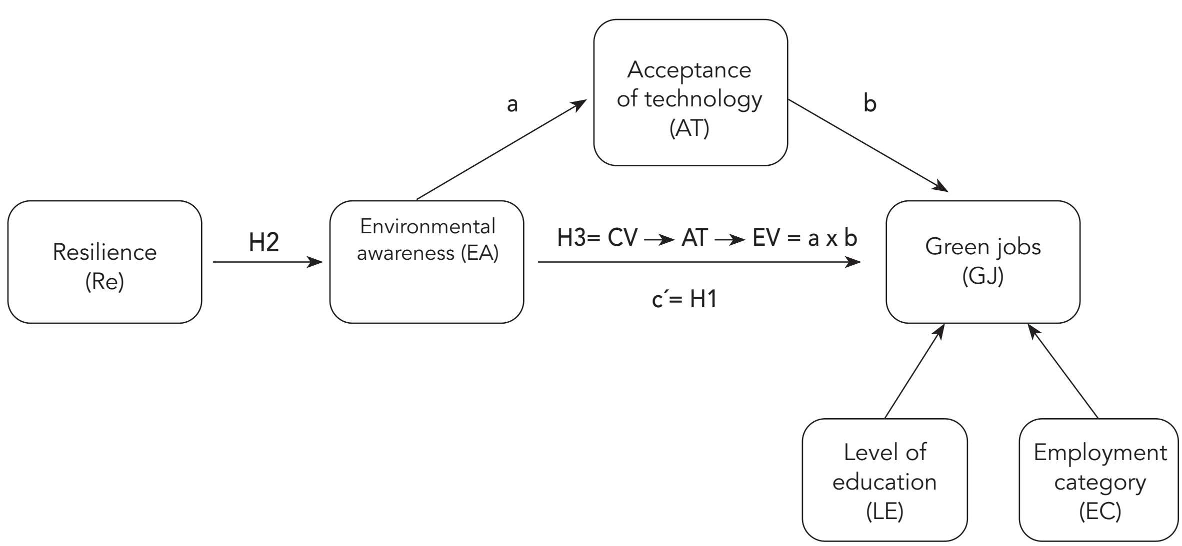
tain technologies (digital payments) mediate the relationship between people's ecological awareness and their actual green habits, enabling more environmental actions (An *et al*., 2022). By analogy, in a company, an environmentally committed employee will need appropriate tools and systems to translate their good intentions into concrete actions, such as using carbon footprint monitoring software or optimizing processes via Internet to save resources, among other measures. If the employee shows resistance to new technologies, it is likely that even with high environmental awareness, they will fail to improve the environmental performance of their role. In fact, a lack of technological acceptance among workers has been identified as one of the main barriers to the adoption of sustainable practices and green digital transformation in organizations (Leesakul *et al*., 2022). Conversely, a workforce open to technological innovation will be more able to implement environmental improvement initiatives. For all these reasons, Hypothesis 3 is proposed.

H3: Technology acceptance positively mediates the relationship between employee green awareness and outcomes in terms of green jobs.

Additionally, the theoretical model considers two relevant demographic control variables: employee educational level and job position. Educational attainment is typically associated with greater environmental knowledge and a better understanding and implementation of sustainable practices (Dietz *et al*., 1998; Franzen and Meyer, 2010; Gifford and Nilsson, 2014), as well as being linked to the green competencies required by ecological transitions. For its part, the type of position/hierarchical rank largely determines opportunities for action: managers and executives have formal levers to make decisions and introduce green policies, while operational roles channel sustainability through everyday behaviors and environmental citizenship (Boiral, 2009; Norton *et al*., 2015). Controlling for education and position allows for better isolation of the effects of the study's main variables (awareness, resilience, and technology) on green jobs/behaviors, reducing confounding biases linked to differences in human capital and discretionary power (Norton *et al*., 2015).

Figure 1 illustrates the analytical model and the hypotheses proposed in the study.

Figure 1
Proposed analysis model



Note. Own elaboration.

Materials and Methods

Study participants

The sample consisted of 302 workers (n = 302) residing in Spain, selected through voluntary non-probabilistic random (convenience) sampling. Potential respondents were invited to participate through online outreach, professional social media, and institutional contacts, and access was provided via a link to the questionnaire. Participation was anonymous and voluntary, and before starting the survey, an informed consent form was presented explaining the study's objective, the academic nature of the research, and the aggregated use of the data. The inclusion criteria were: (a) being of legal age, (b) being employed at the time of response, and (c) completing the questionnaire in its entirety; as exclusion criteria, incomplete or duplicate records, or those from participants who did not meet the above criteria, were discarded. Data collection was conducted via an online survey between November 2024 and May 2025, following a cross-sectional design.

Instruments and Measures

To measure the constructs, items were taken and adapted from instruments previously used in the literature, distinguishing between established psychometric scales and empirical operationalizations. Specifically, resilience was measured using an abbreviated version of the CD-RISC scale (Connor and Davidson, 2003), which has been extensively validated in previous studies. Technology acceptance was operationalized using items from Weiss *et al*. (2016), adapted to the organizational context of this study. The constructs of green jobs and green skills were measured using items derived from previous work on the green transition and the sustainable labor market (Martínez-Fernández *et al*., 2010; Renfors, 2024), adapted for individual surveys.

The final questionnaire consisted of 53 items. Of these, 16 items corresponded to the main constructs analyzed in the model (technology acceptance: 4 items; resilience: 4 items; green jobs: 4 items; green skills: 4 items), while the rest were allocated to control variables, job characteristics, and sociodemographic data. All items were translated and adapted into Spanish, following a semantic adaptation procedure and evaluated using seven-point Likert scales (1 = strongly disagree; 7 = strongly agree). A pilot test was conducted with 30 employees to assess the clarity, comprehensibility, and cultural appropriateness of the items, with minor wording adjustments made prior to the final data collection.

Data Analysis

The objective of the research was to model the relationship between environmental awareness and green jobs, incorporating two key theoretical extensions: (a) the association between resilience and green awareness, and (b) the mediating effect of technology on the link between environmental awareness and green jobs. Additionally, controls were held for educational level and job position. For this purpose, PLS-SEM with SmartPLS was adopted, following the recommendations of Hair *et al*. (2011), for the following reasons: (1) The main interest is to explain and predict the presence (or intensity) of green jobs based on green consciousness, considering resilience as an antecedent and technology as an explanatory mechanism (mediation). PLS-SEM maximizes the explained variance of the endogenous constructs. (2) PLS-SEM is appropriate for a sample size of 302 subjects and for variables measured on ordinal scales (Likert-type).

Given these methodological criteria, PLS-SEM with SmartPLS aligns with the explanatory nature of the study, accommodates mediation and formative specifications, and provides modern diagnostic tools to support robust conclusions on how resilience fosters green awareness and how technology mediates its translation into green jobs.

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Results and discussion

Sample characteristics

The study was based on 302 participants and featured a business structure dominated by medium and large organizations: 43.0% come from companies with more than 99 employees and 39.8% from firms with 10–99 employees, while only 17.2% work in microenterprises (1–9 employees). By sector, Services (60.9%) predominated over Industry (39.1%). In terms of human capital, the sample is highly qualified: 59.5% hold a university degree, 35.5% have a high school diploma or vocational training, and 5.0% have a primary or secondary education. By job category, employees predominate (56.6%), followed by middle managers (23.5%) and executives (17.9%) (see Table 1).

The composition of the sample—which is dominated by medium- and large-sized organizations, features a greater presence of the service sector, and reflects a high level of education—is appropriate and consistent with the study's objective, as these are environments where sustainability is typically more institutionalized in the form of policies, procedures, and management tools, thereby increasing the likelihood, observing the translation of green awareness into pro-environmental practices and behaviors.

Likewise, the higher educational level facilitates the understanding of environmental initiatives and messages, reducing biases due to a lack of environmental literacy and allowing for a more precise evaluation of the individual mechanisms analyzed.

This configuration does not invalidate the findings but rather delimits their scope: the results are particularly informative for organizations with greater capacity to implement sustainability practices and constitute a relevant basis for future replication in microenterprises or sectors with a lower degree of environmental formalization.

Table 1

Study Participants

Variables	**N**	**%**
Company size		
1 to 9 employees	52	17.2
10 to 99 employees	120	39.8
99+ employees	130	43.0
Sector		
Industrial	118	39.1
Services	184	60.9
Level of education		
Primary and secondary education	15	5.0
High school or vocational training	108	35.5
Bachelor's degree	179	59.5
Job category		
Executive	54	17.9
Middle management	71	23.5
Clerk	177	56.6
N	302	100

Note. Own elaboration.

Measurement Model

The first step in evaluating the measurement model was to analyze the reliability and validity of the indicators. As shown in Table 2, the composite reliability indicates an adequate level of internal consistency for most constructs. Next, convergent validity and discriminant validity are examined.

Table 2

Measurement model results

Construct	VIF	Factor loading	Cronbach's α	FC	AVE
Technology acceptance			0.821	0.823	0.651
Trust in new technologies	1.871	0,.929			
Readiness for new technologies	1.815	0.805			
Increased efficiency through technology	1.472	0.777			
Ease of use of technologies	1.882	0.816			
Environmental awareness			0.702	0.703	0.501
Integration of environmental legislation	1.384	0.708			
Reduction in consumption	1.815	0.702			
Innovative use of resources	1.349	0.738			
I understand the concept of "greenwashing"	1.146	0.701			
Green jobs			0.797	0.799	0.624
Opportunity for stable/sustainable employment	1.728	0.796			
Valuation of green companies	1.606	0.791			
Promotion of economic development	2.142	0.863			
Career opportunities	1.368	0.704			
Resilience			0.703	0.710	0.616
The emotionally strong person	1.506	0.783			
* The person who adapts to change	-	0.564			
The person is optimistic	1.318	0.819			
The person who handles unexpected events	1.323	0.750			

Note. VIF: Variance inflation factor, CR: Composite reliability, AVE: Average variance extracted. * The item has a low factor loading and was therefore removed.

Convergent validity was assessed in Table 3 following Fornell and Larcker (1981), such that the average variance extracted (AVE) values must be > 0.50 (Table 2). Multicollinearity was also verified: all variance inflation factors (VIF) were < 3.3, a threshold commonly accepted as indicative of the absence of problematic collinearity.

AVE was used for both convergent validity (Table 2) and discriminant validity (Table 3). The square root of the AVE (on the diagonal) was calculated and verified to be greater than the correlations between paired constructs. Additionally, the heterotrait-monotrait ratio (HTMT) was used in Table 3 to confirm discriminant validity; none of the values exceeded 0.90, thus meeting this criterion (Henseler *et al*., 2015).

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Table 3

Results of the measurement model. Discriminant validity

Fornell-Larcker criterion							Heterotrait-monotrait ratio (HTMT)					
	AT	**EA**	**GJ**	**Re**	**LE**	**EC**	**AT**	**EA**	**GJ**	**Re**	**LE**	**EC**
AT	0.807						AT					
EA	0.272	0.685					CV	0.370				
GJ	0.382	0.642	0.790				EV	0.471	0.853			
Re	0.509	0.374	0.281	0.785			Re	0.664	0.539	0.371		
LE	0.218	-0.282	-0.161	0.,008	1.000		Ne	0.242	0.363	0.180	0.049	
EC	0.139	-0.225	-0.215	0.048	0.363	1.000	Cl	0.151	0.320	0.138	0.053	0.326

Note. TA: Technology Acceptance, EA: Environment Awareness, GJ: Green Jobs, Re: Resilience, LE: Level of Education, CL: Employment Category.

Structural model

Table 4 presents the main parameters of the two models in the study related to structural evaluation.

Table 4

Structural model results

Relationships	Model 1			Model 2			Supports
	$R^2GJ=0.421$			$R^2EA=0.139$; $R^2AT=0.118$; $R^2GJ=0.464$			
	Trajectory coefficients	t-value	Confidence interval	Trajectory coefficients	t-value	Confidence interval	
H1: EA'GJ	0.636***	16.308	0.575; 0.702	0.438***	8.053	0.436, 0.644	Sí
H2: Re'EA				0.474***	7.078	0.291; 0.467	Sí
EA'AT = a				0.372***	5.540	0.179; 0.377	
AT'GJ = b				0.257***	4.629	0.171; 0.353	
Control variables							
LE	0.049	0.966	-0.050; 0.148	-0.021	0.426	-0.119; 0.077	
EC	-0.092	1.751	-0.195; 0.011	-0.122**	2.315	-0.227; -0.022	

Note. TA: Technology Acceptance, EA: Environment Awareness, GJ: Green Jobs, Re: Resilience, LE: Level of Education, CL: Employment Category.

Model 1 shows the total effect of green awareness on green jobs, which was significant (c = 0.636***). Model 2, which includes the mediating variable, shows how the effect of environmental awareness on green jobs decreases, although it remains significant when technology acceptance is included (c' = 0.438***). Therefore, H1 is supported, indicating that there is a positive and statistically significant relationship between green consciousness and green jobs.

Furthermore, in the same Table 4 (in Model 2), a statistically significant effect can be observed between resilience and green consciousness (0.474***), which allows for the testing of H2, which states that resilience is significantly and positively related to green consciousness. To test H3, it was verified that paths a (0.372***) and b (0.257***) were statistically significant (see

Table 4). Thus, the apparent decrease in the direct effect and the magnitude of the regression coefficients for a and b indicated the potential indirect effect of green consciousness on green jobs, with technology acceptance as the mediating variable (H3).

To confirm Hypothesis 3, the indirect effect was evaluated. The results show partial mediation by technology acceptance in the relationship between green consciousness and green jobs, as the direct effect remained significant, albeit with a smaller magnitude, while the indirect effect (H3) was also significant (0.070**) (see Table 5). Likewise, the variance explained by mediation (VAM) was calculated, which determines the size of the indirect effect (a × b) relative to the total effect (c). When the VAF exceeds 20% (in this case, VAF = 28.66%; see Table 5), partial mediation is considered to exist (Hair *et al*., 2014).

Table 5

Structural model results, mediation effects

Total effect on GJ (Model 1)					Direct effect on GJ (Model 2)					Indirect effect on GJ (Model 2)						
		BCCI					BCCI					BCCI				
Relationship	Path	t	Lower	Upper	Hypothesis	Path	t	Lower	Upper	Hypothesis	Estimated point	t	Lower	Upper	Sig.	VAF
GJ	c= 0.636***	16.308	0.558	0.689	H2	c′ = 0.438***	8.053	0.442	0.620	H3	0.070**	2.765	0.035	0.116	Yes	28.66 %
Control variables																
LE	0.002	0.040	-0.052	0.145		-0.058	1.142	-0.115	0.080							
EC	-0.067	1.480	-0.193	0.011		-0.037	0.780	-0.223	-0.016							

Note. GJ: Green jobs, LE: Level of Education level, EC: Employment category, BCCI: Bias-corrected confidence interval. VAF: Variance accounted for. Sig.: Significance.

Among the control variables, level of education (-0.037) was not significant; conversely, occupational category (-0.122**) was significant. Therefore, as one moves from “Executive” to “Middle Management” and “Employee,” the value of the dependent (or latent) variable decreases.

In terms of explained variance, Model 1 shows moderate-to-high explanatory power for green jobs (R^2 Green Jobs (GJ) = 0.421). By incorporating technological acceptance as a mediator (Model 2), the explained variance in green jobs increases to $R^2GJ = 0.464$, suggesting that the technological mechanism adds incremental explanatory power. Likewise, resilience explains a portion of environmental awareness (R^2 Environmental Awareness (EA) = 0.139) and environmental awareness explains technology acceptance (R^2 Technology Acceptance (TA) = 0.118), indicating that the model captures a chain of psychological and instrumental effects. In terms of magnitudes, the total effect of environmental awareness on green jobs is high (c = 0.636), and it decreases when mediation is introduced (c′ = 0.438), remaining significant, which is consistent with partial mediation. The indirect effect (EA’TA’GJ) is significant (0.070) and accounts for approximately 28.66% of the total effect (VAF), supporting the notion that technology acceptance acts as a relevant, though not exclusive, “bridge” for translating green awareness into green performance.

Discussion of Results

H1. Environmental awareness and its relationship with green jobs/behaviors

The first hypothesis posited a relationship between environmental awareness and green jobs (or behaviors). The results indicate that em-

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ployees' environmental awareness is positively and significantly associated with the performance of green jobs/behaviors. This pattern is consistent with established motivational frameworks, such as the Theory of Planned Behavior and the Value–Belief–Norm model, according to which personal attitudes and norms, when the individual perceives control and moral congruence, translate into intention and action (Ajzen, 1991; Bamberg and Möser, 2007).

From an organizational perspective, environmental awareness increases the priority of ecological goals and the alignment of values with sustainable routines, which facilitates both a preference for tasks with environmental content and the pro-environmental reconfiguration of the job (Norton *et al*., 2015; Boiral, 2009). The existing literature supports this link: published meta-analyses and employee-level empirical studies have documented positive relationships between green attitudes and values and pro-environmental behaviors at work, including environmental citizenship and eco-initiatives, which in turn contribute to "greening" everyday activities (Paillé *et al*., 2014; Katz *et al*., 2022). In line with this, the results of the present study support H1.

H2. Resilience and its relationship with environmental awareness

The second hypothesis proposed a relationship between resilience and employee environmental awareness. The results support this: greater resilience is associated with higher levels of environmental awareness. Resilience provides psychological resources, such as self-efficacy, hope, and optimism, which foster greater attentional breadth and a more active exploration of the environment, as predicted by resource conservation theory and the theory of expansion and construction (Hobfoll, 1989; Fredrickson, 2001).

In contexts of environmental change, such as the adoption of new routines or clean technologies, resilient individuals tend to reinterpret demands as manageable challenges and show a greater willingness to learn about impacts and solutions, which can reinforce their environmental awareness. Previous evidence supports this relationship: studies on psychological capital, including published meta-analyses, have identified consistent associations between these resources and desirable attitudes and behaviors at work (Avey *et al.*, 2011). In line with this, the findings of the present study support H2.

H3. Technological acceptance as a mediator

The third hypothesis proposed a mediating effect of technology acceptance between environmental awareness and green jobs/behaviors. Significant mediation suggests that technology acceptance acts as a hinge that helps transform environmental awareness into operational outcomes.

In line with the *Technology Acceptance Model* (TAM) and the *Unified Theory of Acceptance and Use of Technology* (UTAUT), perceived usefulness and ease of use condition intention and, ultimately, the actual use of technology (Davis, 1989; Venkatesh *et al*., 2003). When applied to the field of sustainability, technologies and information systems geared toward environmental goals can reduce implementation friction and provide timely feedback, facilitating the translation of attitudes into pro-environmental behaviors. Thus, recent evidence suggests that technology can act as an intermediary mechanism between awareness and practice by expanding the repertoire of green actions that individuals perceive as feasible and executable (An *et al*., 2022). Taken together, these arguments are consistent with the observed results and support H3.

Alternative Explanations and Conceptual Tensions

Although the results are consistent with the proposed framework, there are alternative interpretations. First, the directionality between technological acceptance and green performance could be partially inverse or bidirectional: employees more exposed to digital tools or green practices might develop greater acceptance through familiarity or use, or both could depend on unobserved organizational resources and priorities. Second, given the conceptual proximity between an active pro-environmental orientation and the willingness to adopt instrumental improvements, part of the association between environmental awareness and technological acceptance could reflect an underlying factor, such as a focus on innovation or continuous improvement. Finally, the negative effect of job category suggests that the "opportunity to act" (autonomy, discretion, access to tools) may condition the translation of attitudes into behavior, which opens the door to testing moderators and alternative models in future studies.

Control variables (educational level and occupational category)

Regarding control variables, job category showed a significant and negative effect. This pattern can be interpreted as an effect of opportunities for action: as one moves down the hierarchy, the discretion to modify processes, reallocate resources, or prioritize environmental goals tends to decrease; in the absence of formal levers, pro-environmental attitudes may be less likely to translate into observable behavior. However, the association could also be capturing unobserved organizational conditions, such as the degree of environmental institutionalization, access to training and tools, supervisor support, or the sustainability climate of the department, which vary systematically by category and condition the actual capacity for action. Therefore, the effect suggests less of an "automatic" hierarchical gradient and more of a combination of autonomy, resources, and context that enables or restricts the execution of green behaviors (Boiral, 2009; Norton *et al*., 2015).

For its part, educational level did not show significant effects in line with previous literature, and is interpreted primarily as a model adjustment variable, associated with differences in environmental literacy and the ability to process complex information.

Contributions to the Literature

This study integrates frameworks of pro-environmental behavior and technology acceptance by demonstrating that the acceptance of green technologies acts as a mechanism that helps convert environmental awareness into green behaviors and jobs, providing an explanation for the gap between attitudes and behavior (Kollmuss and Agyeman, 2002; Davis, 1989; Venkatesh *et al*., 2003). Furthermore, it situates environmental awareness within psychosocial resources by demonstrating the facilitating role of resilience, consistent with Resource Conservation Theory and the resource expansion and construction approach (Hobfoll, 1989; Fredrickson, 2001; Avey *et al*., 2011).

Implications for management

The findings suggest three levers directly linked to the estimated model: (1) developing and channeling environmental awareness toward specific tasks and routines, including clear objectives and practices, and operational communication of environmental goals; (2) strengthening resilience resources that facilitate openness to learning and persistence in the face of demands for change; and (3) increasing the acceptance and effective use of sustainability-oriented technologies through training, support, and user-centered design (Davis, 1989; Venkatesh *et al*., 2003). In this way, these actions help ensure that pro-environmental attitudes translate into daily practice.

Conclusions

The results show that environmental awareness drives the performance of green jobs and behaviors, and that resilience fosters the development of such awareness. Furthermore, technological acceptance acts as a key bridge for transforming pro-environmental attitudes into concrete actions. Therefore, organizations should promote ecological values, resilience, and user-oriented training/technologies to accelerate an effective sustainable transition.

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From a management perspective, these results suggest treating sustainability as a matter of daily implementation, not just strategic formulation. To achieve this, action should be taken on three complementary ways: (1) clarifying what "green work" means in each role through operational objectives, simple indicators, and observable routines; (2) strengthen personal resources, such as resilience, that sustain persistence when cost, time, or workload pressures arise; and (3) provide tools and systems geared toward environmental goals that reduce friction, facilitate information sharing, and reinforce habits, such as decision guides, consumption tracking, or reminders of best practices. In this way, these actions increase the likelihood that environmental awareness will translate into verifiable and sustained performance.

This study has limitations that open up opportunities for further research. First, the cross-sectional design and the use of self-reports at a single point in time limit causal inference and increase the risk of common method bias and social desirability bias; to mitigate this, anonymous and voluntary participation was ensured, it was indicated that there were no right or wrong answers, and the academic purpose was emphasized; furthermore, the VIFs (also used as a diagnostic for collinearity) do not suggest that common method bias substantially distorts the estimates. Nevertheless, the results should be interpreted as associations consistent with the theoretical framework; therefore, future research should employ longitudinal designs or interventions, for example, training in green technologies or resilience programs, and multiple data sources (supervisors/peers, tool usage logs, objective impact metrics) and incorporate additional tests for common method bias, such as (i) a theoretically unrelated marker variable and (ii) the assessment of the prevalence of a single factor in exploratory analyses. Second, although robust errors were applied, endogeneity was not comprehensively addressed; future studies could use instruments or quasi-experimental designs to strengthen internal validity. Third, replication is warranted with additional tests of measurement validity (invariance) and with alternative models where appropriate. Finally, generalizability may depend on the context; future replications should be expanded to multisectoral and multilevel samples and incorporate contextual conditions not measured here (support/environmental justice, psychological safety, leadership) that could trigger the translation of attitudes into behavior.

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Statement on the use of artificial intelligence

The authors **DECLARE** that, in the preparation of the article titled: "Green Consciousness, Resilience, and Technology: Strategic Keys to Promoting Green Jobs in the Workplace," Artificial Intelligence (AI) was not used at any stage of the process.

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Micromobility App adoption in Chile: Extended TAM and Collaborative Consumption

Adopción de aplicaciones de micromovilidad en Chile: TAM y Consumo Colaborativo

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Abstract: sustainable consumption has become an essential aspect of business, raising awareness of environmental care so that future generations can enjoy it. This study examines the factors that influence users' intention to use sustainable micromobility applications (bikes and e-scooters) in Chile, integrating the Technology Acceptance Model (TAM) with collaborative consumption perspectives. The proposed model deepens the understanding of consumer behavior in the adoption of mobile applications by integrating insights from collaborative consumption and the Technology Acceptance Model (TAM), thereby offering meaningful contributions to the existing literature on sustainable mobility and digital platforms. Based on data from 168 users in Chile and using a covariance-based structural equation model (CB-SEM), this study finds that perceived usefulness and enjoyment play the most important roles in influencing the intention to adopt sustainable transportation. This provides valuable insights into consumer preferences and behavior in Chile, which may be beneficial to mobile application companies already established or seeking to expand in the country. Moreover, the study offers implications for policymakers concerned with transportation planning, environmental sustainability, and the development of smart cities in emerging economies. In addition, this study presents several limitations and outlines avenues for future research aimed at deepening the analysis of sustainable transportation adoption in different socio-economic and technological contexts.

Keywords: consumption, motivation, technology acceptance model, sustainability, sustainable mobility.

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Resumen: el consumo sostenible se ha convertido en un aspecto esencial de los negocios, con el objetivo de crear conciencia sobre el cuidado del medio ambiente para que las generaciones futuras puedan disfrutarlo. Este estudio examina los factores que influencian la intención de uso de aplicaciones de micromovilidad (bicicletas y scooters) en Chile, integrando el modelo de aceptación de tecnología (TAM) considerando la perspectiva del consumo colaborativo. El modelo propuesto profundiza en la comprensión del comportamiento del consumidor en la adopción de aplicaciones móviles, integrando aportes del consumo colaborativo y del Modelo de Aceptación Tecnológica (TAM), ofreciendo así contribuciones relevantes a la literatura sobre movilidad sostenible y plataformas digitales. Con base en datos de 168 usuarios en Chile y utilizando un modelo de ecuaciones estructurales basado en covarianza (CB-SEM), los hallazgos de este estudio destacan que la utilidad percibida y el disfrute desempeñan los roles más importantes en la influencia de la intención de adoptar un transporte sostenible. Esto proporciona valiosas perspectivas sobre las preferencias y el comportamiento del consumidor en Chile, lo cual puede resultar beneficioso tanto para las empresas de aplicaciones móviles ya instaladas como para aquellas que buscan expandirse en el país. Asimismo, el estudio ofrece implicancias para los responsables de políticas públicas vinculadas a la planificación del transporte, la sostenibilidad ambiental y el desarrollo de ciudades inteligentes en economías emergentes. Finalmente, el estudio presenta diversas limitaciones y propone líneas de investigación futura orientadas a profundizar el análisis de la adopción del transporte sostenible en distintos contextos socioeconómicos y tecnológicos.

Palabras clave: consumo, motivación, modelo de aceptación tecnológica, sostenibilidad, transporte sostenible.

Introduction

The pursuit of alternative transportation methods is crucial to advancing cleaner, smarter cities. Acknowledging transportation options is therefore essential. The planet is currently facing a climate crisis driven by global warming, stemming from the overexploitation of natural resources and greenhouse gas (GHG) emissions from various sectors, including transportation.

The transportation sector is one of the major contributors to global carbon emissions and, therefore, to environmental pollution, which underscores the urgent need for collaborative approaches to reduce emissions (Siriwardana & Nong, 2021). The bigger the cities, the greater their contribution to carbon emissions and energy consumption, and the greater the opportunity to contribute through sustainable mobility, which requires infrastructural, technological, and behavioral changes (Winkler *et al.*, 2023).

In Chile, the most recent National GHG Inventory report indicates that the land transportation sector accounts for 24.1% of the country's total GHG emissions, equivalent to 37 million tons of CO2 (Ministerio del Medio Ambiente, 2023). Considering the concentration of people in its capital city, Santiago, with about 20 million inhabitants, it is important to consider different paths to reduce its carbon emissions. Beyond investment in green hydrogen and the promotion of electric vehicles, technology plays an essential role in the transition to sustainability. In this context, mobile applications have facilitated the use of sustainable transport.

Awareness of this situation has motivated the country to take action. In Chile, platforms such as Bike Itaú, Lime, and Grin have registered a remarkable boom. Lime, for example, reached 1 million trips in just 9 months, doubling that figure in the following 6 months, according to national media reports. Zhu *et al*. (2023) and Coppola and Lobo (2022) noted that micromobility (such as bike-sharing and scooter-sharing) is crucial for sustainable development and for reducing urban environmental impacts, especially in mitigating car dependence. Collaborative consumption represents a significant paradigm shift emphasizing access over ownership. This phenomenon, enabled by digital platforms, extends across various sectors, including sustainable transportation (Anthony Jr., 2023; Suryawan *et al.*, 2026; Karami *et al.*, 2025), leaving some effects, such as growing user interest in more flexible, economical, clean, and efficient transportation options, underscores the importance of understanding the drivers behind their adoption.

Although academic studies analyze consumers' reasons for using sustainable transportation applications (Pamidimukkala *et al.*, 2025; Karami *et al.*, 2025; Çallı & Çallı 2024; Suryawan *et al.*, 2026; Razali *et al.*, 2021; Wu 2019), research in emerging economies, particularly in Latin America, remains limited (as in Llanos *et al.*, 2023). In this sense, Santiago de Chile presents itself as an ideal context for this study, being recognized as the city with the highest sustainability and quality of life scores in the region (IESE Business School, 2022), and as the epicenter of the main sustainable transportation mobile apps. The expansion of Intelligent Transporta-

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tion Systems is recognized globally as a revolutionary force aimed at improving network efficiency, safety, and environmental friendliness, and their components contribute to the sustainable smart cities (Elassy *et al*., 2024).

This research contributes to the management and economics conversation on sustainable business models and digital transformation in urban mobility. Specifically, it examines technology adoption in platform-mediated services through an extended Technology Acceptance Model (TAM) and a collaborative consumption (sharing economy) perspective, using evidence from Chile as an emerging market. In doing so, the study offers insights for both platform strategy and public management aimed at accelerating sustainable mobility transitions.

The study advances prior research by moving beyond a single-theory explanation of micromobility adoption. We propose and test an integrated framework that combines TAM beliefs with collaborative consumption mechanisms and enabling conditions, thereby capturing both perceived value and the practical feasibility of use. By validating this framework in Chile, the article extends the boundary conditions of micromobility adoption research and offers a basis for comparative studies in other emerging economies.

Therefore, this study seeks to identify the determinants/drivers of intention to use sustainable transport mobile applications in an emerging economy. In particular, it aims to explore the factors influencing Chilean consumers' intention to use mobile applications for sustainable transport, specifically electric bicycles and scooters.

Using a quantitative methodology based on a covariance-based structural equation model (CB-SEM) and elements of the Technology Acceptance Model (TAM), data collected from 168 users were analyzed using a convenience sample. This methodological approach, widely recognized for its simplicity and theoretical robustness, allows for the explanation of technological adoption across various contexts and environments (Palos *et al*., 2019), as observed in Wu (2019).

The results of this study demonstrate the relevance of Perceived Usefulness and Enjoyment in the Intention to Use sustainable transportation technologies. These findings aim to contribute to the collaborative consumption literature by examining mobile application use in emerging Latin American countries. Additionally, they offer practical implications for sustainable transportation companies in Chile, helping them better understand their market and make more informed strategic decisions. Furthermore, these insights are valuable to policymakers aiming to promote the use of bicycles and electric scooters as part of a vision for more sustainable, smarter cities.

This document is organized as follows: first, the literature review; second, the theoretical framework and development of the hypotheses; third, the research methodology; fourth, the analysis of results; and finally, the discussion and conclusions.

Literature Review: Sustainable Development in Cities

The rapid pace of urbanization is one of the main factors driving increased energy consumption, which, in turn, increases transport demand, leads to biodiversity loss, and makes it more challenging to achieve sustainable development (United Nations, 2018). According to the United Nations (2018), 55% of people worldwide live in cities, and this figure is projected to increase to 13% by 2050, posing a challenge.

The concept of eco-city or smart city was coined in 1975 by Richard Register, who defines it as "a city balanced with nature" (Roseland, 1997). Based on this idea, several authors have defined this concept (Bibri, 2020; Camero & Alba, 2019; Brilhante & Klaas, 2018; Saad *et al*., 2017; Jabareen, 2006; Khan, 2006; Roseland, 1997). From this perspective, the priorities of urban ecology include promoting public transportation, walking, and cycling; social justice; local agriculture; recycling; ecological education; and environmental awareness, while simultaneously discouraging private vehicle use, pollution, and waste generation (Wang, 2018).

According to Camero and Alba (2019), smart city initiatives are classified into six key dimensions:

- **Smart Economy:** Focuses on productivity, labor market flexibility, innovation, and entrepreneurship.
- **Smart Environment:** Aims at environmental protection, pollution reduction, and sustainable resource management.
- **Smart Governance:** Encourages transparent government, citizen participation in decision-making, access to information, and inclusive political strategies.
- **Smart Living:** Ensures access to public services, quality housing, cultural and educational institutions, while improving lifestyles and providing a safe, attractive urban environment for citizens.
- **Smart Mobility:** Advocates for transportation systems, information and communication technology (ICT) infrastructure, and accessible, innovative, sustainable, and safe transportation systems.
- **Smart People:** Emphasizes citizen engagement, creativity, and innovation to build an intelligent city.

Also, in exploring this transition, global research highlights that city-level sustainability is heavily influenced by local psychological and regulatory environments. For example, in countries as Irán, a densely populated urban center, Karami *et al.* (2025) investigated the adoption of shared e-scooters by examining the impact of personality traits. Their results indicate that trust and social influence are the strongest predictors of usage intention, while personality traits like "openness to experience" positively impact adoption and "neuroticism" acts as a barrier. Similarly, in Indonesia, a megacity facing extreme traffic congestion, Suryawan *et al.* (2026) studied e-scooter adoption from a consumer perspective. Utilizing probit and logit regression models, they found that income is the most significant predictor; contrary to trends in developed nations, lower-income groups in Jakarta show a much higher inclination toward e-scooters as a cost-effective alternative to traditional transit.

Furthermore, the role of policy in urban sustainability was examined in United States, in Pamidimukkala *et al*. (2025) applied an extended Theory of Planned Behavior (TPB) to evaluate the adoption of electric vehicles. Their findings reveal that while positive attitudes and moral norms drive intention, monetary incentives (such as tax credits) are the primary catalyst for the consumer shift toward green technology, whereas non-monetary incentives often fail due to bureaucratic friction. These studies underscore that sustainable development is not a one-size-fits-all technological shift but an alignment of individual traits, socioeconomics, and government incentives tailored to specific urban contexts.

This highlights that the creation of smart cities is primarily concentrated in these regions and remains limited in Latin America, which, according to IESE (2022), has the highest urban concentration on the planet.

Sustainable transportation in Chile

The sustainable transport applications currently operating in Chile are Lime, Grin, Bike Itaú, and Uber, the latter offering the Lime scooter and bicycle service on its platform. Lime is an American transportation rental company that arrived in Santiago de Chile in November 2018. In just 15 months, it achieved 2 million trips, making Chile the first country in Latin America to reach this milestone. The Lime app lets you rent electric bicycles or scooters by the trip, with a $500 unlock fee and $160 per minute of use. In addition, it offers flat rates that let you buy travel passes to save money, as well as the option to sign up for Lime Prime, a monthly subscription service with additional benefits.

Since February 2021, Lime electric scooters and bicycles have been available for rent through the Uber application in the Las Condes commune. This option is in the application's main menu, under the name "Two Wheels." The rental prices are similar to those in the Lime app (Uber Newsroom, 2021).

For its part, Grin is a Mexican electric scooter rental company that arrived in Chile in January 2019 (Diario Sustentable, 2019). It currently op-

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erates in Santiago and Viña del Mar, where its rates are $350 for unlocking, $225 per minute of use, or $500 for unlocking for 10 minutes, with an additional $175 per minute.

The Bike Itaú app, operated by the Brazilian company Tembici, arrived in Santiago in 2013 (Sachs *et al*., 2024). Today, the city has 2,500 electric bicycles and 190 stations. The app offers three service plans: daily, monthly, and annual, with costs of $1,990 for up to 60 minutes for 24 hours; $3,990 for up to 120 minutes for one month, and $31,990 for up to 120 minutes for one year.

Literature review: collaborative consumption and shared micromobility

Collaborative consumption describes market arrangements where access temporarily replaces ownership, usually mediated by digital platforms that reduce transaction costs. In urban mobility, this logic underpins bike-sharing and e-scooter services, where platforms coordinate fleet availability, pricing, and payments, enabling trips that can complement public transport and reduce private car dependence (Coppola & Lobo, 2022; Zhu *et al.*, 2023).

Prior evidence suggests that shared micromobility adoption depends not only on functional value (cost, time, convenience) but also on symbolic and experiential value, including enjoyment and lifestyle. For example, studies on bike-sharing highlight that platforms can materialize sustainable collaborative consumption by combining digital affordances with physical infrastructure, which shape perceived value and continued use (Da Silveira *et al*., 2021).

Evidence from emerging markets remains scarce, despite the rapid diffusion of platform-mediated services. Research in Latin America shows that collaborative consumption adoption is sensitive to contextual factors such as economic uncertainty, trust, and infrastructure conditions, which can amplify or constrain the value of platform offerings (Llanos *et al.*, 2023). This gap is especially relevant for micromobility apps because their success depends on both user perceptions and enabling conditions (e.g., safety, bike lanes, parking rules, service reliability).

Building on this literature, our study positions micromobility apps as a form of sustainable collaborative consumption and integrates a technology-adoption lens (extended TAM) with enabling conditions to explain intention to use in Chile. This helps connect platform strategy questions with public management questions and provides a basis for comparison with other emerging economies.

Theoretical framework and hypothesis development

In previous research on the use of micromobility via mobile applications, the most widely used model has been the Technology Acceptance Model (TAM). Proposed by Davis (1985), this model analyzes people's acceptance of new technologies, focusing on two primary constructs that affect intention to use: perceived ease of use and perceived usefulness (King & He, 2006). The TAM provides a solid basis for assessing the impact of external variables on the intention to use a system, highlighting perceived ease of use and perceived usefulness as key factors for analyzing ICT adoption (Legris *et al*., 2003).

Since its creation, the TAM has been tested and extended across multiple investigations, consolidating its status as one of the most effective models for predicting the use of information systems. According to Legris *et al*. (2003), this model has proven capable of explaining approximately 40% of the variation in the use of information systems, thanks to its simplicity, adaptability, and theoretical robustness. These characteristics have made the TAM the most widely employed technology acceptance model today (Palos *et al*., 2019).

From a consumer behavior perspective, we focus on adoption-related motivations captured through TAM constructs (e.g., perceived usefulness, enjoyment, ease of use) and enabling conditions. In this study, "motivation" is therefore treated as a set of belief-based drivers of technology adoption, consistent with established

TAM extensions. Prior studies have extended TAM by incorporating motivation-related constructs (e.g., intrinsic enjoyment and extrinsic usefulness) to explain intention to use in mobility contexts (e.g., Wu *et al*., 2019). Extending the core TAM constructs is essential for shared mobility studies (Akel & Bayir, 2025).

The motivation model defines intrinsic motivation as performing an activity for the simple pleasure of doing it, without external reward expectations. In contrast, extrinsic motivation refers to performing an activity to obtain a valuable or tangible result (Davis *et al*., 1992). According to the authors, to adequately analyze intention to use, it is crucial to consider the effects of intrinsic motivations, which are influenced by factors such as self-efficacy, perceived competence, and self-determination. These aspects are derived from self-determination theory, which holds that these feelings are key determinants of intrinsic motivation (Davis *et al*., 1992).

The measurement constructs considered in the TAM and the main hypotheses of this study are presented below.

Perceived usefulness

Perceived usefulness is one of the primary constructs of the TAM and represents users' extrinsic motivation. According to Davis (1985), subjective perceptions indicate that using a system will improve a user's performance on a specific task, such as renting bicycles or scooters via mobile applications.

In the context of sustainable transportation, perceived usefulness manifests itself in various aspects. Wu *et al*. (2019) note that, for shared bicycles, users value benefits such as their positive environmental impact, cost savings, speed, and their contribution to a healthy lifestyle. On the other hand, electric scooters offer advantages such as time savings, overcoming the limitations of public transport, and their environmentally friendly nature, as they reduce fuel use and prevent pollution (Razali *et al*., 2021).

The analysis of perceived usefulness is crucial because, as Wu *et al*. (2019) highlight, when users perceive that a system meets their expectations, they consider it useful, which significantly influences their intention to use it. In this model, the perceived benefits of sustainable transport serve as key motivators for users to adopt it. Based on the above, the following hypothesis is proposed:

H1. Perceived usefulness has a direct positive effect on the intention to use sustainable transportation applications.

Enjoyment

Enjoyment represents a significant emotional dimension that influences users' intrinsic motivations. In the case of sustainable transportation applications, enjoyment plays an essential role, as it is not linked to obtaining an external reward, as with perceived usefulness, but rather to the pleasure inherent in the activity itself.

According to Wu *et al*. (2019), shared transportation options like bicycles and electric scooters cater to various motivations, with relaxation and enjoyment being particularly significant. These modes of transport not only serve as functional alternatives for commuting but also offer recreational experiences. For instance, Zhang *et al*. (2015) emphasize that tourists are drawn to using bicycles to explore cities, as it enables them to take in the scenery in greater detail and enjoy the surrounding environment.

The enjoyment derived from using sustainable transportation applications can stem from recreational rides alone or with friends, as well as from tourist experiences. In this sense, when users experience pleasure when using these systems, their intention to use them increases.

Since we decided to focus our research on young users (Generation Z), it is essential to recognize that Attitude toward responsible consumption positively influences responsible consumption habits and purchasing behavior. This attitude highlights that the decision to use sustainable transport apps may be deeply rooted in broader pro-environmental and ethical beliefs, linking intrinsic motivations (Enjoyment) to actual purchasing behavior (Cristancho-Triana *et al*., 2024).

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Based on this relationship, the following hypothesis is proposed:

H2. Enjoyment has a direct positive effect on the intention to use sustainable transportation applications.

Perceived ease of use

Perceived ease of use is one of the central variables in TAM. This concept refers to the degree to which a user perceives that using a system does not require significant effort (Davis *et al*., 1989), or, more specifically, to the perception that a system facilitates the development of an activity by requiring less effort (Venkatesh *et al*., 2003). According to several studies, the easier a system is to use, the greater the probability that people will adopt it, since simplicity reduces psychological and operational barriers. Given the above, the following hypothesis is presented:

H3. Perceived ease of use has a direct positive effect on the intention to use sustainable transportation applications.

In addition to the direct impact on intention to use, perceived ease of use also has an indirect effect, mediated by perceived usefulness and enjoyment (Wu *et al*., 2019).

When users perceive that a system, such as a sustainable transportation application, is easy to use and requires little effort, their perceived usefulness increases. In contrast, if the system is complex and challenging to manage, the intention to use it decreases significantly. Ease of use also influences enjoyment, as a simple, smooth experience enhances the positive emotions associated with using the system. In this context, if users find applications intuitive and accessible, their enjoyment increases, encouraging recurrent use. Therefore, the following hypotheses are generated:

H4. Perceived ease of use has a direct positive effect on enjoyment.
H5. Perceived ease of use has a direct positive effect on perceived usefulness.

Enabling conditions

Facilitating conditions refer to external factors that simplify and support the use of a system by the user (Venkatesh *et al*., 2003). In this context, these factors are focused on the environment that facilitates the use of sustainable transport applications, either through public infrastructure such as special lanes for bicycle and scooter use, parking lots, technological support provided by operators, such as the operating system and stable service of the application (Wu *et al*., 2019).

According to Wu *et al*. (2019), facilitating conditions do not directly influence intention to use, but affect perceived usefulness, enjoyment, and perceived ease of use.

Akel and Bayır (2025) found that Perceived Values (including Green Value) significantly affect Perceived Ease of Use and Perceived Usefulness in car-sharing adoption. They also included Privacy Concern (PC) as a key factor influencing Intention to Use. While our study primarily focused on Perceived Usefulness and Enjoyment, future research on Chilean micro-mobility adoption should examine how Green Value and PC influence intention, given the inherent data sensitivity of these app-based services.

The presence of enabling conditions, such as adequate infrastructure and reliable technological services, facilitates system use, reducing users' effort and increasing perceived ease of use. On the other hand, facilitating conditions also affect perceived usefulness. A well-designed infrastructure and efficient technical support increase the perceived benefits of the system. However, inadequate conditions may decrease the user's perception of usefulness. Given this, the following hypothesis is proposed:

H6. Facilitating conditions positively affect perceived ease of use.

H7. Facilitating conditions positively affect perceived usefulness.

Facilitating conditions also influence users' enjoyment. When these are favorable, such as having access to secure infrastructure and reliable technological services, the user experience becomes more pleasant, which motivates users to use the system regularly; on the other hand, if the enabling conditions are not favorable, they can negatively affect enjoyment and intention to use. On the other hand, although the direct impact of facilitating conditions on intention to use is limited, they influence intention to use indirectly by improving ease of use, perceived usefulness, and enjoyment. When users perceive a favorable environment, their willingness to adopt the system increases considerably.

Given the above, the following hypothesis is put forward:

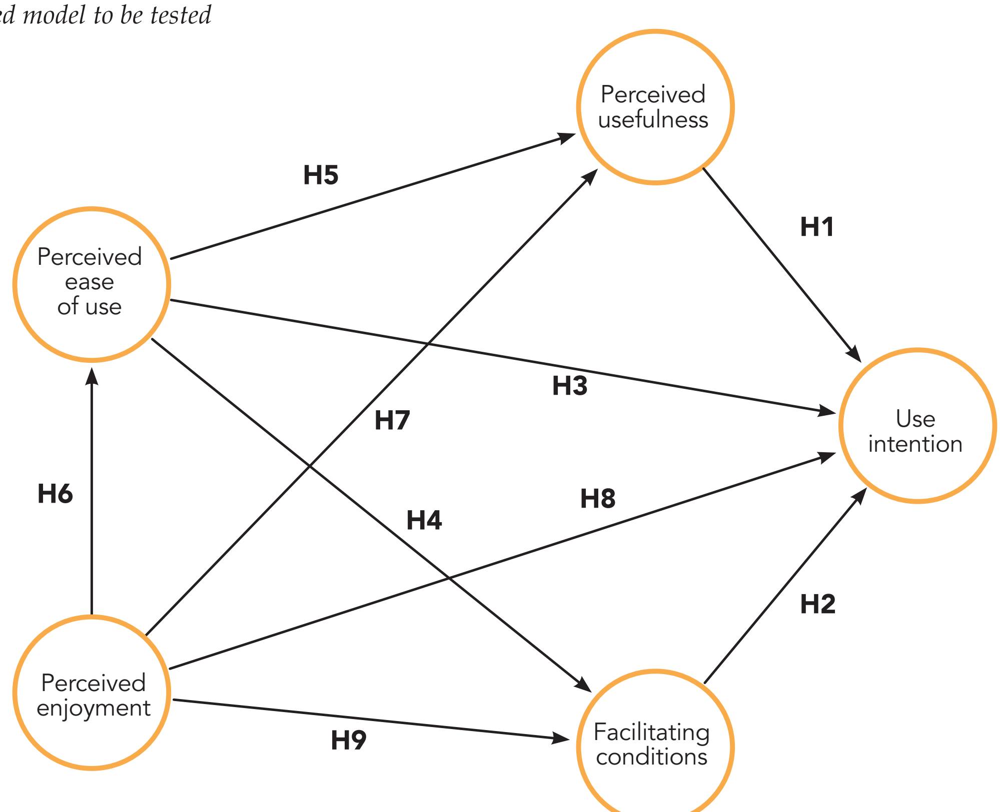
H8: Facilitating conditions positively influence the intention to use sustainable transportation applications.

H9: Facilitating conditions positively influence the perceived enjoyment.

Figure 1 represents the theoretical model for testing.

Figure 1

Proposed model to be tested



Note. Created by the authors based on the study's constructs.

Materials and Methods

The aim of this study is to examine the determinants of Chilean consumers' intention to use sustainable micromobility applications (bikes and e-scooters), integrating an extended Technology Acceptance Model (TAM), collaborative consumption factors, and enabling conditions.

This study employs a quantitative methodology, analyzing data collected through a survey instrument using SmartPLS software, which facilitates structural equation modeling (CB-SEM). SmartPLS offers a user-friendly interface

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and advanced reporting capabilities (Kwong, 2013), making it an effective tool for evaluating construct relationships (De Souza & Da Silva, 2019). This will be done using the experiences of previous studies on TAM items and the determination of factors affecting intention to use (Ozmen, 2023; Karami *et al*., 2025).

Instrument: Survey

The survey instrument was built from previously validated scales commonly used in technology adoption research (TAM-based measures and related extensions). It was developed based on the authors Davis *et al*. (1989), Davis *et al*. (1992), Thompson *et al*. (1991), and Ashraf *et al*. (2014), from which the scales for the respective constructs used to measure the intention to use sustainable bicycle and/or scooter transport were obtained. The questionnaire consisted of two parts. First, the study participants were asked for sociodemographic information such as age, occupation, income range, applications they use to get around, and reasons for using those applications; and second, they were asked about constructs that could explain the drivers for using sustainable transport. In the first section, the questions were multiple-choice. In contrast, in the second section, the questions used a 5-point Likert scale: 1 = totally disagree, 2 = disagree, 3 = neither agree nor disagree, 4 = agree, and 5 = totally agree. The details are presented in Table 2.

The instrument was prepared in Spanish since the potential respondents were native Spanish speakers. Therefore, the instrument was prepared based on the authors mentioned above, translated into Spanish, validated by experts in the marketing field, and five pilot tests were conducted to evaluate the consistency of the questions. The questionnaire was then ready to be used.

Sample

Data were collected in Chile using a non-probabilistic sampling approach, targeting adult users with familiarity or experience with app-based micromobility services (bikes and e-scooters). The questionnaire was administered online, participation was voluntary and anonymous, and responses were collected anonymously. At the beginning of the survey, respondents were informed of the study's academic purpose and provided consent to participate. To ensure data quality, incomplete responses were removed, and additional screening criteria were applied (e.g., eliminating duplicate entries and responses with evident lack of engagement, such as straight-lining patterns or unrealistically short completion times).

A total of 172 responses were obtained, of which only 168 were used because their answers were consistent across all items in the instrument. The participants were people aged 18 or older, primarily students and employees, who indicated that they mainly used the service to reach their educational centers or workplaces, though at different frequencies. The potential participants had to be located in the capital of the Latin American country, Santiago, since that is where the main mobile applications for sustainable transport are concentrated: bicycles and scooters.

Data collection was conducted by the research team using a non-probabilistic approach. First, potential participants were invited through social networks (e.g., posts and direct messages) to reach adults who were familiar with app-based micromobility services. Second, to complement online recruitment and increase access to active users, in-person invitations were carried out in two high-traffic areas of Santiago where micromobility use is concentrated: the surroundings of Costanera Center (the largest shopping center in Chile) and the El Golf neighborhood in the Las Condes district. In both recruitment modes, respondents accessed the same online questionnaire via a survey link/QR code and participated voluntarily and anonymously.

After data collection, the database was reviewed, and missing responses were removed, leaving N=168 respondents. Table 1 below provides details of the participants in this study.

Table 1

Study Survey Sample

Respondents		Total	%
Gender	Female	80	46,51
	Male	89	51,74
	I would rather not say	1	0,58
	No answer	2	1,16
Age	18-22	27	15,70
	22-28	71	41,28
	28-34	36	20,93
	34-40	14	8,14
	40-46	12	6,98
	46-52	6	3,49
	52-58	3	1,74
	58-64	2	1,16
	64-70	1	0,58
Occupation	Student	57	33,14
	Employee	86	50,00
	Self-employed	22	12,79
	Others	7	4,07
Revenue*	Less than 500	45	26,16
	Between $500 and $1,000	51	29,65
	Between $1,000 and $1,500	28	16,28
	Between $1,500 and $2,000	13	7,56
	Between $2,000 and $2,500	14	8,14
	Others	21	12,21
Reasons	Healthy lifestyle	49	28,49
	Affordable	57	33,14
	Eco-friendly	30	17,44
	Other	36	20,93
Applications	Lime	55	31,98
	Uber	52	30,23
	Bike Itaú	47	27,33
	Grin	18	10,47
Frequency	Every day	14	8,14
	3 to 5 times a week	29	16,86
	1 to 3 times a week	35	20,35
	Occasionally	94	54,65

* Values in thousands of Chilean pesos.

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Table 2

Measurement scales for the study constructs

Constructs	Items	Source
Perceived Usefulness (PU)	Using sustainable transportation apps allows you to reach your destination faster.	Davis *et al.* (1989)
	Using sustainable transportation apps saves time.	
	Using sustainable transportation apps increases travel efficiency.	
	Using sustainable transportation apps makes traveling easier.	
	Using sustainable transportation apps is very useful for traveling.	
Enjoyment (ENJ)	Using sustainable transportation apps is pleasant.	Davis *et al.* (1992)
	Using sustainable transportation apps is enjoyable.	
	Using sustainable transportation apps is fun.	
Perceived Ease of Use (PEOU)	Sustainable transportation apps are clear.	Davis *et al.* (1989)
	Sustainable transportation apps are understandable.	
	It will be easy to become proficient with sustainable transportation apps.	
	Sustainable transportation apps are easy to handle.	
	Sustainable transportation apps are easy to use.	
	Sustainable transportation apps are convenient.	
Facilitating Conditions (FC)	Bike lanes are available for you when using sustainable transportation apps.	Thompson *et al.* (1991)
	Sustainable transportation apps let you leave the vehicle on the street when you are finished using them.	
	Technical services for the apps are available to you when using sustainable transportation apps.	
	Usage instructions for the transportation app are provided within the sustainable transportation app.	
	Support for the sustainable transportation app is available if you have any difficulties.	
Intention to use (INT)	You predict that you will use sustainable transportation apps for your short-distance trips in the future.	Ashraf *et al.* (2014)
	You plan to use sustainable transportation apps for your short-distance trips in the future.	
	You intend to use sustainable transportation apps in the future if they are available.	

Note. Prepared by the author based on various sources.

Results and discussion

Before testing the proposed model, rigorous evaluations are conducted to assess the reliability and validity of the constructs. These use metrics such as Cronbach's Alpha and Average Variance Extracted (AVE). All constructs reach values over 0.8 for Cronbach's Alpha and values over 0.5 for AVE, indicating reliability. This is detailed in Table 3. Then, the discriminant validity of the constructs is assessed using the Heterotrait-Monotrait Ratio and the

Fornell-Larcker Criterion. For the latter, diagonal values are larger than other values in their row and column, which shows validity. Tables 4 and 5 present these values. The constructs meet the established criteria for conventional reliability and validity.

Table 3

Reliability and Validity of the Constructs

	Cronbach's alpha (standardized)	Cronbach's alpha (unstandardized)	Composite reliability (rho_c)	Average variance extracted (AVE)
Facilitating Conditions	0.808	0.808	0.817	0.596
Enjoyment	0.842	0.842	0.853	0.656
Perceived Ease of Use	0.921	0.92	0.921	0.749
Intention to use	0.877	0.877	0.886	0.717
Perceived Usefulness	0.868	0.867	0.866	0.622

Table 4

Discriminant validity: heterotraits-monotraits ratio

	Facilitating Conditions		Perceived Ease of Use	Intention to use	Perceived Usefulness
Facilitating Conditions					
Enjoyment	0.549				
Perceived Ease of Use	0.661	0.585			
Intention to use	0.511	0.621	0.586		
Perceived Usefulness	0.520	0.516	0.602	0.574	

Table 5

Discriminant validity: Fornell-Larcker criterion

	Facilitating Conditions	Enjoyment	Perceived Ease of Use	Intention to use	Perceived Usefulness
Facilitating Conditions	0,772				
Enjoyment	0,542	0,810			
Perceived Ease of Use	0,600	0,559	0,865		
Intention to use	0,496	0,531	0,530	0,847	
Perceived Usefulness	0,524	0,387	0,597	0,531	0,788

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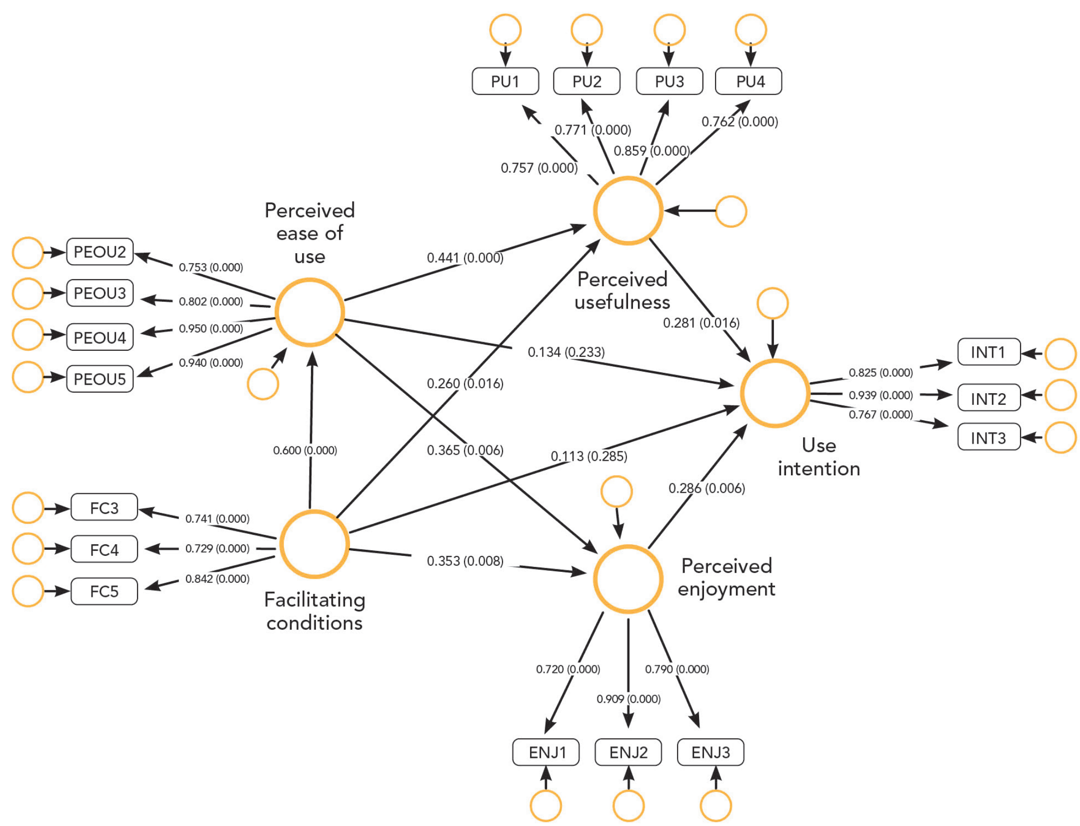
The result of the proposed model is presented in Figure 2.

The chi-square for the basic model was 614.626 (df = 43: $p < 0.001$) and some relevant indices for the analysis were CFI = 0.923, TLI = 0.905, NFI = 0.908, all above the cut-off point of 0.9 (Hair *et al*., 2010) and RMSEA = 0.091, a value slightly above the conventional indicator (Hair *et al*., 2010).

The above model suggests a positive and significant relationship ($p < 0.001$) between the constructs and the hypothesized relationships.

Table 6 shows the estimated parameters, the significance levels, and whether the results support the hypotheses. Overall, seven of the nine hypotheses were supported. Perceived usefulness (H1) and enjoyment (H2) were significant direct drivers of intention to use, reinforcing that users adopt micromobility apps when they perceive both instrumental benefits (time/efficiency) and hedonic value (fun/pleasant experience) in the service (Wu *et al*., 2019; Rejali *et al.*, 2021). Perceived ease of use did not show a significant direct effect on intention (H3), but it did increase both usefulness (H5) and enjoyment (H4), indicating an indirect pathway consistent with TAM extensions in mobility contexts.

Figure 2
Model Results



Facilitating conditions were strongly related to perceived ease of use (H6) and also contributed to usefulness (H7) and enjoyment (H9). However, their direct effect on intention (H8) was not significant, suggesting that infrastructure and service support primarily operate as 'enablers' that improve the user experience rather than as independent motivators.

This study investigated the drivers/determinants of intention to use sustainable transportation applications, incorporating elements of the TAM model. The results validate the measurement model, demonstrating that the constructs exhibit strong reliability and validity, ensuring that the items effectively capture the intended dimensions.

The analysis reveals that the intention to use construct is significantly influenced by other factors, with at least 80.04% of respondents expressing willingness to use such applications. Among these factors, perceived ease of use has the most substantial impact on intention to use. Additionally, enjoyment plays a critical role in shaping user behavior toward sustainable transportation applications. It not only affects the intention to use but is also valued by 80.43% of respondents, highlighting its importance in enhancing user engagement and adoption. After analyzing each construct, support was found for the proposed hypotheses.

While perceived usefulness and enjoyment were the strongest predictors of intention in the Chilean context, other studies examining car-sharing reveal that perceived values (functional, social, green) and privacy concern are also critical predictors of behavioral intention. Future research should measure these dimensions (e.g., green value and privacy concern) in the context of micro-mobility to gain a more holistic understanding of user motivations beyond standard TAM predictors (Akel & Bayir, 2025). On the other hand, Llanos *et al*. (2023) indicate that enjoyment plays a significant role in shaping Uber consumers' behavioral intentions.

Regarding the constructs of the TAM model, except the Facilitating Conditions construct, the option with the highest percentage is 5 (totally agree), where the constructs with the highest percentage are Enjoyment (52.13%) and Intention to Use (52.13%), which shows that the vast majority of people enjoy using sustainable transport applications and intend to use them. The following constructs have the highest percentages: Perceived Usefulness (40.12%) and Perceived Ease of Use (40.81%), indicating that people find sustainable transport applications helpful and easy to use. Finally, for the Facilitating Conditions construct, the percentage corresponding to option 5 is 23.64%, but the highest percentages for this construct are for option 4 (28.49%) and option 3 (27.91%).

Our finding that facilitating conditions show mixed agreement and a less direct impact on intention to use highlights the existing infrastructure gaps in emerging markets. This contrasts with the imperative for intelligent transportation system development in smart cities globally, where real-time data from sensors and cameras, along with communication systems like 5G, are essential for traffic management and enhancing safety. Effective intelligent transportation system integration is key to achieving significant sustainability benefits, such as reducing travel time and greenhouse gas emissions, as demonstrated in cities like Los Angeles, United States, and Barcelona, Spain (Elassy *et al*., 2024).

Regarding Perceived Usefulness, on the one hand, question 1, "Using sustainable transport applications allows you to get to your destination faster," is the one with which people agree the most, with 42.44%. On the other hand, question 3, "Using sustainable transport applications increases the efficiency of trips," has the lowest percentage for the option "Totally agree," at 37.79%.

For the construct of Enjoyment, on the one hand, question 3, "Using sustainable transport applications is fun," is the one with which people agree the most, at 56.40%. On the other hand, question 2, "Using sustainable transport applications is pleasurable," has the lowest percentage for the "Totally agree" option at 47.09%.

The positive adoption rates observed in Santiago, driven by utility and enjoyment, support the literature emphasizing that mobility solutions enabled by ICT can encourage a modal diversion away from private vehicles. Policymakers should leverage these findings to design systems that improve accessibility and overcome persistent car-dependency habits (Coppola & Lobo, 2022).

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Table 6

Hypotheses, Parameters, and Significances

	Original sample (O)	Sample mean (M)	Standard deviation (STDEV)	T statistics (|O/STDEV|)	P values	H	Support Hypothesis
Perceived Usefulness→ Intention to use	0,319	0,320	0,136	2,337	0,020	1	Supported Supported
Enjoyment→ Intention to use	0,345	0,351	0,135	2,549	0,011	2	Supported
Perceived Ease of Use→ Intention to use	0,146	0,134	0,125	1,167	0,244	3	Not Supported
Perceived Ease of Use→ Enjoyment	0,329	0,324	0,130	2,528	0,012	4	Supported
Perceived Ease of Use→ Perceived Use-fulness	0,423	0,421	0,115	3,679	0,000	5	
Facilitating Conditions → Perceived Ease of Use	0,512	0,518	0,082	6,270	0,000	6	Supported
Facilitating Conditions→ Perceived Use-fulness	0,213	0,215	0,095	2,249	0,025	7	Supported
Facilitating Conditions→ Intention to use	0,105	0,113	0,105	0,998	0,319	8	Not Support-ed
Facilitating Conditions→ Enjoyment	0,248	0,258	0,105	2,353	0,019	9	Supported

The strong influence of enjoyment and perceived usefulness supports the premise that digital platforms effectively provide the required features and benefits (nonhuman actors) to realize sustainable collaborative consumption. As shown in bike-sharing case studies, digital platforms and physical infrastructure mediate connections and inducements that stimulate alternative mobility through health, sustainability, and cost-effectiveness (Da Silveira *et al*., 2021).

In the Perceived Ease of Use construct, on the one hand, question 3, "It would be easy for you to become proficient in sustainable transport applications," is the one with which people agree the most, at 50.00%. On the other hand, question 2, on whether "Sustainable transport applications are understandable," had the lowest percentage for the "Totally agree" option at 31.98%.

In the Facilitating Conditions construct, question 4, "Instructions on the use of transport are offered in the sustainable transport application," is the one with which people agree the most, at 31.40%. On the other hand, question 3, "The technical services of the applications are available to you when you use sustainable transport applications," has the lowest percentage in the "Totally agree" option at 18.60%.

In the construct Intention to Use, on the one hand, question 3, regarding whether "The person predicts using sustainable transport applications in the future if available," is the one with which people agree the most, with 58.72%. On the other hand, question 1, which asks whether "The person predicts that they will use sustainable transport applications in the future on short-distance trips," has the lowest percentage for the "Totally agree" option at 47.67%.

From a collaborative consumption perspective, these results align with the idea that digital platforms and physical urban systems jointly 'materialize' access-based mobility. When platform interfaces are intuitive and cities reduce friction (lanes, parking rules, safety), users experience the service as both useful and enjoyable, reinforcing sustainable collaborative consumption outcomes (Da Silveira *et al.,* 2021). This may be particularly important in emerging markets, where uncertainty and uneven infrastructure can otherwise constrain the perceived reliability and attractiveness of shared services (Llanos *et al.,* 2023).

Conclusions

This study contributes original evidence on micromobility app adoption by testing an integrated extended TAM–collaborative consumption framework with enabling conditions in Chile, an under-studied emerging-market context. Specifically, the article makes three contributions: (1) Extending the literature on TAM in sustainable transport contexts. By integrating key elements of the model that allow understanding of user behavior towards sustainable transport applications. These findings reinforce the relevance of constructs such as ease of use, perceived usefulness, and enjoyment in emerging markets, such as Latin America. (2) Contributing to sustainability and collaborative consumption by connecting collaborative consumption with sustainable practices and highlighting how transportation apps can support smarter cities and potentially reduce environmental impact. (3) Exploring enjoyment as a key factor in sustainable transport. This finding not only affects usage intention but also complements the functional usefulness of these applications, highlighting their impact on users' emotional engagement.

This study also offers practical implications for sustainable transport companies. The results offer valuable insights for sustainable transport companies to design and optimize applications that balance ease of use and user experience. This can help companies better engage their target market and encourage greater adoption of sustainable services.

Furthermore, the empirical evidence provided by this study not only helps understand the drivers/determinants of intention to use of sustainable transport but also serves as a tool for public policymakers to design targeted strategies, such as subsidies, adequate infrastructure, and awareness campaigns.

Given the environmental challenges associated with urban transport, app-based micromobility offers a promising approach to promoting low-emission travel alternatives for short-distance trips. The findings in this study show that the intention to use these services is shaped by Technology Acceptance Model (TAM) beliefs, including perceived usefulness, ease of use, and enjoyment, as well as by enabling conditions that support practical adoption.

In line with the study objective, the evidence indicates that the intention to use micromobility apps in Chile is best explained by a dual value logic: users seek practical performance gains (usefulness) while also valuing the experience (enjoyment). Strategically, this means that operators should treat the product as a service platform, not only a transport utility: UX design, gamified engagement, transparent pricing, and reliability initiatives can be as adoption-critical as fleet size or coverage.

For public management, the findings suggest a 'complementor' role for cities: enabling conditions improve perceptions that ultimately drive intention, even if they are not direct motivators. Policies that standardize parking, expand protected lanes, and improve safety communication can increase perceived ease of use, which then cascades into higher usefulness and enjoyment. Future research should extend this framework by incorporating perceived risk, trust, green value, and privacy concern as additional platform-relevant mechanisms, and by testing the model with larger, more diverse samples and longitudinal designs to connect intention to actual usage behavior (Akel & Bayir, 2025).

Also, this study is not without limitations. The sample size and composition, together with

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the reliance on self-reported data and a cross-sectional design, may affect the generalizability and precision of the findings. Moreover, important variables such as perceived risk, trust in the use of transportation applications, and concerns regarding information privacy were not included. Future research could incorporate larger and more diverse samples, longitudinal designs, and additional constructs to further advance the understanding of the determinants of actual use of sustainable transportation applications.

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Gonzalo Llanos-Herrera	Formal analysis, research, methodology, writing. Original draft, writing. Review and editing.

Statement on the use of artificial intelligence

The authors **DECLARE** that in the preparation of the article titled: "Adoption of micromobility applications in Chile: Extended TAM and collaborative consumption," Artificial Intelligence (AI) was used to assist in the preparation of the manuscript. The authors declare that they reviewed and validated the content and assume full responsibility for the final version of the article.

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Boycott reaction to greenwashing according to consumer profile: a survey in Brazil

Reacción de boicot al greenwashing según el perfil del consumidor: una encuesta en Brasil

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Abstract: not all responsible or sustainable organizational claims reflect genuine practices, but rather are characterized as greenwashing, a misleading communication strategy in which organizations exaggerate their environmental practices to improve their image in the market. With the current scenario of greenwashing proliferation, aggravated by the continued absence of effective regulatory mechanisms, the responsibility for regulating greenwashing practices is shifted to consumers. In this way, this study aimed to understand consumer reactions to the practice of greenwashing, particularly in terms of knowledge, judgment, and boycott motivation behavior, by investigating differences derived from consumer profiles. As a methodological procedure, a quantitative survey was conducted with a sample of 1,251 Brazilian consumers, performing a general descriptive analysis, followed by parametric analysis of variance (ANOVA). This made it possible to observe the high criticality of the sample in judging the practice of greenwashing, with a considerable self-declared predisposition in behavior motivating boycott. In addition, differences were identified in relation to all consumer profile variables in virtually all metrics investigated, such as gender, education, age, income, and professional management experience, with a greater reaction attributed to female consumers, those with high income and education, elder consumers, and also those with management experience. As a consequence, this study contributes to the understanding of consumer reactions to greenwashing based on their profiles.

Keywords: greenwashing, misleading, boycott, reaction, consumer, behavior, survey, Brazil.

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Resumen: no todas las afirmaciones responsables o sostenibles de las organizaciones reflejan prácticas genuinas, sino que se caracterizan por ser greenwashing, una estrategia de comunicación engañosa en la que las organizaciones exageran sus prácticas medioambientales para mejorar su imagen en el mercado. Con el panorama actual de proliferación del greenwashing, agravado por la continua ausencia de mecanismos reguladores eficaces, la responsabilidad de regular acaba recayendo en los consumidores. Este estudio tiene como objetivo comprender las reacciones de los consumidores ante el greenwashing, particularmente en términos de conocimiento, juicio y comportamiento de motivación al boicot, investigando las diferencias derivadas de los perfiles de los consumidores. Se realizó una encuesta con 1251 consumidores brasileños, realizando un análisis descriptivo general, seguido de la técnica de análisis paramétrico de varianza (ANOVA). Se observó la alta criticidad de la muestra en juzgar la práctica del greenwashing, con una predisposición autodeclarada en el comportamiento que motiva el boicot. Además, se identificaron diferencias en todas las variables del perfil de los consumidores en prácticamente todas las métricas investigadas, como el género, la educación, la edad, los ingresos y la experiencia profesional en gestión, con una mayor reacción atribuida a las consumidoras, a las personas con altos ingresos y educación, con más edad y con experiencia en gestión. Contribuye a una comprensión las reacciones.

Palabras clave: greenwashing, engañosa, boicot, reacción, consumidor, comportamiento, survey, Brasil.

Introduction

The growing discussion on economic models and their environmental impacts has consolidated concerns about environmental issues in society (Forliano *et al.,* 2025; Zhang; Dou, 2024). In this scenario, consumers have become more conscious of their consumption decisions, adapting their purchasing habits to minimize the environmental impact of their choices (Braga *et al.,* 2019; Martínez et al., 2020). Consequently, there is a growing demand for more sustainable, environmentally, and socially responsible organizational attitudes (Janz *et al*., 2024; Zhang; Dou, 2024).

However, not all organizational claims in this regard reflect genuine practices and can be characterized as greenwashing (Montgomery et al., 2023). Introduced in the 1980s, the term greenwashing quickly became established as a misleading communication strategy in which organizations exaggerate their environmental practices to improve their image in the market (Forliano *et al.,* 2025; Ibrahim Nnindini & Dankwah, 2024). The concept of greenwashing is broad, involving a variety of communication practices, which increases its occurrence and makes it difficult to define precisely and identify in practice (Nygaard & Silkoset, 2023; Ioannou *et al.,* 2023).

The relevant literature is unanimous in arguing that the current scenario of proliferation of greenwashing practices is alarming (Forliano *et al*., 2025; Montgomery et al., 2023; Wang et al., 2023). This is aggravated by the continued absence of effective regulatory mechanisms, which should monitor organizational actions to identify and, above all, punish such conduct (Kolcava, 2023; Andreoli *et al.,* 2025). As a result, the responsibility for regulating greenwashing practices is shifted to consumers, who are expected not only to be able to identify it, but more importantly, to react to it (Andreoli et al., 2025; Liu et al., 2023). This means that consumers, as the target audience, can question current organizational practices and demand changes towards a more environmentally friendly stance (Liu *et al*., 2023; Andreoli *et al.,* 2025).

Among the possible regulatory actions, the consumer boycott movement stands out, especially because of its anti-consumption character, with a direct negative impact on the target organization (Nguyen & Duong, 2025; Senan *et al*., 2025). In this sense, boycotts are understood as a form of protest, repudiation, and/or retaliation by consumers, who express this by refusing to buy and consume a particular product or brand (Nguyen & Duong, 2025; Senan et al., 2025). Despite this, a recent mapping of academic production shows that research on consumer boycotts of greenwashing practices remains scarce (Andreoli & Silva, 2024). Considering the above, this study aimed to understand consumer reactions to greenwashing, particularly in terms of knowledge, judgment, and boycott motivation behavior, and to investigate any differences derived from consumer profiles.

The study's rationale relates to the need for a better understanding of greenwashing practices in relation to consumers, the target audience and those most interested (Montgomery *et al.,* 2023), especially considering its possible regulatory role (Liu et al., 2023). Thus, this study addresses the theoretical gap in research on more critical consumer reactions to greenwashing (Nguyen & Duong, 2025; Senan *et al*., 2025),

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extending the understanding through a theoretical-empirical approach by considering possible differences according to the consumer's profile, with basic demographic variables.

The geographical scope of the study, Brazil, is justified by its relevance as one of the largest emerging economies and consumer markets, combined with increasing societal attention to environmental issues and sustainable consumption (Braga *et al.*, 2019). In addition, the proliferation of organizational environmental claims in contexts marked by institutional and regulatory challenges may intensify the risks and impacts of greenwashing practices (Kolcava, 2023; Montgomery et al., 2023). Previous Brazilian studies have indicated consumer sensitivity to misleading environmental communication (Andreoli & Negrais, 2023; Andreoli *et al*., 2025), reinforcing the importance of examining this phenomenon in a national context that remains underexplored in the international literature. In this sense, Brazil offers a relevant empirical setting to advance the understanding of consumer reactions to greenwashing in emerging markets.

Greenwashing and consumer boycotts

Not all socio-environmental claims made by organizations are necessarily true, a practice characterized as greenwashing, which has recently attracted the attention of both the literature and the market (Freitas Netto *et al.,* 2020; Santos *et al*., 2024). Greenwashing comprises the organizational practice of intentionally misleading consumers with false, empty, and/or ambiguous claims while managing public perceptions and shaping brand reputation (Braga *et al.,* 2019; Martínez *et al.,* 2020).

Identifying greenwashing by consumers is a significant challenge, as the practice tends to generate confusion and mistrust, making it difficult to distinguish between genuinely sustainable products and those that merely make misleading claims, especially given the multitude of ways in which this phenomenon can manifest (Freitas Netto *et al.,* 2020; Sajid *et al.,* 2024). However, when detected, this inconsistency between discourse and practice can generate negative repercussions for the organization, including consumer boycotts (Neureiter *et al.,* 2024; Tao, 2025).

A boycott is defined as the voluntary and intentional abstention of consumers from purchasing and/or consuming a product or brand as a form of retaliation or punishment against the organization in question (Kim *et al.,* 2022). Thus, it represents a conditional anti-consumption manifestation in which the consumer breaks off relations with the organization in response to unfavorable conduct or behavior considered inappropriate (Nguyen & Duong, 2025; Senan *et al.,* 2025). Generally, these movements stem from consumer dissatisfaction and are driven by a sense of moral outrage and a desire for change, in which it is believed that anti-consumption actions can influence an organization's behavior or mitigate its negative impacts (Zejjari & Benhayoun, 2025; Cummings *et al*., 2025). However, consumer boycott motivation behavior is complex and needs to be better understood, especially when related to the practice of greenwashing (Andreoli *et al.,* 2025; Nguyen & Duong, 2025; Senan *et al.,* 2025). This reinforces the need to deepen our understanding of consumer behavior according to variables in their profiles, such as gender expression, education, income, age, and professional experience.

First, in general, women are generally considered more sensitive to environmental changes and more willing to accept higher prices for products that do not cause environmental damage (Kreczmańska-Gigol & Gigol, 2022). More specifically, female consumers are more skeptical of greenwashing than men, as shown in a survey of university students and professors predominantly residing in Germany, Pakistan, and Indonesia, conducted by Farooq and Wicaksono (2021). According to the authors, this result supports previous studies from different fields, which relate the female gender, first, to greater environmental concern, and second, to a lower belief in institutions.

Previous studies have analyzed the relationship between gender and the propensity to boycott, although not specifically linked to greenwashing practice. They defend that women show greater motivation to boycott, with a greater propensity for adherence and engagement (Klein *et al.*, 2004; Barda & Sardianou, 2010; Mata *et al.*, 2023; Kim *et al.*, 2023; Park & Jang, 2024). Complementarily, Li *et al*. (2025) emphasized that women have a strong sense of ethics and social responsibility, which may discourage them from engaging with organizations that practice greenwashing, and they prefer to favor more reasonable, legally compliant, and mutually beneficial business relationships.

Greater female involvement may be related to historical and social factors, such as the gender roles traditionally assigned to women, which position them as more collectivist, caring, and empathetic (Cruz et al., 2013). Consequently, and linked to a more holistic view, women show greater environmental concerns (Farooq & Wicaksono, 2021). Furthermore, historically, the responsibility for managing family life has been delegated to women, reinforcing peer care (Barda & Sardianou, 2010). As a result, this condition has also placed them at the forefront of domestic consumption, causing them to make purchasing decisions (Barda & Sardianou, 2010). This includes the pre-purchase stage of researching and mapping options, which may have made them more attentive to corporate communications focused on socio-environmental claims (Barda & Sardianou, 2010). Consistent with this, women report lower trust in institutions and their socio-environmental claims, possibly because of their greater critical thinking skills (Farooq & Wicaksono, 2021). This may favor greater sensitivity to practices perceived as deceptive, such as greenwashing, as well as stimulate more incisive reactions, such as boycotts, which are derived from greater engagement.

Therefore, the first hypothesis relates to the expectation of greater criticality in judging the practice of greenwashing and greater boycott motivation behavior among female consumers, as explained below.

H1- Female consumers account for (a) greater knowledge about greenwashing and related topics, (b) greater criticality in judging the practice, and (c) greater boycott motivation.

Second, education is another variable of interest. More broadly, Schmuck et al. (2018) found that environmental knowledge was positively and significantly correlated with formal education, suggesting that more educated individuals tend to have greater access to socio-environmental information. Complementarily, Witek and Kuźniar (2020) highlighted that the level of education is generally associated with greater knowledge of issues of environmental degradation and threats to the environment, which favors conscious purchasing behavior and prioritizes ecological products.

Furthermore, Gopal and Pisharady (2024) observed that consumers with higher levels of education tend to be more aware and skeptical of the practice, focusing on the cosmetics industry. Nguyen et al. (2019) also found that knowledge influences the ability to identify and differentiate greenwashing practices, which negatively affects green purchase intentions. Gardberg and Newburry (2013) argued that education provides access to information and knowledge about social and corporate issues, which can contribute to empowering individuals to try to change adverse conditions such as greenwashing, encouraging adherence to boycott movements.

Thus, the level of education is also related to the propensity to boycott, which defends the representativeness of consumers with higher levels of education (Mata *et al.*, 2023; Park & Jang, 2024). Mata et al. (2023) explored the profile of European consumers who participate in boycotts for political, ethical, or ecological reasons, based on data from the 2022 European Social Survey, finding a tendency for greater participation by consumers with higher levels of education, as well as females. This had already been argued by Gardberg and Newburry (2013), who found a significant association between higher education and boycotts related to environmental issues. Park and Jang (2024) found similar results in relation to education when investigating motivations for participating in a tourist boycott promoted in South Korea against Japan due to political and historical tensions.

This argument is supported by the fact that higher levels of education expand participants'

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general knowledge and enhance their ability to interpret complex social issues (Mata et al., 2023). As a result, it is attributed not only to ease of access to information, but also to more skilled processing, contributing to a greater critical sense (Mata et al., 2023). Higher education also influences sustainable purchasing behavior and the willingness to pay more for products that do not cause environmental harm (Kreczmańska-Gigol & Gigol, 2022). This makes education a key variable in predicting participation in critical consumption practices, such as boycotts (Mata *et al*., 2023; Park & Jang, 2024). More educated consumers tend to be more aware and skeptical of practices such as greenwashing (Gopal & Pisharady, 2024), which may encourage them to adopt protest behaviors, such as boycotting, when they perceive corporate practices to be misleading.

Based on this, in the second hypothesis, it is expected that consumers with higher education will have a more critical stance in judging greenwashing practices, accounting for greater boycott motivation behavior.

H2- Consumers with higher levels of education account for (a) greater knowledge of greenwashing and related topics, (b) greater criticality in judging the practice, and (c) greater boycott motivation behavior.

Third, income has also been the subject of research. Jog and Singhal (2024) found that income level has a significant impact on environmental awareness and sustainable purchasing behavior, showing that the higher the income level, the greater the environmental awareness, which, in turn, results in greater green purchasing behavior. Similarly, Kreczmańska-Gigol and Gigol (2022) found that financial status influences sustainable purchasing behavior, noting that people in better financial conditions accept higher prices for products that do not harm the environment.

Regarding greenwashing, income was the only variable in the consumer demographic profile that returned a significant relationship in the study by Van Kehnove and Biro (2016), which found that higher income levels were related to greater degrees of skepticism. It has also been argued that consumers with higher income levels are more likely to boycott (Park & Jang, 2024). Neilson (2010) conducted a study with a sample of 21,535 individuals, using data from the 2002/2003 European Social Survey (ESS), with the aim of analyzing boycotts in the context of political consumerism, finding a positive correlation between income and involvement in boycotts.

The main justification for consumers with greater purchasing power is the possibility of greater autonomy in purchasing decisions (Van Kenhove; Biro, 2016; Cruz *et al.,* 2013; Kreczmańska-Gigol; Gigol, 2022). Thus, these consumers have a greater capacity to adopt sustainable consumption patterns by purchasing ethical products or products that align with their ideals, even at higher costs (Kreczmańska-Gigol; Gigol, 2022). This makes the adoption of concerns and attitudes towards sustainable causes relatively easier, as well as favoring a more critical stance towards environmental claims (Kreczmańska-Gigol; Gigol, 2022; Jog; Singhal, 2024). In addition, greater purchasing power allows for flexibility in the purchasing decision-making process, including increasing the possibility of engaging in anti-consumption actions, especially when misleading environmental practices are perceived, making boycotting a viable alternative (Cruz *et al.,* 2013).

Given this, consumer income is expected to influence not only the level of criticality in judging greenwashing practices but also the motivation to boycott, comprising the third hypothesis of the study, presented below.

H3- Consumers with higher income levels account for (a) greater knowledge of greenwashing and related topics, (b) greater criticality in judging the practice, and (c) greater motivation to boycott.

Furthermore, regarding age, our fourth point, elder people demonstrated greater knowledge of environmental issues in general, as well as greater ecological awareness, both directed at themselves and at organizational attitudes (Boermans *et al*., 2024). A similar defense was found in relation to elder consumers' greater knowledge of green products (Witek & Kuźniar, 2020).

The study by Boermans *et al*. (2024) mentioned above, exposed the greater criticality of elder consumers in relation to organizational environmental practices, reporting tangible skepticism by this audience, both in terms of the credibility and authenticity of the actions promoted. However, there was no explicit mention of the term greenwashing. With direct mention, some studies worked with specific generational segments, mainly with the selection of younger audiences, as in the cases of the studies by Szabo and Webster (2020) and Bulut *et al*. (2021), which analyzed the influence of the perception of greenwashing on consumer behavior, the former with the delimitation of Generation Z and the latter with post-millennials.

Despite this, age has already been investigated in relation to boycott movements, and it has been argued that elder consumers are more willing to participate (Barda & Sardianou, 2010; Park & Jang, 2024). Barda and Sardianou (2010) analyzed Greek consumers during a period of high prices and, by observing which personal characteristics influenced participation in economic boycotts, found that age (in addition to gender) played a relevant role. This was corroborated more recently by Park and Jang (2024), who indicated that age influences the propensity to participate in boycotts, along with gender, education, and income.

This argument is justified by the maturity of the elder audience, resulting from greater life experience, with a wealth of information and experiences, including those related to the organizational sphere, which can help consolidate a more critical sense of the content. There is also the inference that elder consumers are possibly in a better personal and professional situation, which would allow them to take advantage of the benefits discussed in relation to their greater purchasing power (Gardberg & Newburry, 2013).

Thus, it is expected that age will be associated with more critical consumer judgment regarding greenwashing practices, as well as with boycott motivation behavior. This leads to the fourth hypothesis of this study, which is formulated as follows:

H4 - Elder consumers account for (a) greater knowledge about greenwashing and related topics, (b) greater criticality in judging the practice, and (c) greater boycott motivation.

Finally, no articles were found that specifically researched professional experience in relation to greenwashing, similar to age-related studies. The closest study to this was the consideration of the profession from a qualitative perspective in the study by Szabo and Webster (2020), who interviewed professionals who held management positions in green organizations to capture their perceptions of greenwashing in the context of their activities. The participants reported examples of greenwashing observed in other organizations and recognized its potential negative impact on consumer trust, brand loyalty, purchase intentions, and attitudes toward companies. Given this, they emphasized the importance of more authentic and transparent communication strategies, in addition to the use of third-party certifications as mechanisms to mitigate the perception of greenwashing and increase the credibility of environmental actions in the public's perception. These findings indicate a degree of criticality among these professionals in identifying misleading environmental practices, suggesting that individuals with management experience may be more critical of greenwashing.

Similarly, Andreoli and Negrais (2023) conducted a focus group with consumers to ascertain their opinions on greenwashing and marketing practices, noting greater scrutiny in reports of both identification and indignation at misleading communications. Other examples relate to the analysis of employees' perspectives on greenwashing, showing that the negative consequences of the practice are influenced by factors such as employees' personal and professional values and their level of knowledge about environmental issues and organizational practices (Miao *et al*., 2023; Robertson *et al*., 2023).

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There is no precedent in the literature on the relationship between management and boycott movements. Despite this, Gardberg and Newburry (2013) indirectly investigated the relationship between public marginalization and the propensity to support boycotts, discussing the possibility that the sample was composed of more established professionals closer to the corporate elite, but without directly investigating this relationship.

Nevertheless, the argument is that professional management experience allows for a better understanding of the organizational environment, with a deeper understanding of internal processes, including marketing and communication skills. This competence contributes to a more refined critical sense of the reality of organizations, enabling them to identify inconsistencies between promoted communications and actual environmental practices.

Thus, this professional profile is expected to be associated with both greater criticality in judgment and greater motivation to boycott brands that practice greenwashing, supporting the formulation of the following hypothesis, albeit exploratory:

H5–Consumers with management experience account for (a) greater knowledge of greenwashing and related topics, (b) greater criticality in judging the practice, and (c) greater motivation to boycott.

Materials and methods

This study was non-experimental, cross-sectional, with descriptive-comparative design. The methodological procedure was submitted for evaluation to the university's Ethics Committee, which approved it in 2025.

A quantitative survey was conducted with 1,251 Brazilian consumers selected for convenience sampling. Data collection was conducted remotely from July to October 2023. The collection link was widely publicized, being made available in various WhatsApp groups and on social networks, as well as relying on partnerships to boost its reach (researchers, students, teachers, digital influencers on related topics, and organizations related to them). The platform allowed only one response per device per participant. It should be noted that despite the high reach of the survey, the sample was not representative.

The research instrument consisted of four metrics of interest: judgment about the practice of greenwashing, a reverse scale used by Andreoli *et al.* (2025), with 13 statements; boycott motivation behavior, with an adaptation of the scale validated by Cruz et al. (2013), with seven statements; and knowledge about topics and terms related to greenwashing, with five statements. All these scales had random presentation of statements for each participant, who was asked to assign a score, with the first three being agreement on an 11-point Likert scale, anchored at 0=strongly disagree and 10=strongly agree, and the one on knowledge of performance.

Exploratory factor analyses were conducted for these metrics, ensuring that consistency assumptions were met ($n \geq 5$ for each variable; multivariate normality of data; significant Bartlett's sphericity test; MSA ≥ 0.5; communality ≥ 0.5). This allowed for a classification score of the subjects in the evaluated metric, complemented by Cronbach's alpha coefficient, to attest to the reliability and internal consistency. All metrics of interest comprised a single factor, with the following results: judgment of greenwashing practices, with 62% of the total variance explained (KMO=0.956 and α=0.948); boycott motivation behavior, with 62% (KMO=0.890 and α=0.892), and knowledge of related topics and terms, with 67% (KMO=0.806 and α=0.872).

Discriminant analysis was conducted to better understand the data structure and determine how the five sociodemographic variables behave in differentiating the groups for each of the three metrics of interest. Thus, the measurements of knowledge, judgment, and boycott were categorized into a dummy variable (below and above the overall average) and analyzed with the independent variables of gender, education, income, age, and management experience, reporting the Wilks' Lambda test.

Considering the normal distribution of data, parametric analysis of variance (ANOVA) was adopted to investigate possible differences according to the variables of the respondents' profile, namely gender expression, education, age, income, and professional management experience. To this end, some classifications were made, considering the composition of the sample: gender expression included cisgender female and cisgender male; education comprised postgraduate, higher education, and others; age was divided into quartiles (<28, 29-39, 40-49, and >50); income was also divided into quartiles (<R$3,000, R$3,001-6,000, R$6,001-10,000, and >R$10,001); and current professional management experience or not. Finally, correspondence analysis was conducted in a complementary manner, generating perceptual maps with the averages obtained from the metrics investigated according to consumer profile variables.

To mitigate the bias common to the method, considering the collection format (online, in which the independent and dependent variables were collected simultaneously), in addition to randomizing the presentation of the scale items to the participants, Harman's single factor test was also performed using non-rotated exploratory factor analysis. This analysis indicated a total explained variance close to 32%, below the critical limit of 50%, accepting that the data collection was free from the bias common to the method.

Results and discussion

The sample (n=1,251) consisted of a preponderance of respondents expressing cisgender female gender (66.5%, followed by male with 32.8%), with high levels of education—the vast majority with postgraduate degrees (49.9%) and higher education (41.9%)—and high income (average of R$ 8,928, SD=9,840), without current professional management experience (76.4%). The average age was 39 years (SD=13.48).

The discriminant analysis returned statistically significant importance for practically all five variables in differentiating the groups for the three metrics of interest. The only exception was gender expression related to knowledge. Thus, the results of the discriminant analysis validated the importance of sociodemographic variables in differentiating the groups for knowledge, judgment, and consumer behavior motivating the boycott of greenwashing.

Table 1

Results of the discriminant analysis

Knowledge	Judgment	Boycott
Gender F=1.799, p=0.180 Education F=20.604, p<0.000 Income F=8.726, p=0.003 Age F=4.740, p=0.030 Management experience F=9.186, p=0.003	Gender F=3.537, p=0.05 Education F=55,112, p<0.000 Income F=5.635, p=0.018 Age F=8.554, p=0.004 Management experience F=3.661, p=0.05	Gender F=5.832, p=0.016 Education F=19.253, p<0.000 Income F=6.211, p=0.013 Age F=32.433, p<0.000 Management experience F=3.571, p=0.05

In terms of knowledge of relevant topics and terms, all statements had averages above the midpoint (between 5.9 and 6.8), with respondents showing moderate knowledge (6.3) of aspects related to greenwashing practices, which may indicate a greater critical sense among the sample population. Four variables in the respondents' profiles showed statistically significant differences. First, education (F=21.676, p=0.001) showed that respondents with postgraduate degrees reported greater knowledge (M=6.70), followed by those with higher education (M=5.99), and then the other levels (M=5.35). Second, age (F=11.660,

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p<0.000), with younger respondents (M=5.78, SD=2.19) reporting less knowledge compared to all others (M=6.42, SD=2.09; M=6.23, SD=2.33; M=6.83, SD=2.02; respectively). Third, income (F=9.651, p<0.000) was significant, with the lowest income group (M=5.97, SD=2.02) reporting less knowledge than the two highest income groups (M=6.57, SD=2.06 and M=7.06, SD=2.05, respectively), the latter also differing from the second income stratum (M=6.35, SD=2.25). Finally, current professional management experience (F=37.187, p=0.001), in which manager participants stated that they knew more about the subjects (M=7.01) than non-managers did (M=6.08). Thus, these results validate four of the five hypotheses, failing to support the difference in relation to gender.

Regarding the judgment of greenwashing practices, all statements had an average below the midpoint (between 2.5 and 4.2), with a low average (3.4), which shows the significant self-declared criticality of respondents. Statistically significant differences were found according to the respondents' profiles, related to gender expression, education, age, income, and current professional management experience. First, in relation to gender expression (F=7.423, p=0.007), women declared themselves to be more critical (M=3.22, SD=2.07) than men (M=3.58, SD=2.05). Second, regarding education (F=33.93, p<0.000), respondents with postgraduate degrees were more critical (M=2.87, SD=1.89), followed by those with higher education (M=3.71, SD=2.11), and then those with other levels of education (M=4.38, SD=2.22). Third, in terms of age (F=7.215, p<0.000), with younger respondents (M=3.75, SD=2.07) returning lower criticality compared to all others (M=2.95, SD=2.07; M=3.27, SD=2.10; M=3.29, SD=1.94; respectively). Fourth, in terms of income (F=7.205, p<0.000), with the lower-income group (M=3.85, SD=2.24) responding with lower criticality compared to all others (M=3.17, SD=2.06; M=3.07, SD=1.97; M=3.12, SD=2.01; respectively). Finally, in terms of professional management experience (F=5.909, p=0.015), managers were more critical (M=3.15) than others (M=3.50).

More importantly, in terms of boycott motivation behavior, all statements had high averages (between 6.8 and 8), with a significant result (7.4), corroborating the high criticality discussed above, in this case, actually carried out in a real action, with a high self-declaration of predisposition to join the demonstration. Statistically significant differences were observed in all variables of the respondents' profiles, consistent with the results of the assessment of greenwashing practices. First, in relation to gender expression (F=9.340, p=0.002), women declared themselves more prone to boycott-motivated behavior (M=7.51, SD=2.09) than men (M=7.09, SD=2.26). Second, regarding education (F=10.156, p=0.001), respondents with postgraduate degrees were more likely (M=7.65, SD=2.07), followed by those with higher education (M=7.07, SD=2.24), and those with other levels (M=6.99, SD=2.25). Third, age (F=20.970, p<0.000), with younger respondents (M=6.65, SD=2.18) showing a lower propensity to boycott compared to all others (M=7.27, SD=2.30; M=7.65, SD=1.98; M=7.98, SD=1.99; respectively). Fourth, in terms of income (F=4.574, p=0.003), the lowest income group (M=7.02, SD=2.19) showed the lowest propensity compared to the second and highest strata (M=7.61, SD=2.16 and M=7.75, SD=2.10, respectively). Finally, regarding current professional management experience (F=9.227, p=0.002), managers were more likely to agree (M=7.71, SD=2.03) than non-managers (M=7.25, SD=2.21). Thus, all five hypotheses defined in this study were confirmed.

Table 2

Hypotheses and study results

H1- Women	H1b - Judgment $F = 7.423$, $p = 0.007$, $\eta^2 = 0.01$	Women (M = 3.22, SD = 2.07) < Men (M = 3.58, SD = 2.05)
	H1c - Boycott $F = 9.340$, $p = 0.002$, $\eta^2 = 0.01$	Women (M = 7.51, SD = 2.09) > Men (M = 7.09, SD = 2.26)
H2- Consumers with higher levels of education	H2a - Knowledge $F=21.676$, $p<0.000$, $\eta^2=0.04$	Graduate degree (M=6.70, SD=2.18) > Higher education (M=5.99, SD=2.12) > Others (M=5.35, SD=2.19)
	H2b - Judgment $F=33.93$, $p<0.000$, $\eta^2=0.06$	-- Graduate (M=2.87, SD=1.89) < Higher education (M=3.71, SD=2.11) < Others (M=4.38, SD=2.22)
	H2c - Boycott $F=10.156$, $p<0.001$, $\eta^2=0.02$	Graduate degree (M=7.65, SD=2.07) > Higher education (M=7.07, SD=2.24) and others (M=6.99, SD=2.25)
H3- Consumers with higher income levels	H3a - Awareness $F=9.651$, $p<0.000$, $\eta^2=0.04$	Lower income (M=5.97, SD=2.02) < the two highest income brackets (M=6.57, SD=2.06 and M=7.06, SD=2.05, respectively), the second income stratum (M=6.35, SD=2.25)
	H3b - Judgment $F=7.205$, $p<0.000$, $\eta^2=0.02$	Lowest income (M = 3.85, SD = 2.24) > all others (M = 3.17, SD = 2.06; M = 3.07, SD = 1.97; M = 3.12, SD = 2.01; respectively)
	H3c - Boycott $F=4.574$, $p=0.003$, $\eta^2=0.02$	Lower income (M=7.02, SD=2.19) < second stratum (M=7.61, SD=2.16) and highest income bracket (M=7.75, SD=2.10
H4- Elder consumers	H4a - Knowledge $F=11.660$, $p<0.000$, $\eta^2=0.03$	Younger consumers (M=5.78, SD=2.19) < all others (M=6.42, SD=2.09; M=6.23, SD=2.33; M=6.83, SD=2.02; respectively)
	H4b - Judgment $F=7.215$, $p<0.000$, $\eta^2=0.02$	Younger individuals (M=3.75, SD=2.07) > all others (M=2.95, SD=2.07; M=3.27, SD=2.10; M=3.29, SD=1.94; respectively)
	H4c - Boycott $F=20.970$, $p<0.000$, $\eta^2=0.05$	Younger individuals (M = 6.65, SD = 2.18) < all others (M = 7.27, SD = 2.30; M = 7.65, SD = 1.98; M = 7.98, SD = 1.99; respectively)

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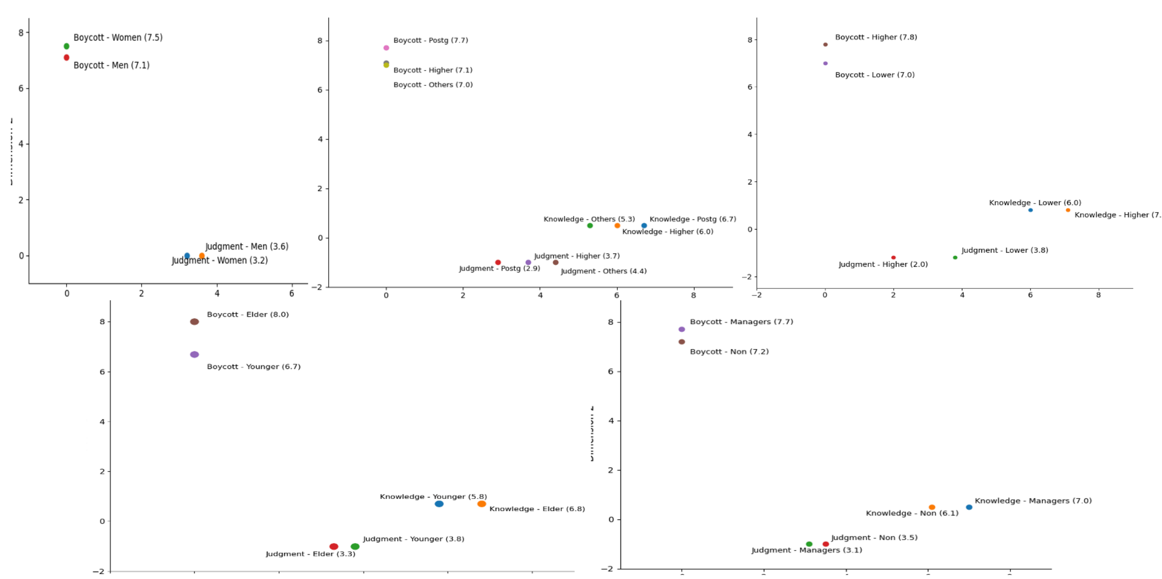
H5- Consumers with management experience	H5a - Knowledge F=37.187, $p<0.000$, $\eta^2=0.033$	Managers (M=7.01, SD=2.00) > non-managers (M=6.08, SD=2.21)
	H5b - Judgment F=5.909, $p=0.015$, $\eta^2<0.01$	Managers (M=3.15, SD=2.01) < non-managers (M=3.50, SD=2.15)
	H5c - Boycott F=9.227, $p=0.002$, $\eta^2<0.01$	Managers (M=7.71, SD=2.01) > non-managers (M=7.25, SD=2.15)

In addition, to facilitate visualization, perceptual maps of the averages obtained in the metrics investigated were generated according to the five variables of the consumer profile through correspondence analysis.

Figure 1

Perceptual map (correspondence analysis model)



Discussion of the results

The results obtained in this study show that consumers are critical of greenwashing, as shown by their greater knowledge of greenwashing and related topics, more critical judgment of organizations' environmental communications, and considerable predisposition toward boycott motivation behavior. These findings reinforce the understanding of the role of consumers as possible regulatory agents capable of pressuring the market toward authentic and transparent attitudes in communicating environmental practices (Andreoli *et al.*, 2025; Liu *et al.*, 2023).

Consumers' knowledge of greenwashing and related topics proved to be moderate, which corroborates the trend argued by the literature on consumers seeking information, who express greater interest and concern about the socio-environmental implications of organizations and their own choices (Braga *et al*., 2019; Martínez *et al*., 2020). Given this, we emphasize the importance of knowledge as an initial step toward greater awareness, enabling consumers not only to identify but also to question misleading environmental actions, as well as to exert social pressure for more environmentally friendly attitudes (Le *et al.*, 2024; Liu *et al*., 2023).

Consumers showed a critical stance toward greenwashing practices, which adds to the argument about the challenges consumers face in identifying greenwashing, especially given the ambiguity and communicational complexity involved (Freitas Netto *et al.*, 2020; Sajid *et al.*, 2024). Furthermore, it corroborates the literature that highlights the importance of consumer criticality in exercising its regulatory function in the face of misleading discourse (Nguyen & Duong, 2025; Senan *et al.*, 2025). Finally, it also validates the metric used in this study as an important measurement tool for the practice of greenwashing, a point argued as a research gap (Bernini *et al.*, 2024).

Regarding boycott motivation behavior, the results reveal consumers' concrete willingness to act in the face of greenwashing practices, which shows that the criticality previously identified in the judgment of environmental practices translates into an effective intention to retaliate through the non-consumption of products. This finding is consistent with studies that understand boycotts as a response motivated by moral indignation and a desire to transform organizational behavior (Cruz *et al*., 2013; Cummings *et al.*, 2025), reinforcing the role of consumers as regulatory agents of greenwashing practices.

The results indicate the emergence of a more conscious, engaged consumer profile willing to adopt a critical stance and actively reject organizations that, although positioning themselves as sustainable, are perceived as inconsistent or misleading in their environmental communications. The high predisposition to boycotts identified in this study highlights consumers' expectations regarding the authenticity and transparency of environmental communication promoted by organizations.

To deepen this understanding, this study proposed five hypotheses that relate consumer profile variables to their levels of knowledge about greenwashing and related topics, criticality in judging the practice, and behavior motivating the boycott. As a result, it was possible to validate practically all of them, showing the influence of gender, education, income, age, and current professional management.

First, the possible regulatory role of women stands out, who, in line with the literature, demonstrate greater criticality in their judgment regarding greenwashing (Farooq & Wicaksono, 2021) and greater motivation to boycott (Klein *et al.*, 2004; Mata *et al*., 2023; Li *et al.*, 2025). Second, a more comprehensive result was found in relation to consumers with higher levels of education, in line with previous studies, returning greater knowledge on the topics concerned (Witek & Kuźniar, 2020) and criticality towards greenwashing (Gopal & Pisharad, 2024), as well as greater motivation to boycott it (Mata *et al*., 2023; Park & Jang, 2024). Third, there was a similar emphasis on consumers with higher incomes, corroborating the literature by finding greater knowledge (Jog & Singhal, 2024; Kreczmańska-Gigol & Gigol, 2022) and greater critical awareness of greenwashing (Van Kehnove & Biro, 2016), in addition to greater motivation to boycott (Park & Jang, 2024). Fourth, the emphasis on elder consumers reinforces more general studies related to the greater maturity of this audience and its consequences in terms of reactions to organizational practices (Boermans *et al*., 2024; Barda & Sardianou, 2010; Park & Jang, 2024). In the absence of more specific findings, this study contributes to the literature by confirming this logic in relation to greenwashing, both in terms of knowledge and judgment, and in terms of behavior motivating boycotts. Finally, consumers' professional management experience was also highlighted, supporting broader arguments focused on the contribution of organizational experience in assessing corporate conduct, including in the context of greenwashing

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practices (Szabo & Webster, 2020). As discussed previously, in the absence of more direct investigations, this contributes to validating the influence of the profession on reaction behavior, both in terms of greater knowledge and critical judgment, and in terms of behavior motivating a boycott of greenwashing practices.

Thus, the confirmation of the five hypotheses reinforces the possible role of consumers as regulators in the face of greenwashing practices, highlighting more accurate knowledge about greenwashing and related topics, more critical reactions to the practice, and more considerable boycott-motivated behavior. Among them, female consumers with higher education and income, elder consumers, and those with professional management experience were prominent. These results pose relevant challenges for organizations, which must not only review their discourse but also align their environmental practices with what they communicate, with responsibility, authenticity, and transparency, at the risk of facing rejection by increasingly conscious and discerning consumers.

This study highlights the importance of organizations considering different consumer profiles when developing environmental communication strategies, especially when targeting specific segments or audiences. As discussed here, the demographic characteristics of consumers substantially differentiate their reactions to greenwashing practices, influencing both their stated knowledge and the criticality of their attitudes toward flaws in the authenticity of environmental messages and the expressiveness of anti-consumerist reactions.

It should be noted that, although previous studies have supported some of the hypotheses of this study, there is little research focused on consumer profiles and the relationship between their variables and their reaction to greenwashing practices. In this sense, the present study offers theoretical and empirical contributions by integrating this, and promoting an understanding of consumer behavior motivating boycotts of greenwashing practices based on consumer profiles.

Conclusions

This study aimed to understand consumer reactions to greenwashing, particularly in terms of knowledge, judgment, and boycott motivation behavior, and investigated possible differences derived from their profile. As a result, a high criticality of the sample was observed, with a considerable self-declared predisposition toward boycott motivation behavior. In addition, differences were identified in relation to all consumer profile variables in virtually all metrics investigated, such as gender, education, age, income, and current professional management experience. Overall, the findings reinforce that consumer resistance to greenwashing constitutes a relevant, yet socially differentiated, mechanism of market accountability, whose effectiveness depends not only on awareness but also on the structural conditions that shape consumers' capacity to critically evaluate and react to such environmental misconduct.

In this sense, validating all the hypotheses of the study, it was found that cisgender female consumers, elder, with higher levels of education and income, and with current professional management experience, accounted for more accurate knowledge of greenwashing and related topics and greater criticality in judging the practice, as well as greater motivation to boycott. Thus, this study deepens the discussion on the role of consumers as possible regulatory agents in the market, highlighting their ability to exert pressure through the active rejection of brands that engage in deceptive environmental practices. Taken together, these findings indicate that the reaction to greenwashing is not uniformly distributed among consumers but is associated with specific sociodemographic characteristics. The predisposition to boycott appears stronger among individuals with higher levels of educational, economic, and professional capital and among women. This suggests that the consumer' possible regulatory role in the context of greenwashing is socially structured rather than generalized across the market. Therefore, market-based regulation through consumer response may depend on segments with greater access to information, critical capacity, and decision-making skills.

This study makes an academic contribution to the understanding of consumer behavior in the face of greenwashing by investigating it as a possible regulatory agent. Thus, it deepens the understanding of consumer reactions, both in relation to declared knowledge and criticality and to the manifested predisposition to boycott behavior. In addition, it contributes to a greater understanding of the influence of demographic variables on consumer profiles. Thus, it defends the effort of this study to understand consumer behavior motivated by boycotts of greenwashing practices, both in general and in detail. By demonstrating that boycott predisposition and critical judgment are associated with structural and demographic characteristics, this study advances the greenwashing literature by challenging homogeneous assumptions about the "green consumer" and highlighting that consumer-based regulation is not a uniform phenomenon but one conditioned by social positioning and access to resources.

From a managerial perspective, the stronger boycott predisposition observed among women, higher-income, and more educated consumers suggests a greater likelihood of negative consumer responses in segments characterized by greater informational access and critical awareness. Organizations targeting these segments should adopt stricter transparency standards and ensure consistency between environmental discourses and actual practices.

The higher predisposition identified among consumers with managerial experience indicates that resistance to greenwashing may also emerge among individuals with organizational influence and decision-making authority. This finding suggests that reactions to misleading environmental claims may extend beyond private consumption choices, reinforcing the importance of ethical environmental communication in broader stakeholder environments.

So, given the consumers' growing sensitivity to greenwashing, companies must ensure consistency between their organizational discourse and the environmental practices they implement. A commitment to genuine, transparent, and consistent environmental action is fundamental to protecting the brand from negative consumer reactions, such as boycott movements. In this sense, the findings of this study highlight the risk that greenwashing practices pose to organizations while emphasizing the possible active and critical role of consumers in the face of this type of conduct, manifesting a predisposition to boycott as a form of protest against it. Organizations that work with more specific market segments should consider the particularities of their target audience, especially if they comprise women with higher education, income, and age, as well as professional management experience.

Simultaneously, the small effect sizes observed suggest that demographic characteristics explain only part of consumer reactions. This indicates that reliance on consumer-driven regulation may be limited, reinforcing the importance of complementary institutional and regulatory mechanisms to curb greenwashing practices. In this sense, the social contribution of the study is argued to discuss and better understand the phenomenon of greenwashing, given its negative potential.

However, the limitations of this study must be considered. Thus, it should be noted that this is a methodological procedure developed by the authors with a specific research instrument applied to a convenience sample with a cross-sectional design. In addition, the use of self-reported data should be considered, as well as the limitations of the analysis techniques, which do not allow for causal inferences. Therefore, although a substantial number of consumers responded, the results cannot be generalized.

In view of this, some suggestions for future studies emerge. Further research is needed on potential consumer reactions to greenwashing, either maintaining the scope of boycott movements or extending the scope to other similar movements, such as protests. In this sense, other variables can be considered as derivatives of the perception of greenwashing, such as consumer

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disappointment and hatred directed at the practicing brand. In addition, it is important to cover other variables in the consumer profile, whether demographic, such as ethnicity or housing, or psychographic, such as environmental concern or sustainable consumption behavior. Finally, it would be interesting to detail consumer reactions to this practice in different contexts, such as specific markets, certain product categories, or even defined target brands. In this regard, analyses and comparisons with other locations are encouraged.

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Author Declaration - CRediT Taxonomy

Authors	Contributions
Taís Pasquotto Andreoli	Conceptualization, formal analysis, research, methodology, supervision, writing. Original draft, writing. Review and editing.
Isabela Marques Kumer	Writing. Original draft, writing. Review and editing.

Statement on the use of artificial intelligence

The authors **DECLARE** that, in the preparation of the article titled "Boycott Reaction to Greenwashing According to Consumer Profile: An Interview in Brazil," artificial intelligence (AI) was not used at any stage of the process.

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Emerging technologies to optimize environmental sustainability in the textile industry: a systematic review

Tecnologías emergentes para optimizar la sostenibilidad ambiental en la industria textil: una revisión sistemática

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Abstract: the textile industry is characterized by high resource use and a significant environmental impact, associated with high water and energy consumption, chemical pollution, and waste generation. In this context, emerging technologies seek to reduce the environmental footprint of production processes and strengthen organizational competitiveness. The objective of this study is to systematically analyze technological innovations applied in the textile industry aimed at mitigating environmental impacts, with an emphasis on transformed production processes, environmental performance metrics, adoption barriers, and emerging trends. The methodology is based on a systematic literature review conducted according to the PRISMA 2020 guidelines, with a descriptive quantitative synthesis of a bibliometric nature based on the frequency analysis of coded variables. The results show that digital platforms, clean technologies, recycling systems, and advanced materials are the most recurrent innovations, contributing to greater resource efficiency, waste reduction, and improved energy performance. Significant barriers persist, such as high implementation costs, regulatory restrictions, and financial limitations in supply chains.

Keywords: sustainability, innovation, technology, pollution, efficiency, competitiveness, energy, industry.

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Resumen: la industria textil se caracteriza por una elevada intensidad en el uso de recursos y un impacto ambiental significativo, asociado al alto consumo de agua y energía, la contaminación química y la generación de residuos. En este escenario, la innovación tecnológica ha adquirido un papel estratégico para disminuir la huella ambiental de los procesos productivos y, simultáneamente, fortalecer la competitividad organizacional. El objetivo de este estudio es analizar de manera sistemática las innovaciones tecnológicas aplicadas en la industria textil orientadas a la mitigación de impactos ambientales, con énfasis en los procesos productivos transformados, las métricas de desempeño ambiental, las barreras de adopción y las tendencias emergentes en sostenibilidad. La metodología se fundamenta en una revisión sistemática de la literatura desarrollada conforme a las directrices PRISMA 2020, complementada con una síntesis cuantitativa descriptiva de carácter bibliométrico basada en el análisis de frecuencias de variables codificadas. Los resultados evidencian que las plataformas digitales, las tecnologías limpias, los sistemas de reciclaje y los materiales avanzados constituyen las innovaciones más recurrentes, contribuyendo a una mayor eficiencia en el uso de recursos, la reducción de residuos y mejoras en el desempeño energético. Sin embargo, persisten barreras relevantes, como altos costos de implementación, restricciones regulatorias y limitaciones financieras en las cadenas de suministro.

Palabras clave: sostenibilidad, innovación, tecnología, contaminación, eficiencia, competitividad, energía, industria.

Introduction

The status of current global environmental problems poses a significant threat of the 21st century, particularly from continued deterioration of ecosystems due to production and mass consumption (Leal *et al.*, 2024). Within this frame, the textile sector takes on special importance as it is one of the most polluting industries globally. The water and energy consumption of the industry, heavy chemical use, solid waste production, and the release of microplastics into the environment are highlighted sectors of the sustainability agenda (Orisadare *et al*., 2025).

The environmental footprint denotes the set of impacts a specific productive activity creates on the earth and is therefore a significant measure in evaluating how detrimental textile business is to the environment. This dimension incorporates natural resource use, greenhouse gas emissions, and soil and water pollution that are important aspects to guide sustainable development strategies (Bibi *et al.*, 2024). Technological advances are considered a key driver of the change in productive behavior and their environmental impact amelioration. Technologies towards energy efficiency, fiber recycling, use of biodegradable materials and the digitalization of processes are areas where transition opportunities can be considered from this sector to a cleaner and more sustainable industry (Dutta & Bansal, 2024). Globally, integrating clean technologies has yielded promising outcomes, and initiatives emerging in Latin America reflect a greater interest in integrating sustainability as an economic factor to drive competitiveness within the textile industry. The textile industry is recognized as one of the biggest industries to impact the environment and is even more affected, due to the volume of production techniques and to the consumption model promoted through it. Textile production requires a lot of water and resources - a huge water use, energy, and chemicals. Excessive extraction of these resources has severe consequences for the ecosystems. Planting natural fibers like cotton consumes huge amounts of water.

In synthetic fiber production, heavy energy loading and a reliance on petroleum derivatives are striking. Dyeing, bleaching and other chemicals that, in many cases, end up in rivers and seas add to the pollution. Industry, on the other hand, creates waste in bulk, such as textile waste and microplastics, which only serve to worsen environmental pollution and threaten human health and biodiversity (Hossain *et al*., 2024). In recent years, several technological advancements have been invented to alleviate these impacts. Nonetheless, their deployment is disconnected and misaligned. Recent achievements have been observed around energy efficiency and fiber recycling, biodegradable materials and production processes that are in the process of digitalizing. The adoption of these innovations is now uneven across the sector. The scientific literature focuses on single innovations or processes without consideration for the broader picture, which may cover what has changed or must still be solved (Bibi *et al*., 2024).

This situation exposes the gap between the present stage of technology application and its systematic use within textiles. There is no consolidated framework that allows us to assign which innovations are applied most often,

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which production processes undergo the most transformations, which indicators are used to measure environmental outcomes, or which technical, economic and social barriers limit their adoption (Chourasiya & Pandey, 2024). The lack of this articulation has a limiting impact between the sector, which may be moving towards sustainable production models, and decreases the utility of the academic findings in the decision-making process. The implications created in the latter context indicate the pressing need of taking a rigorous and systematic approach to understand in depth the achievements and constraints and opportunities technological innovation has created in minimizing the environmental footprints within textile sectors (Glogar *et al*., 2025).

Therefore, the objective of this study is to systematically analyze technological innovations applied in the textile industry aimed at mitigating environmental impacts, with an emphasis on transformed production processes, environmental performance metrics, adoption barriers, and emerging trends. Accordingly, the questions considered are:

- Which technological innovations are most frequently applied in the textile sector?
- Which production processes have been most transformed?
- What metrics or indicators are used to evaluate progress?
- What technical, economic, or social barriers limit adoption?
- Which recent trends show the greatest potential for consolidating sustainability in the textile industry?

The findings will contribute to the academic literature by proposing a comprehensive framework that allows understanding technological advances within the textile industry in relation to environmental sustainability, and recognizing emerging trends, evaluation metrics, and barriers to adoption.

Materials and Methods

PRISMA 2020 provides a standardized and transparent framework for conducting and reporting systematic reviews, ensuring that the steps of identification, selection, eligibility, and inclusion can be carried out rigorously, consistently, and reproducibly (Page *et al.*, 2021). In this context, PRISMA is particularly relevant for managing the heterogeneity of the literature and facilitating the structured synthesis and comparison of evidence, as well as for evaluating the environmental performance of the textile sector.

Eligibility Criteria

Priority was given to research based on empirical evidence and systematically reviewed in scientific journals, academic books, and conference proceedings, which were considered valid sources with methodological rigor. Documents chosen for the studies were necessary to state technological innovations applied to the textile industry regarding a reduction in the environmental footprint, or carbon footprint, water footprint, life cycle analysis, sustainability, or the circular economy. In addition, submissions needed to include works proposing or evaluating eco-innovative practices within processes, materials, products, or business models in the textile and fashion industry. To capture most of the relevant scientific productions and to facilitate an appropriate interpretation of the findings, only publications in English and Spanish were included in the inclusion language. This includes not only advances that were made after 2000, but also those up to 2025 that have further consolidated the notion of textile sustainability.

The exclusion process took place in three stages sequentially. Duplicate records or those with indexing errors were removed as the first step. Second, documents lacking full text were discarded, as this prevented a detailed examination of methods and results. Third, studies that, while meeting formal requirements, did not satisfy the defined thematic or methodological criteria were excluded. These included studies focused on sectors other than textiles, articles addressing environmental dimensions only tangentially, and studies in which technological innovation was not an explicit focus.

Sources of Information

Scopus and Web of Science were chosen because they are recognized as high-impact databases worldwide, in addition to having rigorous indexing standards and covering a wide range of disciplines that reinforce the scope and validity of systematic reviews. Their emphasis on peer-reviewed and highly cited articles provides reliable and relevant studies in engineering, innovation, and sustainability for a robust and methodologically rigorous academic analysis.

The database is characterized by a wide range of indexed documents and a rich multidisciplinary body of literature the areas of circular economy, eco-innovation and sustainable practices. This renders it a suitable framework for investigating the complexity of the environmental footprint of textile use as a single project through this systematic review. Web of Science, managed by Clarivate Analytics, is unique in the selectivity of the indexing rules, and its ability to trace citations of documents, as records go back to the early 20th century. The analysis here is of interest to the academic fields of environmental science, engineering, and sustainability management with a basis of comparability between research on technological innovation and environmental impact reduction. Integration of the two databases reduces bias and increases the representativeness of findings. Asubiaro *et al*. (2024) showed that there are substantial differences between regions in the representation of scientific production in textile sustainability, highlighting the importance of linking to receive an all-encompassing perspective on the topic.

Search Strategy

The search strategy was defined based on the inclusion criteria and consisted of a specific equation for each database. In Scopus, Boolean operators and keywords related to innovation, sustainability, and environmental footprint in the textile industry were used, with the fields being limited to the title and abstract to narrow the results to relevant studies. The equation utilized was:

- *Scopus:* TITLE (innovation OR "eco-innovation" OR "technological change" OR "new product development") AND TITLE ("environmental footprint" OR "ecological footprint" OR "environmental impact" OR "carbon footprint" OR "water footprint" OR "life cycle assessment" OR sustainability OR "sustainable development" OR "circular economy" OR "green practices" OR eco-friendly) AND TITLE-ABS-KEY ("textile industry" OR textiles OR "apparel industry" OR clothing OR "fashion industry" OR garment)
- In Web of Science, the same conceptual structure was adapted to database-specific syntax using topic and keyword fields: *Web of Science:* TS=(innovation OR "eco-innovation" OR "technological change" OR "new product development") AND TS=("environmental footprint" OR "ecological footprint" OR "environmental impact" OR "carbon footprint" OR "water footprint" OR "life cycle assessment" OR sustainability OR "sustainable development" OR "circular economy" OR "green practices" OR "eco-friendly") AND AK=("textile industry" OR textiles OR "apparel industry" OR clothing OR "fashion industry" OR garment).

Selection and Data Processing

Figure 1 presents the PRISMA flowchart used for this review, illustrating the stages of identification, screening, eligibility, and inclusion. Data were processed in Microsoft Excel to extract, organize, and categorize information from the consulted databases. To that end, the studies were presented in spreadsheets to support comparative analysis and apply the eligibility criteria and organized systematically around the groups based on the categories selected from the research questions. These were classified into the following: "Technological In-

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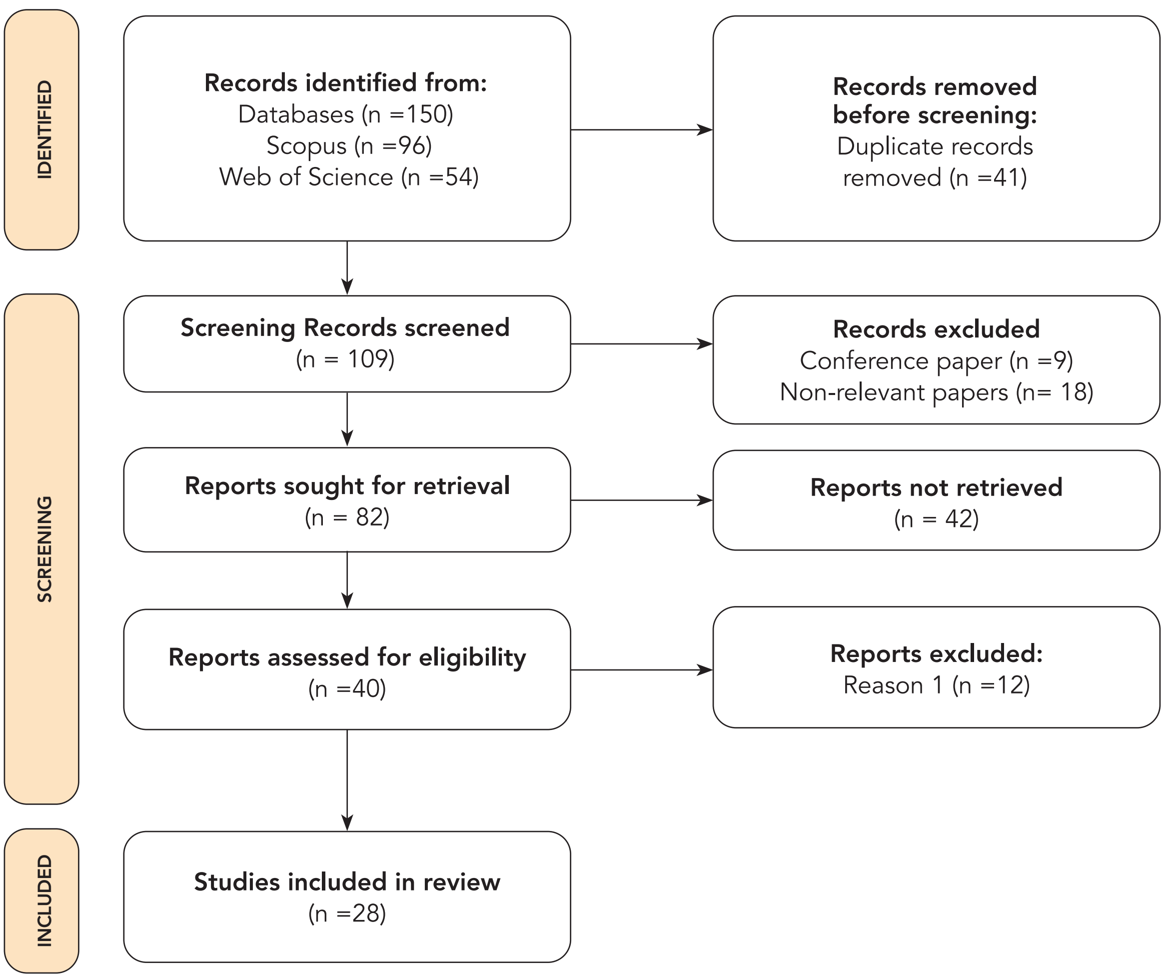
novations" and "Transformed Production Processes" and "Key Environmental Metrics" and "Barriers to Technology Adoption" and "Recent Sustainable Trends". Furthermore, when it comes to environmental measurement, carbon footprint, water consumption, and life cycle analysis were incorporated.

This process was independently performed by every researcher, with disagreements resolved by consensus through discussion that were, when necessary, subject to the intervention of another reviewer. Study selection criteria were relevance to research objectives. Although this analysis did not attempt to establish causal relationships, it relied on a quantitative synthesis that aimed to characterize the prevalence of variables identified from the reviewed literature. Dominant patterns and thematic concentrations were described using frequency-based graphs and descriptive statistics.

Figure 1

PRISMA Flow Chart



Note. Prepared by the authors using data from Scopus and Web of Science.

Forty-two records collected during the screening could not be retrieved for evaluation. The availability of these files was restricted by publisher paywalls or the absence of full texts. Since the full text was a necessary element for analyzing methodological quality, technological relevance, and environmental performance measures, these were removed from the analysis to ensure a consistent and transparent review. Subsequently, from this selection, after applying the filter, a total of 12 articles were excluded at the eligibility stage. These exclusions were determined based on explicit and predefined criteria: (i) the lack of a direct focus on the topic, (ii) the peripheral treatment of sustainability concepts without empirical or analytical evidence, (iii) the research's focus on different sectors, and (iv) the absence of clearly defined or measurable indicators.

Risk of bias

Potential bias in selection and analysis was considered as databases such as Scopus and Web of Science, and the search terms in the search equations, could influence the representativeness of the results. Similarly, publication bias, which arises from the greater visibility of positive findings, was acknowledged. To mitigate these risks, predefined inclusion criteria were applied, along with independent review processes and cross-checking of information.

Given the heterogeneity of designs across the retrieved literature (e.g., empirical studies, qualitative analyses, modeling-based contributions, and systematic reviews), quality appraisal was conducted using general and transparent criteria rather than a single design-specific scoring tool. More specifically, the evaluation concerns the following issues: (i) clarity of research aims and context; (ii) sufficiency and transparency of approach (data sources, procedures, analytic steps); (iii) coherence between methods, results, and conclusions; (iv) the precise expression of environmental metrics or evaluation procedures (e.g., carbon/water footprint indicators, life cycle assessment assumptions, or operational efficiency measures); and (v) the disclosure of limitations and potential conflicts of interest when applicable.

Studies that provided inadequate methodological clarity, vague measurement methods, or were poorly aligned between proposed novelties and reported environmental outcomes were considered with more interpretive care on synthesis. As such, results were not evaluated by meta-analytic approach, and the review focuses on emergent themes that emerged through descriptive synthesis as well as on the differences in study quality on the strength and comparability of measured impact.

Contributions to the current state of the art

The results are presented in accordance with the research questions, thereby facilitating a systematic relationship with the stated objectives and ensuring consistency in the analysis process. The organization by thematic axes facilitates comparison between studies and the identification of the role of technological innovation in reducing the environmental footprint in the textile sector, ensuring an orderly interpretation of the evidence supported in Table 1, which summarizes the studies included for detailed analysis.

Table 1

Studies included in the research

Número	Título	Autores
1	Assessing Chinese Textile and Apparel Industry Business Sustainability: The Role of Organization Green Culture, Green Dynamic Capabilities, and Green Innovation in Relation to Environmental Orientation and Business Sustainability	Xiaoyi *et al.* (2023)

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2	Business Model Innovation for Circular Economy in Fashion Industry: A Startups' Perspective	Ostermann *et al.* (2021)
3	Characterization of Atlantic Forest Tucum (Bactris setosa Mart.) Leaf Fibers: Aspects of Innovation, Waste Valorization and Sustainability	Flohr *et al.* (2024)
4	Circular Economy Solutions: The Role of Thermoplastic Waste in Material Innovation	Ochigue *et al.* (2025)
5	Developing textile sustainability education in the curriculum: pedagogical approaches to material innovation in fashion	Wood *et al.* (2023)
6	Digitalization for a Sustainable Performance: Dual-Study Analysis of Digital Leadership, Circular Economy, and Technological Innovation	Khan *et al.* (2024)
7	Do Intelligent Manufacturing Concerns Promote Corporate Sustainability? Based on the Perspective of Green Innovation	Feng (2023)
8	Drivers and barriers of sustainability-oriented innovations in Brazilian denim treatment facilities: an expert-driven decision support	Brandão *et al.* (2025)
9	From Waste to Luxury Fashion at Elvis & Kresse: A Business Model for Sustainable and Social Innovation in the Circular Economy	Dominguez y Bhatti (2022)
10	How Circular Economy Innovation Can Backfire on the Environment: Quantifying the Rebound Effect of the Textiles and Clothing Sector	Yerushalmi y Saha (2025)
11	Immersive innovations for the communication of heritage, handcraft and sustainability	Cross *et al.* (2025)
12	Qualitative Analysis of Sustainability and Innovation Within the Luxury Business Sector	Grigorescu e Ion (2022)
13	Supplier-customer relationships for sustainability-led innovation in the textile industry	Dominidiato *et al.* (2024)
14	Sustainability Innovation in the Textile Industry: A Systematic Review	Harsanto *et al.* (2023)
15	Sustainability through lignin valorization: recent innovations and applications driving industrial transformation	Jiju *et al.* (2025)
16	Sustainability Values and Strategic Innovation in Sustainable Fashion MSMEs: the Dynamic Capabilities Perspective	Ceicyte-Pran-skune (2025)
17	Sustainability-Oriented Innovation in the Textile Manufacturing Industry: Pre-Consumer Waste Recovery and Circular Patterns	Butturi *et al.* (2025)
18	Where do professionals find sustainability and innovation value? Empirical tests of three sustainable design methods.	Faludi *et al.* (2020)
19	Evaluation of Circular and Integration Potentials of Innovation Ecosystems for Industrial Sustainability	Tolstykh *et al.* (2020)
20	Green HRM practices in textile sector of Pakistan and its impact on green innovation and environmental sustainability	Awais-e-Yazdan *et al.* (2024)
21	Green practices and economic performance: Mediating role of green innovation in Ethiopian leather, textile, and garment industries-An integrated PLS-SEM analysis	Nigatu *et al.* (2024)
22	Harnessing the multifaceted potential of mushrooms: sustainable development, health promotion, and industrial innovation	Lu *et al.* (2025)
23	How Does Corporate Sustainability Increase Financial Performance for Small- and Medium-Sized Fashion Companies: Roles of Organizational Values and Business Model Innovation	Yang y Jang (2020)

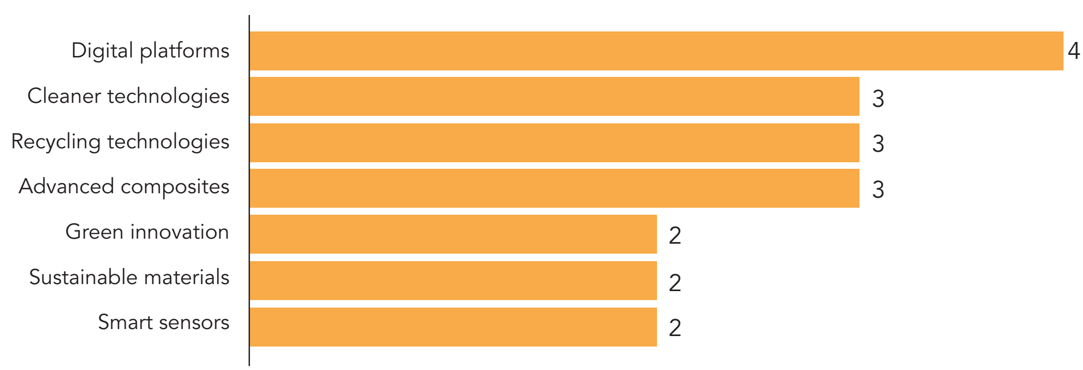
24	Managerial decisions and new product development in the circular economy model enterprise: absorptive capacity and a mediating role of strategic orientation	Stelmaszczyk *et al.* (2023)
25	Review the potential for regenerated protein fibres within a circular economy: Lessons from the past can inform sustainable innovation in the textiles industry	Stenton *et al.* (2021)
26	The relationship between sustainability practices and innovation strategies: the effect of the clusterization in the bop segment	Doliveira *et al.* (2018)
27	The Role of Agile Practices and Green Innovation on Environmental Sustainability Through Waste Reduction in Indian Garment Manufacturing	Nayeemunnisa y Padhy (2025)
28	Transformational leadership and radical innovation for sustainability: mediating role of knowledge management capability and moderating role of competitive intensity	Nabi (2023)

Note. Prepared by the authors based on data from Scopus and Web of Science.

Based on the literature review, the emphasis on digital and green technology innovation solutions is clearly illustrated in Figure 2. Although a total of 28 studies were reviewed, the figures present lower totals, as each graph includes only those studies that explicitly address the corresponding thematic category. Consequently, a single study may appear in more than one category or may not be represented in all figures, depending on its scope and classification criteria. The reviewed studies report that firms are increasingly adopting digital platforms and clean technologies, reflecting a strategic shift toward data-driven approaches to sustainability. Additionally, the prominence of recycling systems and advanced materials highlights a growing research interest in circular economy practices and the development of new materials for textile applications.

Figure 2

Technological innovations in the textile industry



Note. Prepared by the authors based on data from Scopus and Web of Science.

Given that technological innovation has brought about a significant transformation in textile production processes, studies highlight a shift towards smarter and cleaner manufacturing models. These changes indicate a growing integration between production efficiency and environmental sustainability goals, as illustrated in Figure 3.

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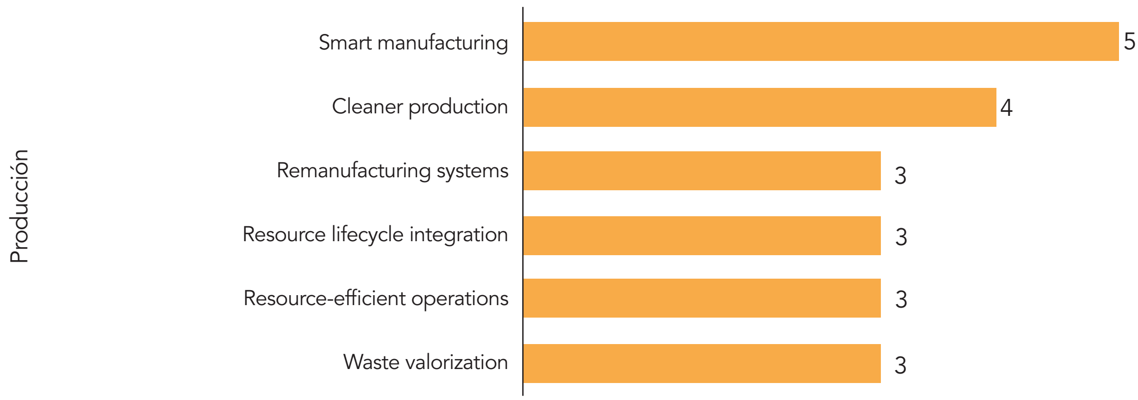
Figure 3

Transformed production processes in the textile industry

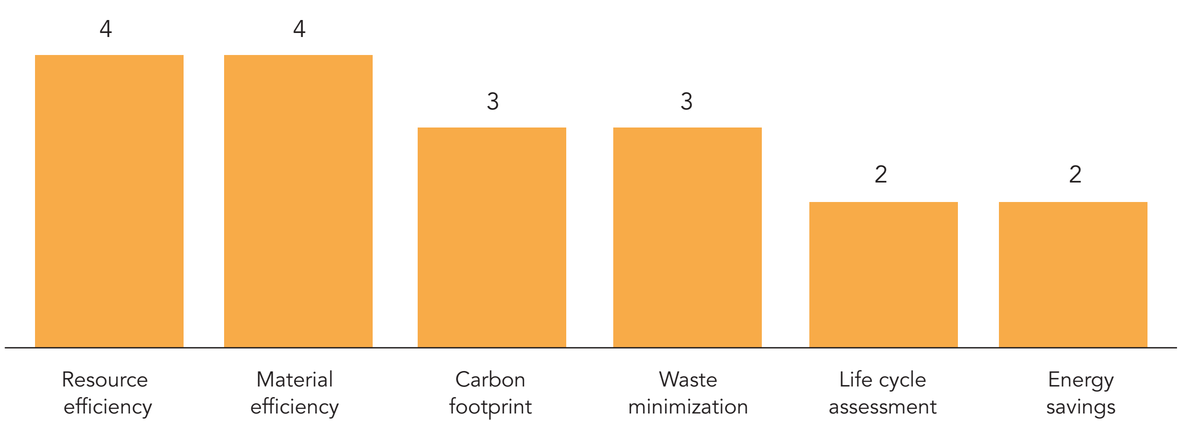


Note. Prepared by the authors based on data from Scopus and Web of Science.

The assessment of the textile industry's environmental performance focuses on efficiency-based indices, as shown in Figure 4. This pattern of repeated use of metrics relevant to resource and material efficiency is consistent with an operational approach focused on minimizing inputs and outputs, while indicators based on footprints and life cycle modalities allow for a broader measurement of environmental impact.

Figure 4

Key environmental metrics in the textile industry

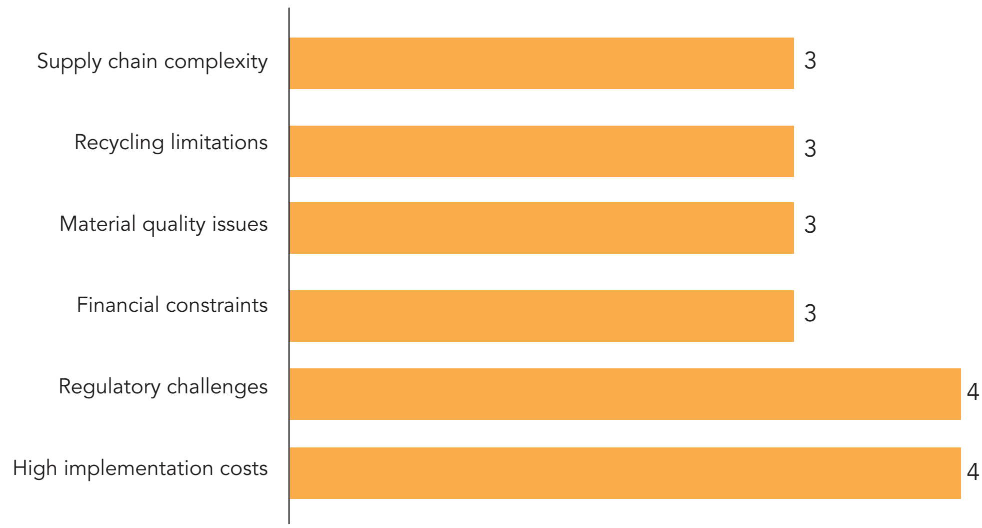


Note. Prepared by the authors based on data from Scopus and Web of Science.

Figure 5 presents a general view of the main challenges hindering sustainable technologies adoption in the textile industry. The results suggest that two broad layers of economic and regulatory constraints become central, along with the structural (material, recycling systems and supply chain complexity) ones. These barriers underscore the distance between the technology available and implementing at scale efficiently.

Figure 5

Barriers to technology adoption in the textile industry

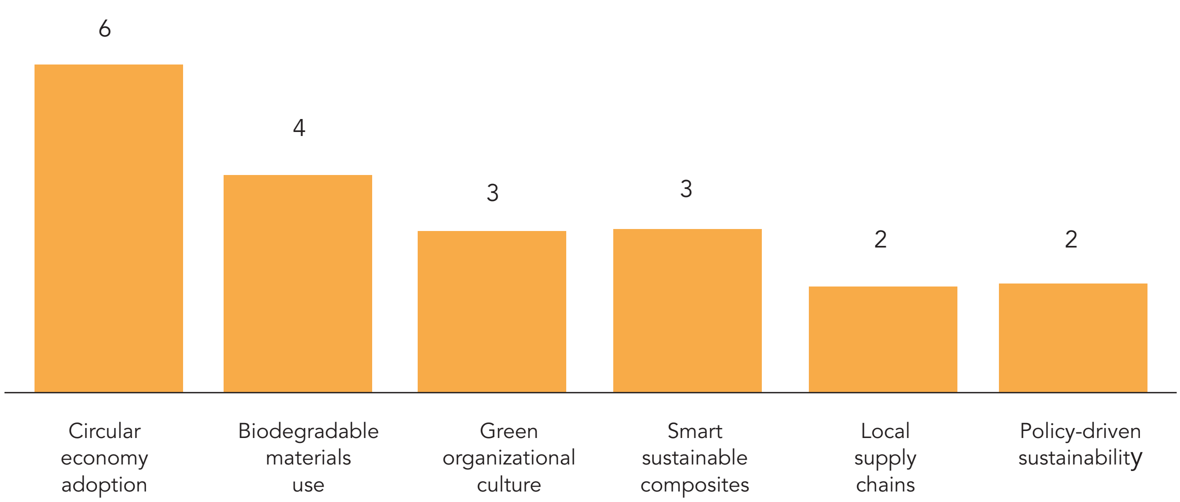


Note. Prepared by the authors based on data from Scopus and Web of Science.

Sustainable trends in the textile sector are being guided more by circular economic considerations. Trends are biodegradable materials, environment-focused corporate cultures, a localized supply chain, supplemented by policy frameworks, pointing to a multifaceted view of sustainability beyond the technology, consistent with the results presented in Figure 6.

Figure 6

Recent sustainable trends in the textile industry



Note. Prepared by the authors based on data from Scopus and Web of Science.

This classification provides a detailed survey summarizing the advancements reported in literature and identifies the chances and difficulties that lie ahead for a change which will see textile industries in more sustainable and technologically advanced form.

Results and Discussion

The discussion has been arranged in such a way that the integration of the findings from technological innovation research for reducing the environmental impact in the textile industry has been considered. First, the article presents an analysis to compare the findings with past publications and to identify commonalities and differences among the literature. A conceptual model based on the obtained findings is in the next part. This section also provides the development of theoretical, policy and practical implications.

Analysis of the results

Textile sector technology innovations are mostly tied to digital transformation and quest for sustainable solutions. Notably, a significant portion of digital platforms have been found, in addition to technology in the areas of environmental efficiency, recycling, and advanced material development, validating the role of green innovation in this sector. These findings have been related to studies highlighting the value of organizational culture and dynamic capabilities for achieving corporate sustainability (Xiaoyi *et al*., 2023) and to studies indicating contextual barriers to sustainable innovation (Brandão *et al.*, 2025). As for changing the production process, there is evidence that there is a change of course toward smart and sustainable practices, with a strategy to optimize resources and reduce environmental impacts. Clearly evidence of the growing integration of digital technology in industrial automation and new advanced manufacturing, with cleaner manufacturing methods and waste recovery strategies emerges.

As such, these findings are congruent with the literature exploring the circular economy and the use of recycled materials in the manufacturing of high-performance innovative products (Ochigue *et al.*, 2025); they are congruent with literature focusing on "sustainable innovation in production processes" (Harsanto *et al*., 2023), i.e., the use of the circular economy and recycled materials in generating high-performance innovation. Key environmental metrics are focused on practices which maximize resource use, reduce waste and support life-cycle assessment. The metrics indicate alignment with efficiency and sustainability-focused strategies, a major component of the circular economy, and educational innovations that intend to embed sustainable materials and techniques within vocational training. This points to the importance of integrating technological innovation and social training for sustainable models of production in the textile industry (Ostermann *et al.*, 2021; Wood *et al.*, 2023).

Not only are barriers to technological adoption identified; alternative materials (especially sustainable fibers) for production (Flohr *et al*., 2024) and the way in which innovation and sustainability interact (Grigorescu & Ion, 2022) are also important areas for consideration. Furthermore, structural and financial barriers to the transition to sustainable practices exist. This text addresses factors related to high implementation costs and regulatory barriers, financing issues, and challenges linked to materials and recycling.

These findings from this systematic review suggest that the advancements of sustainability technologies in the textile sector are not universally progressive or sustainably adopted. These factors digital platform technologies, smart manufacturing technologies, cleaner production technologies and so forth are emerging as dominant strategies but have not been embraced in all regions of the world and whether to use them is contingent on contextual aspects of implementation and use. Hence, existing technological initiatives would not help with supporting systemic, holistic environmental transformation given embedded context on an organizational and strategic level. Therefore, the impact on innovation appears to be determined by firms' internal capabilities, culture, governance framework, sustainability desire and policies on alignment of sustainability aspiration versus implementation of the same, organizational policy.

In comparative analysis, these findings also support previous studies that say sustainability-oriented innovation is the best use when learning, culture and policy change in a company at industry level are required along with technological advancement. But what is clear in this review is also a persistent disconnect between technological development and production, from cost mechanisms and regulatory precarity to supply chain complexity.

The confirmed sustainable development trends reflect the consolidation of the circular economy and the adoption of digital traceability solutions, with an increasing emphasis on value chain transparency and emissions reduction—not only are they desirable components but also fundamental imperatives of sustainability. Also noted are practices of a green organizational culture, recycling, waste recovery and biodegradable and smart materials use. These orientations are consistent with research focusing on the role of smart manufacturing in promoting corporate sustainability (Feng, 2023) and with findings on the importance of strategic preferences concerning strategic values of fashion SMEs (Ceicyte-Pranskune, 2025).

Comparison of Results with Other Studies

The results of this study complement other works on technological innovation and sustainability related to the textile sector. In line with Mansi *et al.* (2025), the findings demonstrate how clean technologies, green chemistry, and life cycle assessment can reduce environmental impacts and provide an approach to the textile sector that enables a more detailed analysis of production processes, environmental indicators, and adoption barriers. Similarly, the convergence with Timbayo *et al.* (2025) describes the contribution of digitalization to sustainability and modernization; however, the current study expands this perspective to digital platforms applied within production systems and environmental management, rather than focusing on e-commerce applications.

Authors such as Sellappa (2025) and Nourin et al. (2025) emphasized that sustainability practices play a crucial role in their work. This is in line with findings for circular economy models. However, while the studies focus on artisanal models, this research investigates a holistic technology perspective to understand the present state of dynamics and potential barriers for their adoption, like the newly emerging paradigms of Industry 5.0 discussed by Sonar et al. (2025) which covers digitalization and traceability, and the resiliency of supply chains.

Proposed Conceptual Framework

The next section offers a five-axis framework, influenced by some of the ideas of the previous sections. Figure 7 conceptualizes the objective of the study as the systematic analysis of technological innovations aimed at mitigating the environmental impacts of the textile industry within a multidimensional context encompassing technological, productive, environmental, and organizational dimensions. Rather than implying a direct reduction of the environmental footprint, the framework frames sustainability improvement as a systemic process informed by transformed production processes, environmental performance metrics, adoption barriers, and emerging trends identified in the literature. This perspective highlights how structural constraints and enabling conditions shape technological change and supports the formulation of more coherent and comprehensive policy and managerial approaches toward more responsible textile production models.

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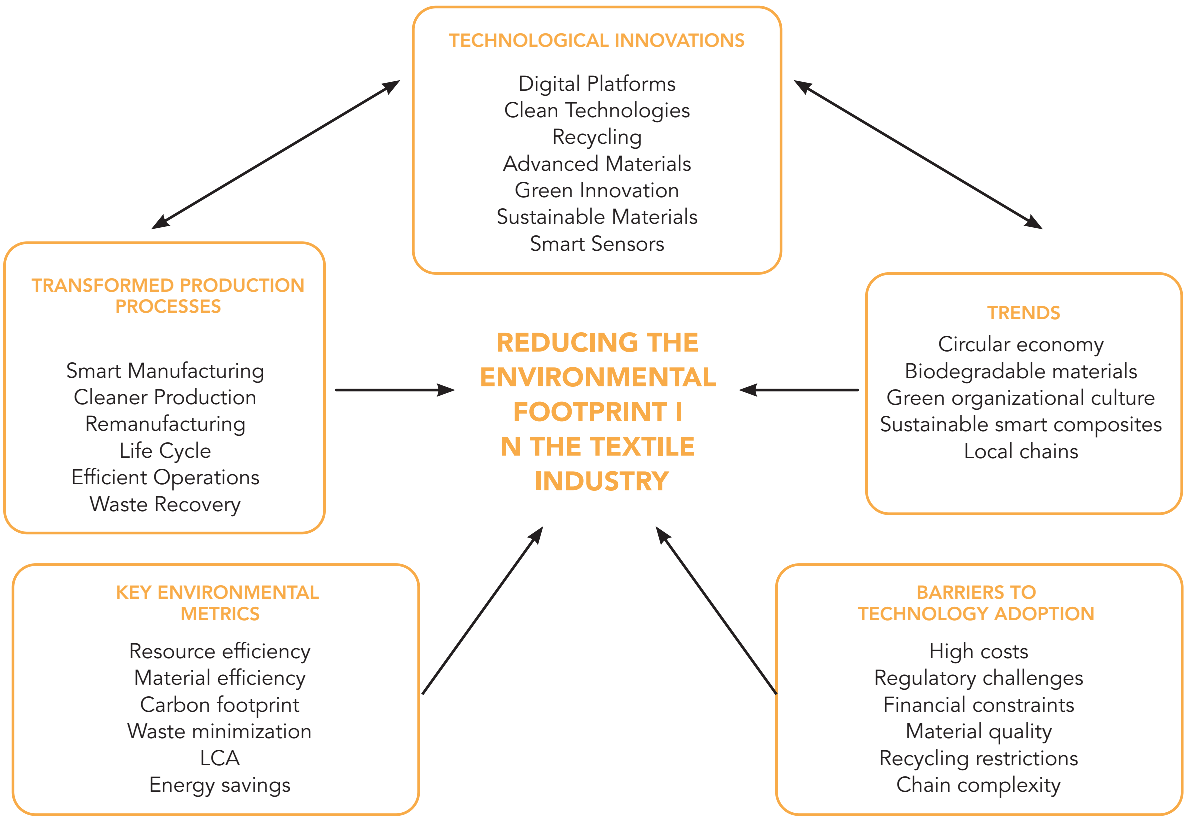
Figure 7

Conceptual framework for technological innovation in the textile industry



Implications

The results have research value in three main categories: theoretical, public policy, and practical. Firs, at the theoretical level, the applicability of comprehensive analytical models is reiterated. It is in line with the second area referred to as well, according to which it offers input for designing strategies and incentive mechanisms to overcome financial barriers and promote adoption of technologies by businesses with a lower environmental impact, so that it can be relevant for those charged with forming public policies.

The third key thing is that the results are practical, as they encourage the use of platforms that manage the ecological footprint, connecting production technologies to recycling systems and advanced materials. Nevertheless, this shift for responsible production must go together with a sustainable organizational culture including the creation of new capabilities and measures. Like this, it would be equally relevant to reflect on economic and structural obstacles because understanding these process hindrances in the transformation stages would help organizations to take sound decision-making strategies and understand dynamics that need further attention. The sector is challenged by adopting new technologies necessitating interdisciplinary perspectives which may be achieved by the effective integration of stakeholders.

Conclusions

Technology innovation, which has increasingly become the enabler in an increasingly modernized textile industry, is the biggest vehicle for making the textile sector more responsible. But barriers social, regulatory and organizational stand in the way. Sustainability should mean not just new, powerful tools to make tech more efficient, but the ability to fit into the reality of complex production systems. Consequently, the adoption of emerging technologies can only become sustainable if a system-level framework is established that encompasses technical solutions, governance mechanisms, business strategies and collaboration processes driven by sector actors.

Thus, innovation is deemed to develop an integrated approach that alters commercial models. Therefore, it is important to construct theoretical and practical paradigms that can make possible a mixed vision which enables the emergence of circular, resilient, and transparent production models. Such models should not only be sustainable development-based but also harmonious with productive activity. Thus, organizations must develop practices which integrate technological innovation and social responsibility in order to become globally competitive in the future.

Both methodological and scope limitations of this study need to be cautiously considered. Methodologically, the research employs a systematic documentary analysis of academic and technical literature, a methodology that at its core is not conducive to the potential confirmation of findings with observable data in the context of a producing environment. Such an obsession with secondary sources places a greater exposure to prejudice in the acquisition and placement of the evidence and the type of information, which is produced may not be standardized, reliable or that other resources are comparable for. The variety of methodological approaches in the works discussed in the review also reduces the possibility of being able to formulate a firm generalization of the ability of technological innovations to be effective in the textile industry, thereby making the findings less robust.

The findings are limited by the lack of long-term studies in which the sustainability of the transformations is measured. The environmental metrics that were analyzed do not consider all potential dimensions included in the search equation, such as social impacts or indirect impacts on global value chains. Additionally, the barriers to technological adoption seen may vary according to geographic, economic, and regulatory factors, limiting the external validity of the results. Additionally, barriers to technology adoption can vary depending on the context. While this does not invalidate the contributions of this study, it does limit the external validity of the results. This highlights the need for future research.

Further study would benefit from further empirical analysis, such as case studies, longitudinal designs, and comparative analyses, to enrich the evidence on implementation in heterogeneous production contexts. Second, it should place a priority on developing more integrated environmental assessment frameworks in which sustainability assessments might be compared on technical, social, and economic grounds. Novel trends such as circular economy practices and digital traceability systems will need to be considered from the perspective of Industry 5.0 to understand their role in value chains and long-term competitiveness. Similarly, it would be helpful for the public and business decision-making process to explore the constraints imposed on technology adoption to frame applicable models.

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Author Declaration - CRediT Taxonomy

Autores Authors	Contributions
Sebastián Cardona-Acevedo	Conceptualization, formal analysis, research, methodology, visualization, writing – original draft, writing – revision and editing.
Alejandro Valencia-Arias	Conceptualization, supervision, validation, project management, fundraising, writing – revision and editing.
Jackeline Valencia	Data curation, formal analysis, research, validation, visualization, writing – review and editing.

Statement on the use of artificial intelligence

The authors **DECLARE** that, in the preparation of the article titled: “Emerging Technologies to Optimize Environmental Sustainability in the Textile Industry: A Systematic Review,” artificial intelligence (AI) was used to assist in the preparation of the manuscript. The authors declare that they reviewed and validated the content and assume full responsibility for the final version of the article.

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Forecasting Slovak GDP based on metal commodity prices as a tool for policymakers

Pronóstico del PIB eslovaco basado en los precios de los metales como herramienta para los responsables políticos

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Abstract: the paper examines the development of selected metal commodity prices in the global market in the context of the development of Slovakia´s GDP as a macroeconomic indicator GDP and identify which of the analyzed metal commodities are most closely linked to the Slovak economy. Research data were obtained from website Investing and Eurostat and converted into time series. Metal commodity prices were expressed in US dollars per ton, while GDP values were expressed in millions of US dollars. The data were processed using artificial intelligence, specifically recurrent neural networks with a Long Short Term Memory layer, which have strong potential to predict such types of time series. The experiment included predictive models based on artificial neural networks. Metal commodities also play a crucial role in the Slovak economy, and the research confirms that the development of copper, zinc and aluminum prices is correlated with Slovakia´s economic performance. Therefore, the country´s GDP can be forecasted with high accuracy based on the price movements of these selected metal commodities. The findings may assist policymakers as well as top management in the manufacturing industry, where input prices can be compared with developments in the national economy.

Keywords: copper, aluminum, zinc, prices, prediction, neural networks, GDP, Slovakia.

Resumen: el artículo examina la evolución de los precios de determinados metales en el mercado global en el contexto del desarrollo del PIB de Eslovaquia como indicador macroeconómico e identifica cuáles de los metales analizados están más estrechamente vinculados a la economía eslovaca. Los datos de la investigación se obtuvieron del sitio web Investing y de Eurostat y se convirtieron en series temporales. Los precios de los metales se expresaron en dólares estadounidenses por tonelada, mientras que los valores del PIB se expresaron en millones de dólares estadounidenses. Los datos se procesaron mediante inteligencia artificial, concretamente redes neuronales recurrentes con una capa de memoria a largo plazo (MPM), que poseen un gran potencial para predecir este tipo de series temporales. El experimento incluyó modelos predictivos basados en redes neuronales artificiales. Los metales también desempeñan un papel crucial en la economía eslovaca, y la investigación confirma que la evolución de los precios del cobre, el zinc y el aluminio está correlacionada con el desempeño económico de Eslovaquia. Por lo tanto, el PIB del país puede pronosticarse con gran precisión basándose en las fluctuaciones de los precios de estos metales. Los hallazgos pueden ser de utilidad tanto para los responsables políticos como para la alta dirección del sector manufacturero, donde los precios de los insumos pueden compararse con la evolución de la economía nacional.

Palabras clave: cobre, aluminio, zinc, precios, predicción, redes neuronales, PIB, Eslovaquia.

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Introduction

A country's gross domestic product (GDP) is shaped by domestic economic factors and external sectors (Gupta & Kumar, 2023). Commodity prices, including those of metals and raw materials, have a significant impact on GDP per capita across different income groups (Sen *et al*., 2024). These prices also serve as valuable indicators of current and future global economic activity, as factors derived from commodity price movements provide useful information for short-term forecasting of global GDP and industrial production (Matsumoto *et al*., 2023). Dependence on commodities is positively associated with economic growth, whereas commodity price volatility shows a negative relationship with economic growth. Moreover, commodity dependence is positively linked to long-term commodity price volatility (Wanzala and Obokoh, 2024). Metals such as steel, which is an indispensable and durable material used across all sectors and contributes significantly to the global economy, must exhibit enhanced mechanical properties to meet contemporary industrial requirements (Kumar and Sil, 2023). The price volatility of industrial metals shows dynamic transmission patterns and interconnectedness with other markets, which have been significantly affected by major global events such as the COVID-19 pandemic and the Russia-Ukraine war (Shao *et al*., 2024). Commodity price shocks also entail important macroeconomic consequences (Ybrayev *et al*., 2024). Commodity-specific demand factors and supply shocks represent key sources of confounding variables (Matsumoto *et al*., 2023).

Volatility in mineral prices can pose significant risks to developing countries, particularly those that are heavily dependent on mineral production, as evidenced by the high sensitivity of fiscal revenues to mineral price shocks (Urbina and Rodríguez, 2023). The depletion of mineral resources has tangible adverse effects on socio-economic outcomes, in particular through rising energy poverty, and thus disproportionately affects economies dependent on mineral extraction (Yasmeen *et al*., 2024). In the V4 countries, GDP growth has been strongly affected by a series of external shocks, including the COVID-19 pandemic and the Russia-Ukraine war, with forecasts indicating a major shock and a shift to a lower steady-growth trajectory (Apanovych *et al*., 2024). Improving the accuracy of macroeconomic expectations is essential for informing effective policy decisions, as information frictions can substantially shape macroeconomic dynamics and policy outcomes (Link *et al*., 2023). Accurate and reliable GDP forecasting is crucial for sound economic policy-making and risk management (Aisy *et al*., 2025). Between 1993 and 2012, the gross

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domestic product (GDP) of the Slovak Republic increased by 128%, and it continues to rise (Hájek and Rezny, 2014). The Slovak Republic can be characterized an industrially oriented economy, with the automotive industry playing one of the most important roles in it (Valásková and Kramárová, 2015). Metal price dynamics are very important for global economic activity, as metals serve as key inputs for industrial production and construction and reflect major global economic developments (Kara *et al*., 2023). Commodity prices have significant and time-varying effects on exchange rates, with the nature of these effects differing across countries, commodity sectors, and macroeconomic conditions (Wang and Cheung, 2023). The above studies clearly indicate that the ability to forecast developments in metal commodity prices and their impact on GDP is crucial for effective economic management and policymaking.

The application of machine learning methods to macroeconomic forecasting has produced promising results. For example, random forest regression was used to forecast medium-term developments in public debt in EU Member States using a broad range of macroeconomic, fiscal, and monetary indicators (Zarkova *et al*., 2023). Commodity prices reflect the process of information discovery related to the global business cycle and information frictions in financialized commodity markets (Peersman *et al*., 2021). Metal commodities are important for forecasting future GDP because they constitute essential inputs for industrial production, signaling trends in economic growth and development. Metals are an irreplaceable industrial raw material and hold strategic importance for economic advancement (Kahraman & Akay, 2023).

Numerous studies have employed various techniques or models to analyze and forecast GDP. Metal price dynamics are highly significant for global economic activity, given their role as key intermediate goods for industrial production and construction, as well as their function as investment assets (Kara *et al*., 2023). Zhang *et al*. (2023) examine the relationship between energy and economic indicators for GDP forecasting using a Long Short-Term Memory model with wavelet analysis. The analysis by Chang and Levinson (2023) identifies time-varying inefficiencies in GDP forecasts between FOMC meetings and provides evidence of inefficiencies in inflation forecasts. Szabo (2024) presents a fully probabilistic approach to combining model-based predictions with survey data, applying this method to estimate a real GDP growth model in the United States. Alkhareif and Barnett (2022) developed monthly GDP forecasts for Saudi Arabia by estimating a Generalized Dynamic Factor Model (GDFM) on a panel of 272 variables covering the period from January 2010 to June 2018.

Santos et al. (2021) used a Long Short-Term Memory (LSTM) architecture to predict Brazilian ethanol spot prices 3, 6, and 12 months ahead, finding that the 63-day model demonstrated the best convergence and produced the smallest forecast errors compared to the 126-day and 252-day models.

Cuaresma *et al*. (2024) developed an econometric framework for forecasting commodity prices that incorporates different dynamics across economic regimes. They tested regime-dependent threshold models on the Goldman Sachs commodity index and its five sub-indices. The results show that allowing for regime-dependent dynamics significantly improves prediction accuracy. Guo *et al*. (2024) developed an improved long short-term memory (LSTM) model combined with convolutional neural networks (CNNs) and multi-year meteorological data to predict complex spatio-temporal patterns. Li *et al*. (2023) demonstrated that the Long Short-Term Memory (LSTM) network architecture has proven to be very promising for forecasting Brazilian ethanol prices, showing strong predictive performance with minimal error. Jovanovic et al. (2025) proposed a fuel price forecasting model based on a multi-headed LSTM network optimized using a modified particle swarm optimization (PSO) algorithm. Li and Guo (2025) introduced a multi-factor method for warning against the risk of oil price volatility, combining risk factor analysis, price prediction, and volatility risk alerts using an LSTM model. The proposed risk-alert mechanism achieves excellent accuracy and can provide a scientifically grounded reference for government intervention policies. Enilov (2023) use the time-varying mixed-frequency autoregressive interpretation vector model (TV-MF-VAR) to examine the causal relationship between monthly commodity prices and quarterly economic growth from January 1980 to March 2020. Wang and Zhang (2025) proposed an innovative hybrid approach to improve the accuracy of oil futures price forecasting. This approach integrates optimized variational mode decomposition, an attention mechanism, and a stochastic error correction algorithm into a deep bidirectional LSTM network. Zhao *et al*. (2025) introduced a three-step LSTM-Transformer-XGBoost fusion framework for highly accurate prediction of gold futures prices. The architecture integrates LSTM for long-term temporal dependencies.

Wang *et al*. (2023) proposed a hybrid EEMD-CNN-ILSTM forecasting model for the price of oil futures. The experimental results indicate that the model is more efficient and accurate compared to the seven benchmark prediction models. Ab Khalil and Abu Bakar (2023) found that among the deep learning algorithms tested for predicting the Malaysian stock market, Long Short-Term Memory (LSTM) model outperformed the Multilayer Perceptron (MLP) and Convolutional Neural Network (CNN) models. Song and Choi (2023) proposed new hybrid models for forecasting the closing prices of the DAX, DOW, and S&P500 indices. Kim and Jang (2023) concluded that for oil price forecasting, both LSTM-based and GRU-based models outperformed existing models, including vanilla LSTM and GRU models, as well as hybrid models incorporating CNN architecture. To improve the efficiency of the Long Short-Term Memory model (LSTM), Chen *et al*. (2023) applied a simulated annealing (SA) algorithm to determine the optimal combination of hyperparameters.

Based on the research carried out on suitable methods applicable for the prediction and analysis of the impact of metal commodities on national economies, the LSTM method was selected, as it appears to be the most appropriate for forecasting time series and for modelling selected metals indicators together with selected macroeconomic indicators in Slovakia. Subsequently, the metal commodity most closely associated with Slovakia´s macroeconomic indicators will be determined. This focus leads to the formulation of the first research question:

RQ1: How is the prediction of selected commodity prices related to the development of the Slovak economy?

Once the relationship between the prices of selected commodities and the Slovak economy has been established, it is necessary to determine which commodity price or which combination of commodity prices has the strongest impact on the economy of Slovakia. This leads to the second research question.

RQ2: Which of the selected metal commodities is most closely linked to the Slovak economy?

The structure of the present scientific article includes a literature review of the problem, followed by the methodology, and the calculation using neural networks. The discussions and final results address the research questions and provide further clarification. The topic is highly relevant for predicting the development of national economies in an uncertain international environment.

Materials and Method

The analysis is entirely focused on the macroeconomic variables of Slovakia. Two data sources were used for data collection, specifically, macroeconomic variables such as GDP, were obtained from the Eurostat database (2023) ec.europa.eu/eurostat while information on the selected commodities, namely copper, zinc, and aluminum, was retrieved from the investing.com (2023) website. Macroeconomic variables were extracted specifically for Slovakia. The price data for metal commodities, except aluminum, are available for the period from 3 January 2012 to 7 June 2024. For aluminum, the

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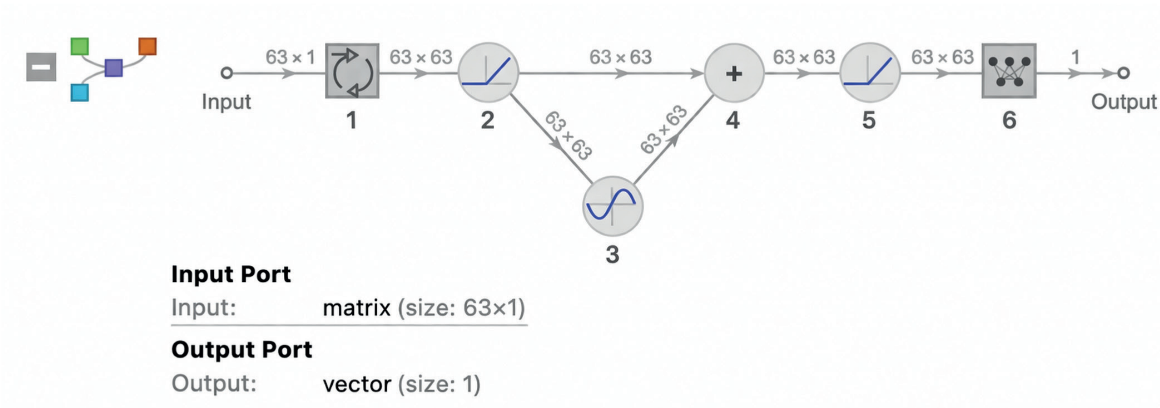
dataset covers the period from 1 July 2014 to 7 June 2024.

Artificial neural network (NN) models, especially the Long Short-Term Memory (LSTM) architecture, are used to predict the future development of macroeconomic indicators. The following parameters are required for constructing the neural network:

a) The number of elements in the neural network model depends on the input data and the model configuration. The input data refer to the dimensionality of the matrix, i.e.,
b) The activation function (Elementwise Layer) is used to facilitate signal propagation between individual NN layers. The selection of activation functions is based on the following options: Sine, Ramp (including the Rectified Linear Unit) and ArcTan.
c) A time series delay can be defined as a sequence of previous values used to predict future values. In this study, a delay of 63 days is applied.

The structure of the NN is identical except for the changes in the parameters. Figure 1 shows a diagram of the NN structure.

Figure 1
Neural network structure with LSTM layer



First, each commodity will be used separately to predict the macroeconomic variable. Subsequently, two variables will be combined, and finally all commodity prices whose inputs are processed correctly will be used together. The neural network consists of six main layers, in addition to the input and output layers. The six layers between the input and output layers are hidden ().

a) Input layer: A matrix representing commodity price data is provided. In the experiment, different matrix sizes will be examined, specifically, an array of size "63 x 2". The value "m" in the array represents the number of consecutive variables needed to calculate the next variable.

b) 1st hidden layer: This is the LSTM layer, which produces an output matrix with dimensions "m x n", where "m" is the time-series delay and "n" is chosen empirically. Here, the 63 x 2 input matrix generates a 63 x 63 output matrix). The value of "n" is incremented by 1.

c) 2nd hidden layer: This layer is built as an Elementwise Layer – Perceptron, which is a simple network acting as a perceptron. The activation functions of these layers will be selected randomly from the predefined set of activation functions.

d) 3rd hidden layer: This layer is another Elementwise layer with the same selection criteria as in the second hidden layer.

e) 4th hidden Layer: The fourth hidden layer, known as the "Plus" layer, performs elementwise addition. It receives input from the second and third hidden layers and transmits the output to the fifth hidden layer.

f) **5th hidden layer:** This layer is an Elementwise layer that uses the same activation function selection criteria as the second and third hidden layers.

g) **6th hidden layer:** The sixth hidden layer is a linear layer, which acts on the data matrix at the input (the picture shows a 63 x 63 matrix). Generates a vector with a single element as output.

h) **Output layer:** this layer predicts the macroeconomic variable.

The Long Short-Term Memory Layer is a network that consists of four components: Input Gate, Exit Gate, Forget Gate, and Memory Gate. LSTM processes an input matrix representing a sequence of vectors and generates a sequence of equal length. Each element of the input sequence element is represented as a vector of size k, while each output sequence element is a vector of size n.

Let denote the input sequence. The LSTM produces a sequence of states . The cell state is defined as follows:

$$c_t = f_t * c_{t-1} + i_t * m_t \quad (1)$$

Where:

c_t is the updated variable state at time t.
f_t Is the forget gate.
$c_{(t-1)}$ Is the initial state of the variable.
i_t Is the input gate.
m_i Is the memory gate.

$$i_t = \sigma[W_{ix}x_t + W_{is}S_{t-1} + b_i] \quad (2)$$

Where:

σ is Logistic Sigmoid.
W_{ix} is an input weight in the input gate matrix *n x k*.
x_t is an input variable, matrix *n x k*.
W_{is} Is the weight of the state in the input gate, matrix *n x n*.
$S_{(t-1)}$ Is the initial state.
b_i Is the bias, vector size *n*.

The state is defined as follows:

$$s_t = o_t * Tanh[c_t] \quad (4)$$

Where:

S_t Is a state of the variable.
O_t Is the output gate.
Tanh Is hyperbolic tangent.

The output gate is defined as follows:

$$o_t = \sigma[W_{ox}x_t + W_{os}S_{t-1} + b_o] \quad (5)$$

Where:

W_{ox} defines the input weight in output gate, matrix *n x k*.
W_{os} Is the weight of the state in output gate, matrix *n x n*.
b_o Is the bias, vector size *n*.

When compared to, for example, a Gated Recurrent Unit, the advantage of LSTM is in the forget gate:

$$f_t = \sigma[W_{fx}x_t + W_{fs}S_{t-1} + b_f] \quad (6)$$

Where:

W_{fx} Is an input weight in forget gate, matrix *n x k*.
W_{fs} Is an input weight in forget gate, matrix *n x n*.
b_f Is the bias, vector size *n*.

The main processes of LSTM include the memory gate (see below):

$$m_t = Tanh[W_{mx}x_t + W_{ms}S_{t-1} + b_m] \quad (7)$$

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Where:

W_{mx} defines the input weight in memory gate, matrix n x k.

W_{ms} Is the weight of the state in memory gate, matrix n x n.

b_m Is the bias, vector size n.

The prices of individual commodities were initially associated with one of the many macroeconomic factors for training the neural network. The analysis was subsequently expanded to include a broader set of commodity prices in the training dataset. First, the prices of individual commodities were selected and trained using an LSTM neural network to predict the GDP of Slovakia. Commodity prices were then combined to create multi-input configurations, allowing for the prediction of future GDP of Slovakia based on price combinations.

This complex procedure aimed to identify the most efficient model, measured by its accuracy in predicting the macroeconomic variable. The Pearson correlation coefficient was used to quantify both the strength and the direction of the linear relationship between actual and predicted macroeconomic values to assess the performance of the model. The most robust neural network configuration was then used to predict future macroeconomic data with greater accuracy and reliability.

The forecasting model is based on a Long Short-Term Memory (LSTM) neural network trained on daily copper, zinc, and aluminum prices, which were preprocessed through forward-fill interpolation and min–max normalization. A fixed 63-day sliding window was applied, where each sequence of 63 consecutive price observations served to predict the subsequent quarterly GDP value. All available historical data were used for training, as the objective of the study is a one-step-ahead forecast of GDP for the most recent quarter rather than generalized out-of-sample prediction. The network architecture follows the structure shown in Figure 1 and consists of an input layer (63 × n), a single LSTM layer with 63 hidden units, three nonlinear elementwise layers with activation functions drawn from {Sin, Ramp, ArcTan}, a combination layer, and a final linear output layer. The model was trained using the Adam optimizer, mean squared error loss, and standard hyperparameters applied uniformly across all commodity configurations.

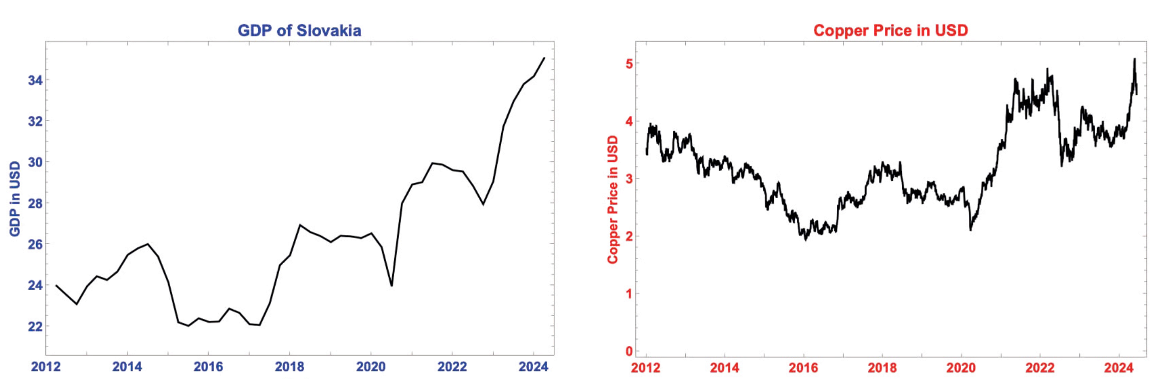
Results and Discussion

a) Prediction of GDP based on Copper Price

Figure 2 shows the quarterly GDP in one of the V4 countries, Slovakia, from 2012-Q1 to 2024-Q1 and the daily prices of copper recorded between 3 January 2012 and 7 June 2024. As shown in Figure 2, Slovakia's GDP exhibits a generally upward trend over the observed period, although several fluctuations are evident. Copper prices show smaller fluctuations.

Figure 2

Slovakia's GDP/Copper Price



Note. Prepared using the results of Smart PLS (p-value <0.05).

- **Prediction of GDP using copper price**

  The NN yields the corresponding correlation coefficients using a lag of 63 trading days, as summarized in Table 1.

Table 1

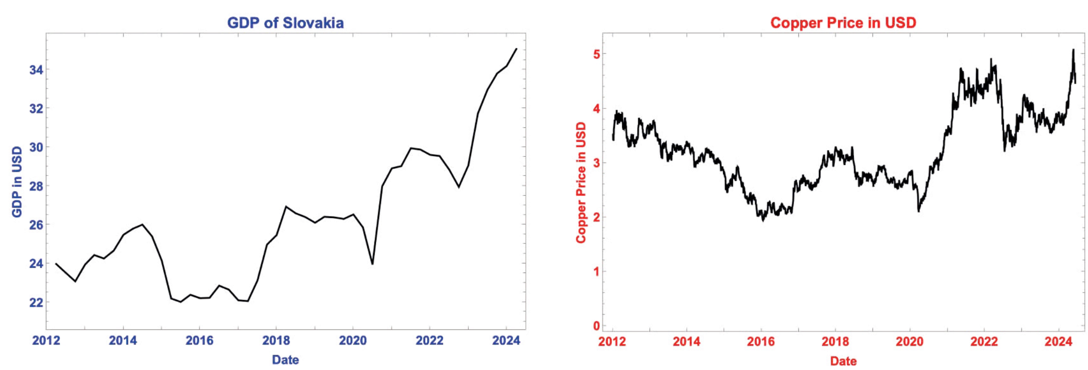
Basic configuration of network parameters and network performance

Network	Performance	1. Activation	2. Activation	2. Activation
1NN63	0.975244	Sin	Sin	Sin
2NN63	0.953500	ArcTan	ArcTan	Ramp
3NN63	0.995623	ArcTan	Sin	Ramp
4NN63	0.981382	Sin	Ramp	Ramp
5NN63	0.926517	ArcTan	ArcTan	ArcTan

Figure 3 shows the comparison between the actual GDP of Slovakia and the GDP predicted by the neural network.

Figure 3

Comparison between actual GDP and predicted GDP / Comparison between actual GDP and the best-performing prediction



Note. Prepared using the results of Smart PLS (p-value <0.05).

Table 2 shows the conditional distribution of actual and predicted GDP values.

Tabla 2

Conditional distribution of actual and forecast GDP values

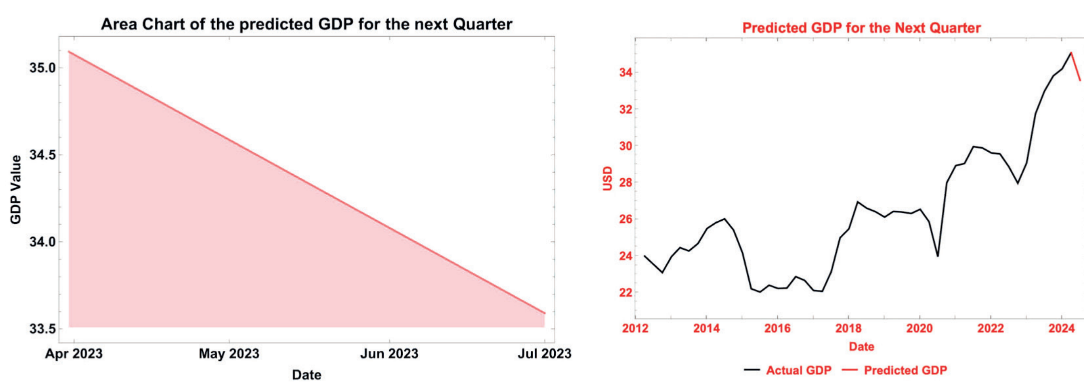
Description	GDP	LSTM NN GDP Prediction
Minimum	22,0582	21.9548
Maximum	31,5854	31.5107
Mean	25,6355	25.6339

Variance	6,76356	6.67973
Standard Deviation	2,60068	2.58452
Quartile Deviation	1,87124	1.74199
Median Deviation	1,93460	2.21883
Mean Deviation	2,13635	2.10184

Figure 4 illustrates the predicted GDP of Slovakia for the next quarter of the year 2024 (Q2). Based on copper prices for the next quarter, the model estimates Slovakia´s GDP at $33,590.2 million.

Figure 4

Area chart for projected GDP for the second quarter of 2024 (2Q) / Line chart for projected GDP for the second quarter of 2024 (2Q)

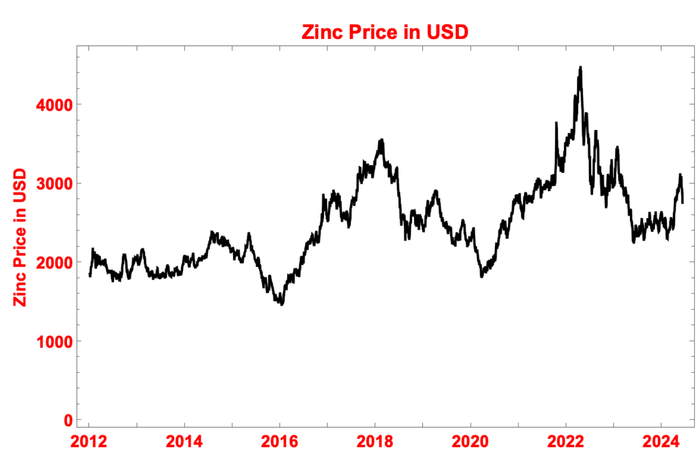


b) Prediction of GDP using zinc price

The NN provides the value of the correlation coefficient based on a lag of 63 trading days, as reported in Table 3.

Figure 5

Time series of zinc prices in USD



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- **GDP forecast using the zinc price**

The neural network provides the correlation coefficient value based on a lag of 63 business days, as shown in Table 3.

Table 3

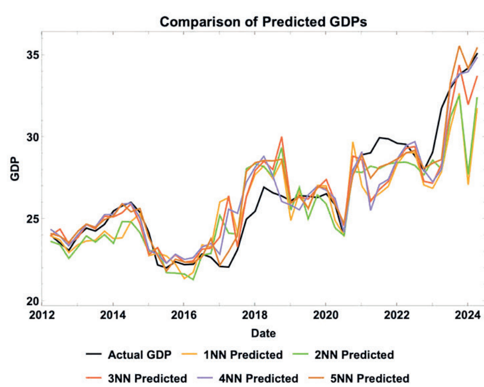
Basic configuration of network parameters and performance

Network	Performance	1. Activation function	2. Activation Function	3. Activation Function
1NN63	0.948407	ArcTan	Sin	Ramp
2NN63	0.958141	ArcTan	Sin	ArcTan
3NN63	0.943974	ArcTan	ArcTan	Ramp
4NN63	0.947254	Ramp	ArcTan	ArcTan
5NN63	0.976273	ArcTan	Sin	ArcTan

Figure 6 shows the comparison between the actual GDP of Slovakia and the predicted GDP values.

Figure 6

Comparison of actual and GDP prediction / Comparison with the most accurate GDP prediction



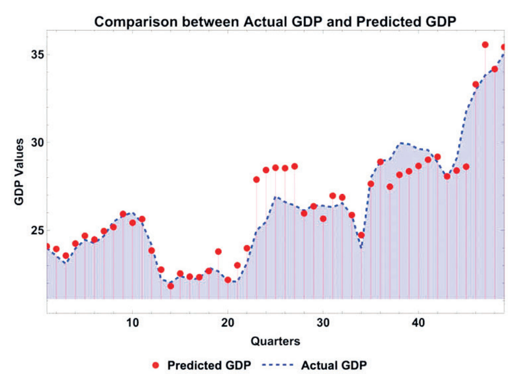


Table 4 shows the conditional distribution of both the actual GDP values and the predicted values.

Table 4

Conditional distribution of actual and GDP prediction values

Description	GDP	LSTM NN GDP Prediction
Minimum	22,0582	21,9913
Maximum	31,5854	30,3319
Mean	25,6355	25,6875
Variance	6,76356	6,33935

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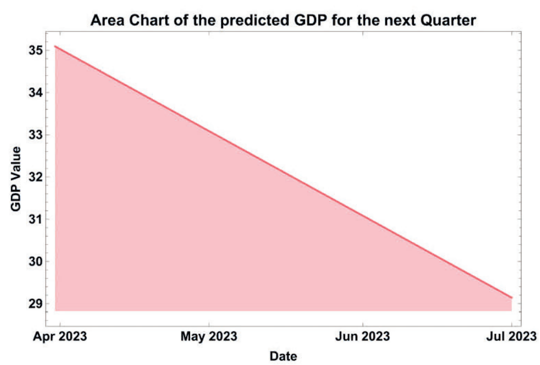
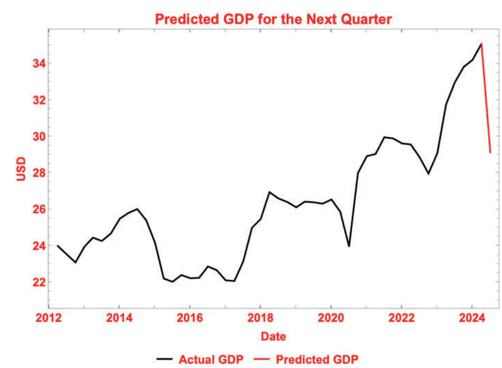
Description	GDP	LSTM NN GDP Prediction
Standard Deviation	2.60068	2.51781
Quartile Deviation	1.87124	2.06431
Median Deviation	1.93460	2.07049
Mean Deviation	2.13635	2.16407

Figure 7 shows the predicted GDP of Slovakia for the next quarter of the year 2024(Q2). Based on the predicted zinc prices, the estimated GDP value is $29,143.3 million.

Figure 7

Area chart and line chart of Slovakia's projected GDP for the second quarter of 2024 (Q2)



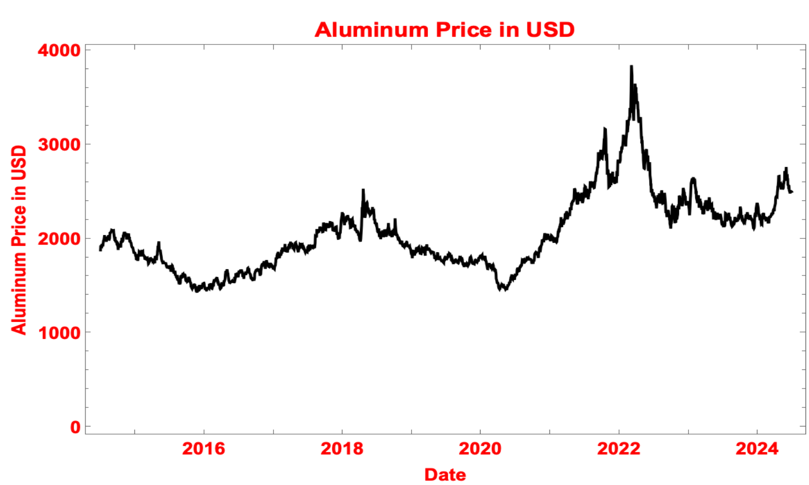


c) GDP forecast based on the price of aluminum

Figure 8 shows daily aluminum prices for the period from July 1, 2014, to June 7, 2024.

Figure 8

Aluminum price



- **Prediction of GDP based on aluminum prices**

 The NN generated correlation coefficients based on a considered lag of 63 trading days, presented in Table 5.

Table 5

Basic configuration of network parameters and performance

Network	Performance	1. Activation function	2. Activation function	3. Activation Function
1NN63	0.985741	ArcTan	Sin	ArcTan
2NN63	0.999964	Ramp	Sin	Ramp
3NN63	0.999620	Ramp	ArcTan	Ramp
4NN63	0.977247	ArcTan	Ramp	ArcTan
5NN63	0.882652	Ramp	ArcTan	Sin

Figure 9 shows the comparison between actual GDP values in Slovakia and the value of GDP predicted by all five NNs, as well as the comparison between the most accurate prediction and actual GDP.

Figure 9

Comparison between actual and predicted GDP / Comparison between actual GDP and the most accurate prediction

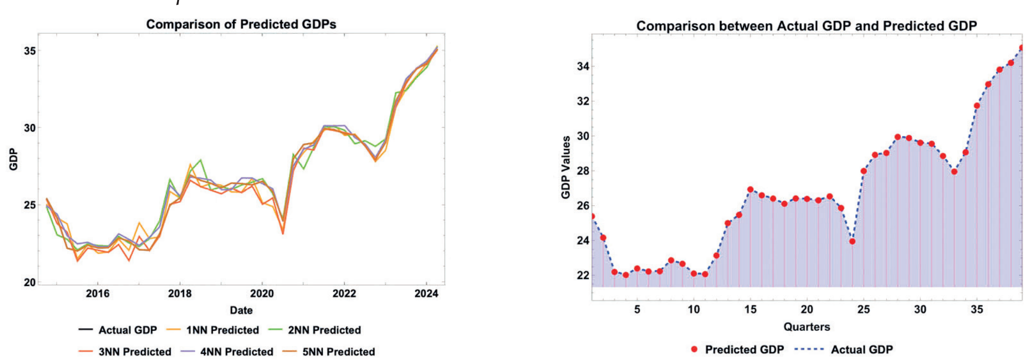


Table 6 summarizes the conditional distribution of actual GDP and predicted GDP values. The differences between the two distributions are minimal, with nearly identical minimum and maximum values.

Table 6

Conditional distribution of actual and predicted GDP values

Description	GDP	LSTM NN GDP Prediction
Minimum	22.0582	22.0539
Maximum	31.5854	31.5862
Mean	25.9508	25.9454
Variance	7.82051	7.81204

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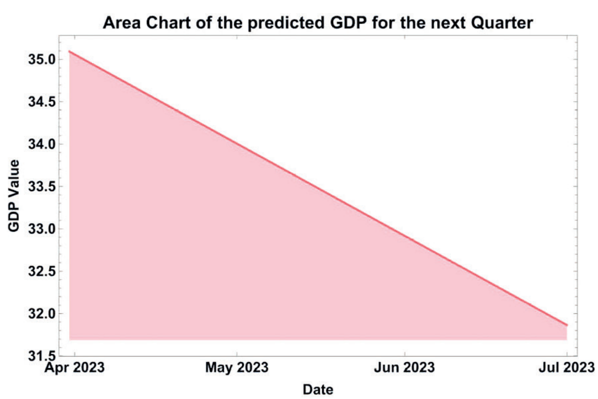
Description	GDP	LSTM NN GDP Prediction
Standard Deviation	2.79652	2.79500
Quartile Deviation	2.72840	2.72827
Median Deviation	2.66945	2.70400
Mean Deviation	2.29805	2.29627

Figure 10 shows the predicted GDP of Slovakia for the next quarter of the year 2024(Q2). Based on aluminum prices, the predicted GDP of Slovakia is $31,865.5 million.

Figure 10

Area chart and line chart of Slovakia's projected GDP for the second quarter of 2024 (Q2)



d) Prediction of GDP based on copper and zinc prices

Prediction of GDP using zinc and copper prices: The NN produced the correlation coefficient values with a considered lag of 63 trading days, shown in Table 7.

Table 7

Basic configuration of network parameters and performance

Network	Performance	Activation Function	Activation Function	Activation Function
1NN63	0.996931	ArcTan	ArcTan	Sin
2NN63	0.999334	Ramp	Sin	Ramp
3NN63	0.997197	Sin	Ramp	ArcTan
4NN63	0.999281	Ramp	Sin	ArcTan
5NN63	0.999350	ArcTan	Sin	Sin

Figure 11 shows the comparison between the actual GDP of Slovakia and the GDP values predicted by the five NNs, as well as the comparison between the most accurate result provided by the neural network and the actual GDP.

Figure 11

Comparison of actual and GDP prediction values / Comparison of actual GDP and the most accurate prediction value of Slovakia's GDP

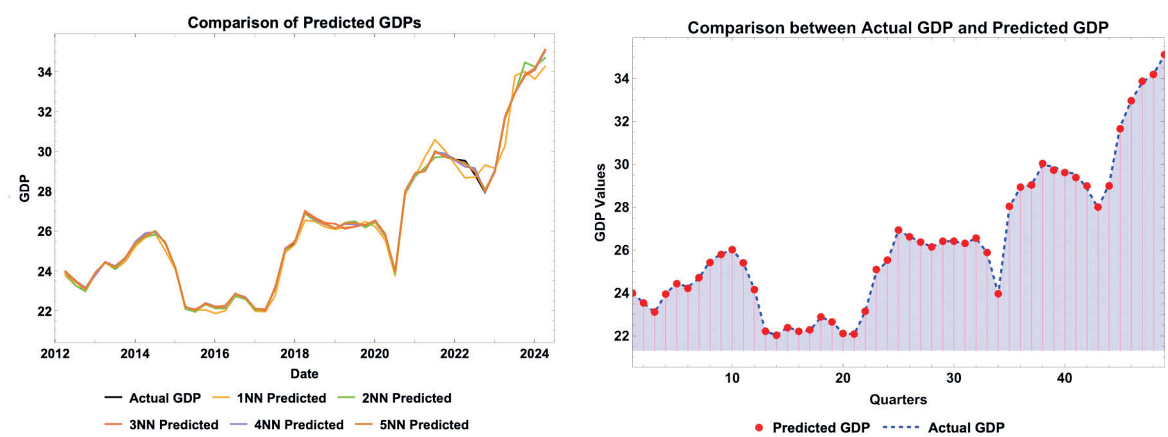


Table 8 shows the conditional distribution of the GDP and the predicted GDP. The differences in the conditional distribution of both GDP values are very small, and the minimum and maximum values are almost identical. This ensures very high accuracy, which is useful for future predictions and obtaining more precise values.

Table 8

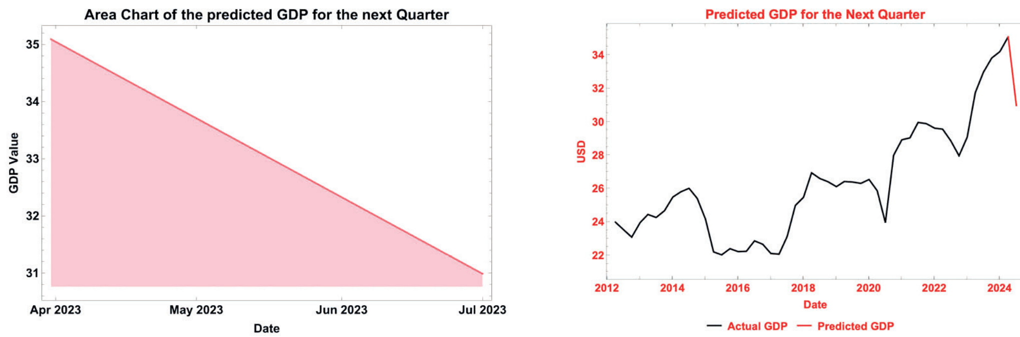
Conditional distribution of actual and GDP prediction values

Description	GDP	LSTM NN GDP Prediction
Minimum	22.0582	22.0678
Maximum	31.5854	31.4099
Mean	25.6355	25.6336
Variance	6.76356	6.73464
Standard Deviation	2.60068	2.59512
Quartile Deviation	1.87124	1.87715
Median Deviation	1.93460	1.97280
Mean Deviation	2.13635	2.13894

Figure 12 shows the predicted GDP of Slovakia for the next quarter of the year 2024(Q2). Based on zinc and copper prices for the next quarter, the predicted GDP of Slovakia is $30,988.4 million.

Figure 12

Area chart and line chart of Slovakia's projected GDP for the second quarter of 2024 (Q2)



e) Prediction of GDP based on copper and aluminum prices

- **Prediction of GDP using aluminum and copper prices:** The NN provides correlation coefficient values with a considered lag of 63 trading days, as shown in Table 9.

Table 9

Basic setting of network parameters and performance

Network	Performance	Activation function	Activation function	Activation function
1NN63	0.999553	Ramp	Sin	Ramp
2NN63	0.999655	Sin	ArcTan	Ramp
3NN63	0.986352	Sin	ArcTan	ArcTan
4NN63	0.997681	Ramp	Sin	Ramp
5NN63	0.999927	Ramp	ArcTan	Ramp

Figure 13 shows a comparison between Slovakia´s actual GDP and the predicted GDP values from all five NNs, as well as a comparison between the most accurate predicted value and the actual value of GDP.

Figure 13

Comparison between actual and GDP prediction / Comparison between actual GDP and the most accurate prediction

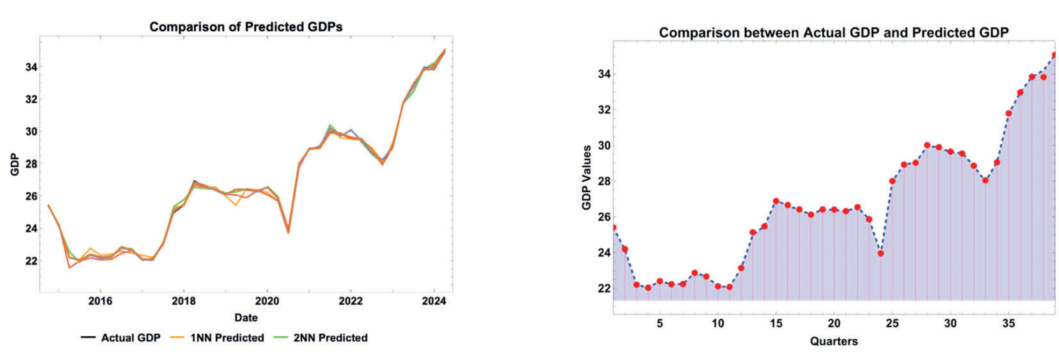


Table 10 shows the conditional distribution of actual and predicted GDP. The differences in the conditional distribution of both GDPs are minimal, with the minimum and maximum values nearly identical.

Table 10

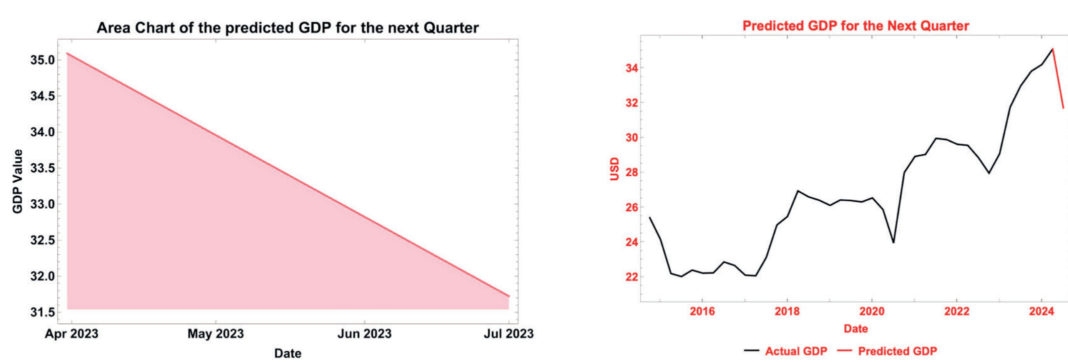
Conditional distribution of actual and GDP prediction

Description	GDP	LSTM NN GDP Prediction
Minimum	22.0582	22.0465
Maximum	31.5854	31.5866
Mean	25.9508	25.9621
Variance	7.82051	7.86151
Standard Deviation	2.79652	2.80384
Quartile Deviation	2.72840	2.72584
Median Deviation	2.66945	2.63684
Mean Deviation	2.13635	2.30752

Figure 14 shows the predicted GDP of Slovakia for the next quarter of 2024 (Q2). Based on aluminum and copper prices for the next quarter, the predicted GDP value is $31,724.1 million.

Figure 14

Area chart and line chart of projected GDP for the second quarter of 2024 (Q2)



f) Prediction of GDP based on aluminum and zinc prices

- **Prediction of GDP using aluminum and zinc prices:** The NN generates correlation coefficients with a considered lag of 63 trading days, shown in Table 11.

Table 11

Basic configuration of network parameters and performance

Network	Performance	Activation function	Activation function	Activation function
1NN63	0.999577	Ramp	ArcTan	Ramp
2NN63	0.997978	Sin	Ramp	Ramp

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Network	Performance	Activation function	Activation function	Activation function
3NN63	0,997074	Ramp	ArcTan	ArcTan
4NN63	0,999543	Ramp	ArcTan	Ramp
5NN63	0,982891	ArcTan	Sin	Sin

Figure 15 shows a comparison between Slovakia's real GDP and the projected GDP value.

Figure 15

Comparison of actual and GDP predicted values/Comparison of actual GDP and the most accurate GDP predicted value

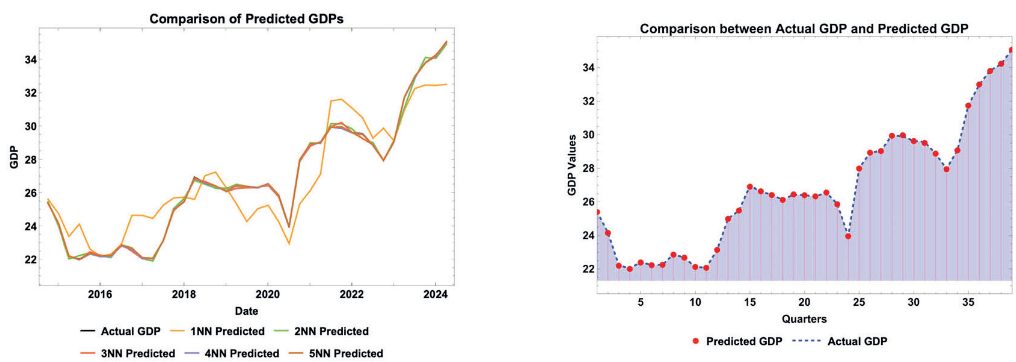


Table 12 shows the conditional distribution of actual and GDP predicted values. The differences in the conditional distribution are minimal, with nearly identical minimum and maximum values.

Table 12

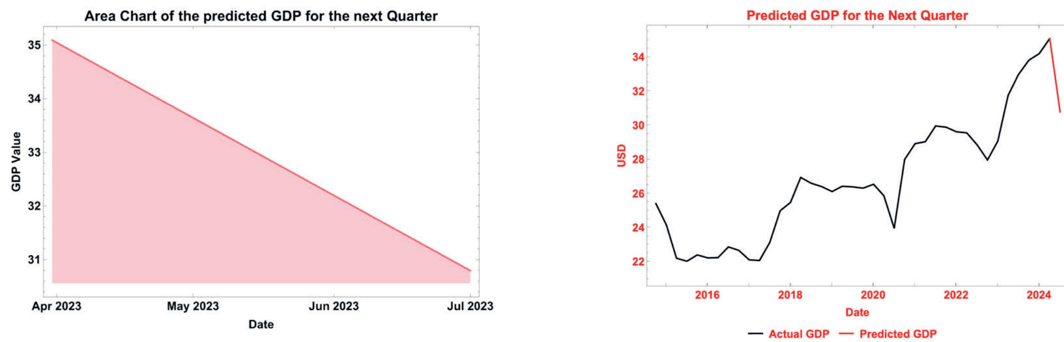
Conditional distribution of actual and GDP predicted values

Description	GDP	LSTM NN GDP predicted
Minimum	22.0582	22.0799
Maximum	31.5854	31.3627
Mean	25.9508	25.9503
Variance	7.82051	7.73149
Standard Deviation	2.79652	2.78056
Quartile Deviation	2.72840	2.72928
Median Deviation	2.66945	2.65914
Mean Deviation	2.29805	2.29061

Figure 16 shows Slovakia's GDP predicted for the second quarter of 2024 (Q2). Based on aluminum and zinc prices, Slovakia's predicted GDP is $30,795.6 million.

Figure 16

Area chart and line chart of GDP predicted for the second quarter of 2024 (Q2)



g) Prediction of GDP based on zinc, copper, and aluminum prices

- **Prediction of GDP using aluminum, zinc, and copper prices:** The NN provides correlation coefficients with a lag of 63 trading days, shown in Table 13.

Table 13

Basic configuration of network parameters and performance

Network	Performance	Activation function	Activation function	Activation function
1NN63	0.999899	Sin	Sin	Sin
2NN63	0.999987	ArcTan	Ramp	Ramp
3NN63	0.999124	Sin	Ramp	ArcTan
4NN63	0.999964	Ramp	Sin	Ramp
5NN63	0.999999	Ramp	ArcTan	Sin

Figure 17 shows the comparison between actual and predicted values of Slovakia´s GDP.

Figure 17

Comparison of actual and predicted GDP / Comparison of actual GDP and the most accurate GDP prediction

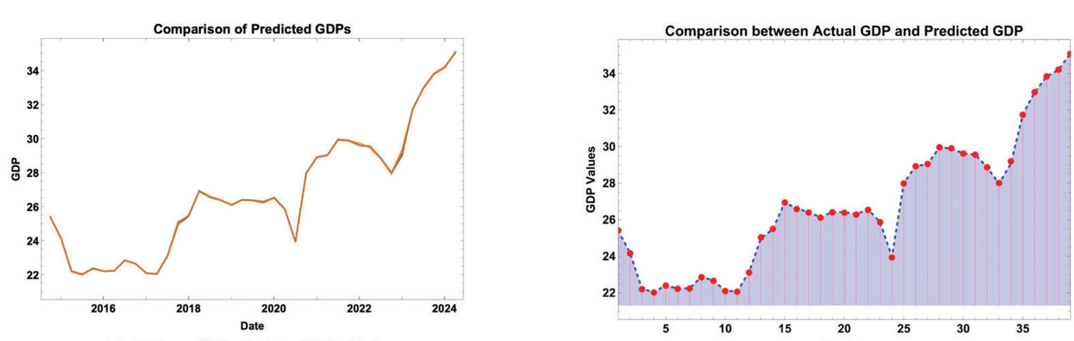


Table 14 shows the conditional distribution of actual and predicted GDP values. The differences in the conditional distribution of both GDPs are minimal.

Tabla 14

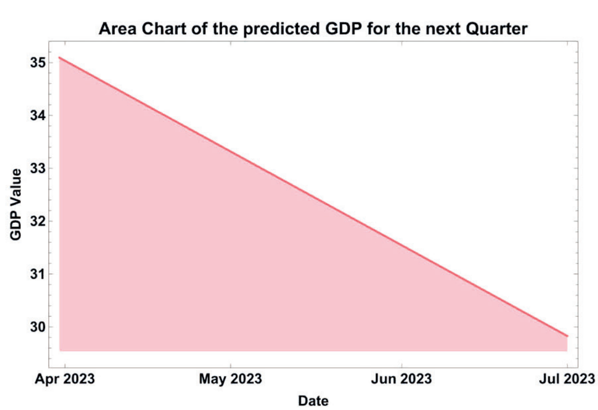
Conditional distribution of actual and predicted GDP

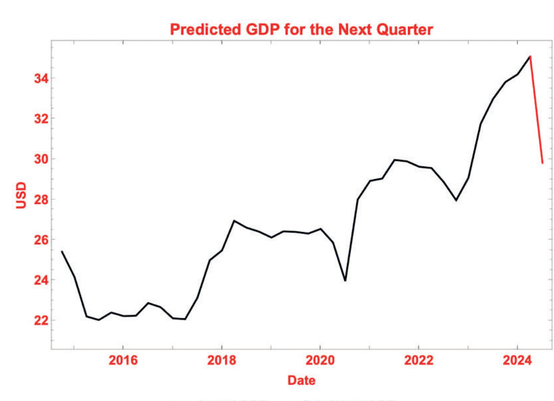
Description	GDP	LSTM NN GDP Predicted
Minimum	22.0582	22.0520
Maximum	3.5854	31.5857
Mean	25.9482	25.9488
Variance	8.05027	8.04900
Standard Deviation	2.83730	2.83708
Quartile Deviation	2.86282	2.86139
Median Deviation	2.60780	2.60935
Mean Deviation	2.36135	2.36104

Figure 18 shows the predicted GDP of Slovakia for the next quarter of the year 2024 (Q2). Based on aluminum, zinc, and copper prices, the predicted GDP of Slovakia is $29,828.4 million.

Figure 18

Area chart and line chart of predicted GDP for the second quarter of 2024





The comparison of prediction accuracy based on combinations of metal commodities yields the most accurate GDP prediction for the next quarter, as shown in Table 15.

Table 15

Accuracy of GDP Forecasts

Metal commodities	Accuracy	Predicted value
Zinc	0,976273	28,3054
Copper	0,995600	29,3196
Aluminum	0,999964	27,1593
Zinc and copper	0,999350	27,4339
Zinc and aluminum	0,999577	29,8282
Aluminum and copper	0,999927	28,9072
Aluminum, copper, and zinc	1,000000	30,1207

When forecasting Slovakia's future GDP based on individual metal commodities, the predicted GDP values exhibit fluctuations. The predictive method indicates that Slovakia's GDP for Q2 2024 is expected to decrease by between \$1.5028 and \$5.9497, suggesting a decline in economic output.

Although no additional statistical models were applied, internal robustness is supported by the consistency of results across all 15 LSTM configurations. Regardless of the activation functions or combinations of commodities used, all models produce extremely high correlation coefficients (0.97–1.00), and the conditional distributions of predicted GDP closely correspond to those of the actual data. The stability of these results across multiple network structures serves as an internal robustness check, demonstrating that the key findings are not dependent on a single model specification.

Discussion for RQ1:
How is the prediction of selected commodity prices related to the development of the Slovak economy?

The presented results include a graphical representation of the price time series trend for zinc, copper, and aluminum. The tables provide statistics on the distribution of actual and projected GDP on the basis of individual metal commodities and their combinations.

The selected time series proved to be the most suitable basis for predicting future developments of selected metal commodities in relation to Slovakia's GDP. For zinc and copper, the time series covers the period from 1 January 2012 to 7 June 2024. For aluminum, prices were available for the period from 1 July 2014 to 7 June 2024. The results confirmed the assumption that neural networks with an LSTM layer and a 63-day lag are the most suitable for predicting the future price developments of the selected metal commodities.

When forecasting Slovakia's GDP using aluminum, zinc, and copper prices, the NN provides the values of the correlation coefficient with a considered lag of 63 trading days. Among the five neural networks evaluated, the 5NN63 neural network (0.999999) demonstrated the highest accuracy, employing a combination of Ramp, Sin, and Sin as activation functions.

Based on these findings, it can be concluded that the development of selected metal commodities is strongly linked to the development of GDP in Slovakia. The most accurate GDP forecasts of Slovakia's GDP range between \$29.1433 billion and \$33.5902 billion, with the most accurate result being achieved when using aluminum prices. Slovakia's projected GDP for the second quarter of 2024 is \$31.8655 billion.

Overall, it can be stated that the predictions of prices for selected commodities, namely zinc, copper, and aluminum, can be associated with the Slovak economy via the macroeconomic indicator of GDP.

The article contributes to the existing literature by demonstrating the relationship be-

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tween the prices of selected metal commodities, including their combinations, and selected macroeconomic indicators of Slovakia. The findings are consistent with those of Rokicki & Perkowska (2021), who identified a strong correlation between steel consumption and economic indicators in the Czech Republic.

The novelty of the article is also evidenced by the demonstrated ability to predict Slovakia's GDP using copper, aluminum, and zinc prices. Overall, the results show that LSTM models capture the link between metal prices and GDP with high accuracy, ranging from 0.97 to 1.00. Models based on aluminum perform about 2–3% better than those based on zinc, indicating that the Slovak economy responds more strongly to metals with higher industrial relevance. The narrow gap between actual and predicted values confirms that commodity-driven LSTM forecasts can reliably reflect short-term economic movements.

Discussion for RQ2:
Which of the selected metal commodities is most closely linked to the Slovak economy?

Most of the research focuses on forecasting Slovakia's GDP through the development of zinc, aluminum, and copper prices using neural networks.

First, Slovakia's GDP was predicted based on the prices of individual selected commodities, followed by predictions using all possible combinations of copper, zinc, and aluminum prices. Projections were made for the second quarter of 2024.

When evaluating the impact of individual commodities, aluminum prices showed the strongest link to the development of Slovakia's GDP. The 5NN neural network with a 63-day lag, achieved a reliability of 0.999999 and a predicted GDP value of $31.8655 billion. In the case of zinc, the reliability was lower (0.948931), also determined using the 5NN63 neural network. The projected value of Slovakia's GDP based on zinc prices is $29.1433 billion. Predicted GDP values for all selected commodities show a decline compared to the previous quarter.

Regarding combinations of individual metal commodities, the combination of zinc and copper achieved the highest accuracy using the 3NN63 neural network (0.999896), with a projected GDP in Slovakia for the second quarter of 2024 being $30.9884 billion. The combination of copper and aluminum shows comparable accuracy (0.999987) using the 2NN63 neural network, projecting a GDP of $31.7241 billion. The combination of zinc and aluminum demonstrates slightly better accuracy (with a reliability of 0.999983) using the 5NN63 neural network, projecting a GDP of $30.7956 billion.

For the combination of all three selected metal commodities (zinc, aluminum, and copper), the second highest accuracy was achieved by the 5NN63 neural network (0.999997). Based on aluminum, zinc, and copper prices, Slovakia's GDP is predicted to be $29.8284 billion in the second quarter of 2024. GDP forecasts based on combinations of selected metal commodities decreased compared to the previous quarter, reflecting the impact of the economic crisis in Europe caused by the war conflict in Ukraine and the fading effects of the COVID-19 pandemic.

These results confirm that Slovakia's GDP development can be predicted with high reliability using global market prices of zinc, copper, and aluminum. Among all analyzed commodities, aluminum prices have the greatest impact on GDP forecast of Slovakia. The differences in predicted GDP values provide useful policy-oriented scenario insights. For example, copper-based forecasts exceed zinc-based forecasts by more than USD 4 billion, showing that weaker metal prices correspond to lower GDP expectations. A 10% decline in key metal prices would likely shift forecasts toward the lower end of the range observed in zinc-based models. Such scenarios can help policymakers anticipate how external commodity shocks may affect short-term GDP dynamics.

Conclusions

The aim of the paper was to examine the relationship between predicted prices of selected metal commodities, namely copper, zinc, and aluminum, and the development of GDP in Slovakia, on the example of selected metal commodities. The research was limited to a specific geographical area and period.

Based on the findings regarding GDP forecasting, it can be concluded that numerous methods and approaches exist, each with its own limitations and advantages. Therefore, it is important to combine traditional econometric methods with modern machine learning and deep learning techniques, alongside careful selection of appropriate predictors, is essential. Significant fluctuations in GDP growth may reduce the predictive power. This highlights the importance of stable economic indicators and the analysis of factors contributing to economic volatility.

The GDP data for Slovakia cover the period from the first quarter of 2012 to the first quarter of 2024. The experiment included predictive models based on artificial neural networks (NN) with an LSTM layer, with a considered lag of 63 days. For zinc and copper, the analysis covered trading days from 3 January 2012 and 7 June 2024; for aluminum, from 1 July 2014 to 7 June 2024. Using neural networks, the study analyzed the development of selected metal commodity prices and the prediction of Slovakia's GDP, which enabled answers to the first research question and forecasting GDP for the second quarter of 2024.

The GDP forecast for all selected commodities and their combinations indicate a decline compared to the previous quarter. The authors believe that this decline is partly attributed to the economic crisis in European countries, exacerbated by the war conflict in Ukraine, which has had a significant impact on economic growth itself.

The second research question addressed which commodity is most closely linked to the economy of Slovakia. The research focused primarily on GDP as a macroeconomic indicator, which reflects the key components of the national economy. The results indicate that the prices of all selected metal commodities are directly related to the development of Slovakia's GDP. The price of aluminum has the greatest influence on GDP forecasts. Among the selected metals, aluminum also shows the highest consistency in predicted values. As shown by the results, the value of GDP predicted using selected metal commodities decreased compared to the previous quarter. LSTM neural networks indicate that Slovakia's GDP in Q2 (2024) is expected to decline by between \$1.5028 million to \$5.9497 million. This finding reflects the impact of the economic crisis in Europe caused by the war conflict in Ukraine and the diminishing effects of the COVID-19 pandemic.

Using zinc and copper prices to predict Slovakia's GDP yields a correlation coefficient of approximately 95% between actual and predicted values. When aluminum prices are used, despite a shorter data series of less than two years, prediction accuracy increases by approx. 5%. This is further observed when combining zinc and aluminum, copper and aluminum, and zinc, copper, and aluminum. Even the long-term combination of zinc and copper prices from 2012 to 2024 demonstrates high predictive accuracy comparable to that achieved using aluminum. The individual price of the metal commodity and the combination of metal commodity prices, therefore, have a substantial influence on the prediction of Slovakia's future GDP.

This study provides insights for Slovak policymakers regarding the relationship between metal commodity prices and Slovakia´s GDP. Understanding these relationships highlights the relative impact of each metal commodity and their combinations on GDP forecasts. Focusing on commodity metals in Slovakia can thus significantly affect future economic development. Using more detailed datasets with longer time series and incorporating data from a more open economy could improve predictive accuracy. For the purposes of this study, data from the European market were considered sufficient. Potential future research may focus on a larger geographical area and longer time series. This study has several limitations. GDP data are quarterly while commodity prices are daily, which may introduce aggregation bias. Only three metals were included, excluding

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other economic drivers. The model was trained on the full sample for one-step-ahead forecasting, without long-term out-of-sample validation. Nevertheless, LSTM models achieve up to 5% higher accuracy than the weakest configurations, confirming their usefulness for short-term GDP assessment.

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Effects of technostress on continuance commitment and organizational performance in Chilean higher education institutions

Efectos del tecnoestrés sobre el compromiso de continuidad y el rendimiento organizativo en instituciones de educación superior chilenas

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Abstract: in the digital age, the use of multiple technologies and the need to continuously adapt to different tools and platforms generate new pressures and demands for workers. In this context, the present study examines the effect of technostress and job satisfaction influence in continuance commitment and organizational performance in Chilean universities. To this end, a questionnaire previously adapted and validated from previous studies was administered to civil servants and administrative staff at universities in southern Chile who use digital technologies in their work. A total of 240 valid responses were obtained and analyzed using structural equations (PLS-SEM). The results show that technostress has a positive and significant effect on commitment to continuity, an atypical finding that contradicts the prevailing literature, which traditionally associates technostress with negative consequences on work attitudes. In addition, it was confirmed that job satisfaction is a determining factor in linking commitment and organizational performance. These findings contribute to the literature on technostress in university settings by demonstrating that, under certain institutional conditions, technostress can coexist with attitudes of adaptation and job retention. In addition, the results offer relevant information for promoting digitization strategies aimed at strengthening job satisfaction and people management in digitized environments.

Keywords: technostress, technology, job satisfaction, continuance commitment, organizational performance, universities, digitization, PLS-SEM.

Resumen: en la era digital, el uso intensivo de tecnologías y la necesidad de adaptarse de manera continua a las distintas herramientas y plataformas generan nuevas presiones y exigencias para los trabajadores. En este contexto, el estudio analiza el efecto del tecnoestrés y la satisfacción laboral en el compromiso de continuidad y el rendimiento en instituciones universitarias de Chile. Para ello, se aplicó un cuestionario adaptado y validado desde estudios previos, dirigido a funcionarios y administrativos de universidades del sur de Chile que utilizan tecnologías digitales en su trabajo. Se obtuvieron 240 respuestas válidas, analizadas mediante ecuaciones estructurales (PLS-SEM). Los resultados evidencian que el tecnoestrés presenta un efecto positivo y significativo sobre el compromiso de continuidad, lo que constituye un hallazgo atípico y contrario a lo reportado por la literatura predominante, que tradicionalmente asocia el tecnoestrés con consecuencias negativas en las actitudes laborales. Además, se confirma que la satisfacción laboral constituye un factor determinante en la vinculación del compromiso y el rendimiento organizativo. Estos hallazgos aportan a la literatura sobre el tecnoestrés en el ámbito universitario al demostrar que sus efectos no son homogéneos ni exclusivamente negativos, sino dependientes del contexto institucional. Desde una perspectiva práctica, los resultados ofrecen información relevante para el diseño de estrategias de digitalización orientadas a fortalecer la satisfacción laboral y la gestión de personas en entornos digitalizados.

Kalabras clave: tecnoestrés, tecnología, satisfacción laboral, compromiso de continuidad, rendimiento organizativo, universidades, digitalización, PLS-SEM.

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Introduction

Technology in the digital age has transformed personal and work environments through the integration of resources, tools, and processes that drive innovation and organizational efficiency (Saidy *et al.*, 2022). Higher education institutions have progressively incorporated information systems and technologies for both academic activities and administrative management, particularly through the implementation of academic management platforms, institutional information systems, digital processing tools, and collaborative work solutions (Suresh and Mohanty, 2023). This process has required their employees to acquire new digital skills and continuously adapt to the technological changes accompanying the transformation of higher education (Heo and Jung, 2020). The COVID-19 pandemic has added complexity to the international debate on the risks and benefits associated with technologies, especially in the educational and academic context (Suresh and Mohanty, 2023).

The intensive incorporation of technologies has also generated new stress among workers, a phenomenon identified as technostress. This manifests itself in the face of technological complexity, insecurity regarding one's own digital skills, the need for constant training, the pressure for constant connectivity, and continuous technological changes—factors that can generate stress and overload in users (El Kiassi and Jahidi, 2023). These conditions directly affect well-being, behavior, and job satisfaction (Wang and Rashid, 2022).

Technostress manifests in business, organizational, and technological contexts, as well as in the field of higher education. Although the literature on technostress has grown in recent years, empirical studies conducted in higher education institutions, particularly in Latin America, remain limited (Herrera-Sánchez *et al.*, 2023) and focus on specific contexts where the dynamics of digitalization, working conditions, and institutional resources exhibit different characteristics (Saidy *et al.*, 2022). This limits regional empirical research, hindering the understanding of the impact of technostress on the well-being and performance of university staff, creating a significant gap that this study aims to address. The literature has emphasized the negative effects of technostress on organizational commitment, leaving potential adaptive responses by workers to technological demands in specific institutional contexts largely unexplored.

In Chile, digitalization has advanced, and more than 94% of households report having their own internet access, with digital connectivity serving as a basic service and a tool that enables a range of rights such as health, education, and work (Subsecretaría de Telecomunicaciones, 2023). However, the adoption of technologies in education was forcibly accelerated by the COVID-19 pandemic, driving the implementation of virtual and hybrid modalities (Comisión Económica para América Latina y el Caribe, 2021). However, faculty and administrative staff adopted these technologies without possessing the necessary digital skills, creating a significant barrier to digital transformation processes in higher education. Hence, it is interesting to study how technostress shows in university institutions where digitization impacts both the management and work life of their staff.

In this context, the present study aims to analyze the effect of technostress and job satisfaction on the commitment to continuity and organizational performance of administrative staff at Chilean universities, using a structural equation model based on partial least squares (PLS-SEM).

The main contribution of this study is to demonstrate a positive effect of technostress on continuance commitment, a finding that contrasts with the classical literature and raises the need to revise traditional theoretical models of technostress in light of digital transformation processes in higher education institutions. Furthermore, it offers valuable insights to design strategies related to people management and the use of digital technologies in the digital transformation process.

The study is structured as follows: first, a review of the literature on technostress, job satisfaction, continuance commitment, and organizational performance; followed by the study's hypotheses. Next, the methodology used, the main results of the analysis, and their corresponding discussion are presented. Finally, the conclusions and limitations of the study.

Technostress

According to Salanova (2003), technostress is the inability of individuals to cope with new technologies and can be interpreted as a mismatch between the user's demands and available resources, or as affective symptoms and anxiety related to technologies. For De Oliveira *et al.* (2025), it constitutes mental stress created by using technology, resulting in strong emotional responses associated with fear and anxiety. According to Al-Ansari and Alshare (2019), the experience of technostress is due to the attempt to manage digital technologies that are constantly changing and evolving in work environments. In this sense, technostress is directly associated with the stress experienced by people due to the use of digital technologies, and is considered a negative psychosocial effect of using these tools. This phenomenon is structured into three main dimensions: (a) affective symptoms linked to anxiety and fatigue, (b) unfavorable attitudes toward digital technologies, and (c) negative perceptions regarding one's own technological skills and competencies (Salazar-Concha *et al.*, 2022).

The creators of technostress state five dimensions: technological overload, technological intrusion, technological complexity, technological insecurity, and technological uncertainty (Ragu-Nathan *et al.*, 2008). These dimensions measure the levels of technostress experienced by employees in organizations that arise from the use of technology in the workplace, manifested through the development of physiological and psychological reactions (Kumar, 2024).

Technological overload describes an increase in the pace and volume of work, causing employees to perform their tasks at a rapid pace and spend more time on work. Technological intrusion refers to the invasive effect of technologies, which generates feelings of control and excessive connection to them, with the aim of staying in contact with supervisors and coworkers both during and outside work hours (Tarafdar *et al.*, 2015). When technology is perceived as too complex to perform a task or integrate into work, an employee may experience technological complexity. This is associated with situations where users feel inadequate regarding their skills and are forced to devote time and effort to learning and understanding aspects of the technology, causing the employee to feel intimidated and insecure (Harunavamwe and Ward, 2022). Technological insecurity refers to what workers experience when they fear losing their jobs and being replaced by new information systems or by better-trained employees with greater technological skills (Tarafdar *et al.*, 2019). Technological uncertainty describes situations or feelings of bewilderment caused by constant changes and updates in technology (Alcas *et al.*, 2019; Herrera-Sánchez *et al.*, 2024).

Job satisfaction, commitment to stay, and organizational performance

Job satisfaction is understood as the degree to which employees' needs are met by the organization, reflecting their well-being within the work environment. This construct is associated with the favorable or unfavorable emotions and perceptions that employees develop toward their professional activity (Alcas *et al.*, 2019). It also represents an emotional state arising from employees' appreciation of their jobs and the organization in relation to the stimuli they receive that allow them to meet their needs and expectations in exchange for performing their duties within the organization (Pedraza, 2020). In this sense, it constitutes an element that directly influences occupational health, commitment, and workers' positive attitudes toward their performance (Chiang-Vega *et al.*, 2021).

Commitment to continuity reflects the extent to which employees perceive the costs associated with leaving the organization. According to Becker (1960), an individual incurs a choice cost when they tie their interests to a process, or activity from which it is difficult to disengage in the medium term through a binding choice, such as, in this case, the decision to leave the organization. According to Santiago-Torner (2023), the reasons why an employee with a high level of continuity commitment remains in the organization include the following: a) fear of losing job stability, b) loss of status or professional recognition, c) the psychological and material costs associated with severing the employment relationship, and d) the accumulation of personal and social investments that employees make over time. According to Morais *et al.* (2024), factors such as congruent leadership and organizational support practices intensify commitment among employees with greater tenure. Taken together, these findings demonstrate that tenure and personal investment contribute to maintaining the employment relationship and a sense of belonging within the organization.

Organizational performance has been analyzed from various perspectives, considering the influence of multiple factors and conditions both within and outside the organization. In this regard, over time, non-financial and/or subjective variables have been incorporated to capture information about the organizational environment (Valenzuela and Martínez, 2015). According to Gutterman (2023), the measurement of organizational performance should not be limited solely to traditional financial indicators but should incorporate non-financial factors such as internal processes, innovation, and employee well-being. In the education sector, organizational performance improves processes and the quality of service offered to the academic community, which must be aligned with human resource competencies (Iqbal *et al.*, 2025); this is an important element for improving digitalized environments, where such performance depends largely on adaptability and technological innovation (Tarafdar *et al*., 2019).

Research hypothesis

The literature acknowledges the existence of a relationship between technostress and organizational factors, particularly in digitalized contexts (Tarafdar *et al.*, 2015; Zumayyah *et al.*, 2023; Kumar, 2024; Magno, 2020). Employees' perceptions of technologies can influence their assessment of various work- and organization-related aspects, affecting their work attitudes and behaviors, which are directly linked to individuals' organizational commitment (Heo and Jung, 2020). From this perspective, technostress is a relevant phenomenon for understanding workers' attitudinal responses in digitized environments.

The uncertainty stemming from continuous changes and updates in technologies can generate concerns and additional pressure on

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employees, which encourages them to engage in ongoing training (Harunavamwe and Ward, 2022). In the educational field, technostress takes on specific characteristics associated with institutional processes and the demands inherent to academic work. Empirical evidence shows that professors experienced difficulties adapting to online classes, reporting work overload associated with a lack of experience and insufficient technological competence compared to in-person teaching (Alcas *et al.,* 2019). Authors such as Herrera-Sánchez *et al.* (2024) note that university faculty who combine teaching duties with administrative responsibilities face high work demands, which can impact their well-being and professional performance. Technological overload and the demand for constant connectivity negatively affect faculty members' occupational well-being, organizational commitment, and job satisfaction (Saidy *et al.,* 2022).

Technostress tends to lead to a decrease in organizational commitment (Tarafdar *et al.,* 2015). However, continuance commitment follows a different logic than affective and normative commitment, as it is primarily linked to the perception of costs associated with leaving the organization (Santiago-Torner, 2023). Therefore, the relationship between technostress and continuance commitment may be moderated by the institutional context, the type of tasks, and job stability conditions. In highly digitized university settings, exposure to technological demands can coexist with perceptions of job continuity, professional adaptation, and the need for continuous updating (Hessari *et al.,* 2024), resulting in differentiated effects on continuance commitment. In this regard, even though technostress can undermine work well, and emotional connection to the institution (El Kiassi and Jahidi, 2023), it can also increase the perception of organizational dependence in contexts characterized by contractual stability, cumulative technological specialization, and limited external job alternatives (Taneja and Singh, 2018). Under these conditions and considering the features of the Latin American university context, growing technological demands may reinforce administrative staff's decision to remain, which leads to the following hypothesis:

H1: Technostress has a significant effect on administrative staff's commitment to remain with the organization.

Recent literature confirms that job satisfaction is associated with higher levels of organizational commitment and a greater intention to remain, highlighting the role of commitment as a mechanism that reinforces the positive effects of job satisfaction and reduces turnover intention (Wang and Rashid, 2022; Arce and Rojas, 2020; Olvera *et al.,* 2022). This link is explained by the fact that job satisfaction reinforces perceptions such as organizational justice, the quality of interpersonal relationships, and identification with institutional values (Olvera *et al.*, 2022). Research in higher education indicates that job satisfaction positively influences organizational commitment, which is associated with higher levels of retention and performance in the university context (Wang and Rashid, 2022). Furthermore, job satisfaction among academic and administrative staff is related to greater institutional identification, lower turnover, and better perceived performance, especially in contexts of organizational change and digitalization (Chiang-Vega *et al.*, 2021; Olvera *et al.,* 2022).

However, these effects do not operate in isolation but are shaped through interlinked relationships between work attitudes and organizational outcomes. In this regard, Arce and Rojas (2020) argue that satisfied and committed employees demonstrate greater retention within the organization and, furthermore, adopt prosocial behaviors oriented towards achieving institutional objectives. In this regard, Hernández *et al.* (2024) state that a high degree of job satisfaction has beneficial effects on organizational performance, as it can act as either a driver or a hindrance to achieving organizational objectives. Consequently, employee job satisfaction has a positive impact on organizational performance.

Job satisfaction has been linked to improvements in the quality of institutional services, reduced turnover, and greater effectiveness in digital processes. In the context of digital transformation in Chile, satisfied employees are more willing to use institutional information systems, which positively impacts overall organizational performance. Therefore, job satisfaction and commitment to continuity can act as precursors to performance by fostering alignment between personal and institutional goals. Based on the above, the following hypotheses are proposed:

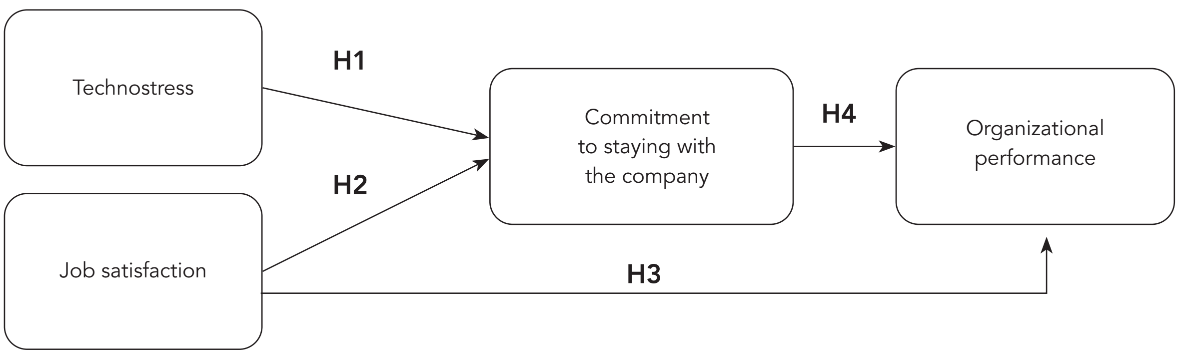
H2: Job satisfaction among administrative staff positively affects commitment to stay.

H3: Job satisfaction among administrative staff positively affects organizational performance.

H4: The continuity commitment of administrative staff has a positive effect on organizational performance.

Figure 1 shows the research model.

Figure 1.
Research Model



Materials and Methods

The study aims to validate the proposed hypotheses through an empirical analysis conducted in higher education institutions. To this end, a questionnaire adapted to the Chilean educational context and validated by experts in information technology and educational management studies was applied. Data were collected between April and July 2024 by administering a questionnaire via the *Google Forms* platform. Additionally, in-person visits were conducted with staff members to increase the response rate.

Participants were selected through non-probabilistic convenience sampling, targeting administrative staff at universities located in southern Chile—specifically in the Biobío and Ñuble regions—who use digital technologies in the performance of their duties and who had been with the organization for at least one year. Participation was voluntary, and all participants provided their informed consent prior to completing the questionnaire.

The measurement instrument was developed based on a review of the specialized literature. To assess technostress, the scale proposed by Tarafdar *et al.* (2019) was used; job satisfaction and commitment to continuity were measured using the scale by Ragu-Nathan *et al.* (2008); while organizational performance was evaluated following the proposal by Cardona and Calderón (2006). All scales used a five-point Likert-type format, with response options ranging from “strongly disagree” (1) to “strongly agree” (5).

The sample consisted of 240 valid responses, which was deemed adequate for structural equation modeling given the number of observed and latent variables in the model (*A-priori Sample Size Calculator for Structural Equation Models*), ensuring stable and reliable estimates of the model parameters.

Descriptive analysis of the data was performed using SPSS software (version 29), and

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partial least squares structural equation modeling (PLS-SEM) was conducted using SmartPLS software (version 4.0). The PLS-SEM technique is widely used in the social sciences for predictive and exploratory models, as it allows analyzing estimates between latent dependent and independent variables (Hair *et al*., 2017).

First, the measurement model—which is reflective and second-order—was evaluated following a two-phase procedure. In the first phase, the first-order dimensions of the technostress construct were evaluated by analyzing the validity and reliability of the items comprising them. Subsequently, these dimensions were grouped to form the second-order construct, whose validity was also evaluated. Once the measurement model was evaluated, the structural model was analyzed, testing the proposed hypotheses (Hair *et al*., 2017).

Results and Discussion

This section presents and discusses the main results of the study. Table 1 shows the descriptive analysis of the sample, revealing that 56.7% of the participants were men and 43.3% were women. Regarding age range, the largest proportion was concentrated on those aged 30–39 (25.0%) and 40–49 (23.3%), indicating a sample largely composed of individuals in the middle stages of their working lives. Regarding work experience, the sample is heterogeneous, as 29.6% of participants have less than 5 years of experience, 35.0% have between 6 and 10 years, 12.5% have between 11 and 15 years, and 22.9% have more than 20 years of work experience. Half of the participants have a university degree, and the distribution by job category reflects the structure of non-academic staff at Chilean universities, where administrative and technical positions requiring higher education predominate. Finally, the geographic distribution is evenly balanced between the Bío-Bío (45.8%) and Ñuble (54.2%) regions.

Table 3
Selection patterns and trade-offs between attributes (n=391)

Category	Subcategory	Number	Percentage
Gender	Female	104	43.3
	Male	136	56.7
Age Range	Up to 30 years 30 años	17	7.1
	30–39 years	60	25.0
	40–49 years	56	23.3
	50–59 years	44	18.3
	60 or older	38	15,8
Years of working experience	1 to 5 years	71	29.6
	6 to 10 years	84	35.0
	11 to 15 years	30	12.5
	16 to 20 years	12	5.0
	Over 20 years	55	22.9
Employment status	Executive	5	2.1
	Professional	38	15.8
	Technician	80	33.3
	Administrative	117	48.8

Level of education	High school	5	2.1
	Vocational training	38	15.8
	College graduate	120	50.0
	Master's	31	12.9
	Doctor	10	4.2
Type of institution	Public	223	92.9
	Private	17	7.1
Region	Bío-Bío	110	45.8
	Ñuble	130	54.2

First-order measurement model

To evaluate the first-order model, the dimensions comprising the multidimensional technostress variable were analyzed, considering the associated items. Both the first-order dimensions and the second-order variables were modeled reflectively in accordance with the recommendations of Hair *et al.* (2017). As part of the results shown in Table 2, it was found that the indicator loadings meet the model's individual reliability requirements, with a value of 0.60 required because this is an exploratory study (Hair *et al.*, 2017). The composite reliability and the extracted average variance meet the accepted parameters (values below 0.70 and 0.50, respectively), satisfying the reliability of the constructs and convergent validity.

Table 2

Loadings, composite reliability, and first-order AVE

Construct/Item		Loadings	Composite Reliability	Extracted Variance Mean (AVE)
Technological Overload (SOBT)			**0.833**	**0.868**
TOL1	Technology forces me to work much faster.	0.682		
SOBT2	Technology forces me to do more work than I can handle.	0.840		
SOBT3	Technology forces me to work under very tight deadlines.	0.645		
SOBT4	I am forced to change my work habits to adapt to new technologies.	0.772		
SOBT5	I have a heavier workload due to the complexity of the technology.	0.817		
Technological Invasion (INVT)			**0.933**	**0.915**
INVT1	I spend less time with my family because of technology.	0.879		
INVT2	I have to stay in touch with my job even during my vacations because of technology.	0.858		
INVT3	I have to sacrifice my vacations and weekends to keep up with new technologies.	0.852		
INVT4	I feel like technology is taking over my life.	0.823		

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	Technological complexity (COMPT)		**0.889**	**0.904**
COMPT1	I do not know enough about technology to do my job satisfactorily.	0.811		
COMPT2	It takes me a long time to understand and use new technologies.	0.802		
COMPT3	I do not have enough time to study and update my tech skills.	0.806		
COMPT4	I find that the new administrative staff or employees at this institution know more about computer technology than I do.	0.808		
COMPT5	I often find it too difficult to understand and use new technologies.	0.818		
	Technological insecurity (INST)		**0.777**	**0.847**
INST1	I feel a constant threat to my job security due to new technologies.	0.713		
INST2	I have to constantly update my skills to avoid being replaced.	0.702		
INST3	I feel threatened by coworkers with new technological skills.	0.844		
INST4	I do not share my knowledge with my coworkers for fear of being replaced.	0.684		
INST5	I feel that there is less knowledge sharing among coworkers for fear of being replaced by technology.	0.672		
	Technological uncertainty (INCT)		**0.976**	**0.892**
INCT1	There are always new developments in the technologies we use at our institution.	0.862		
INCT2	There are constant changes to our institution's software.	0.821		
INCT3	There are constant changes to the computer hardware at our institution.	0.816		
INCT4	There are frequent updates to the computer networks at our institution.	0.782		
	Job satisfaction (JS)		**0.885**	**0.927**
SL1	I enjoy doing the things I do at work.	0.913		
SL2	I feel proud to do my job.	0.900		
SL3	My job is enjoyable.	0.886		
	Commitment to continuity (CC)		**0.839**	**0.878**
CC1	Much of my life would be disrupted if I decided to leave my institution right now.	0.842		
CC2	At this moment, staying at my institution is a matter of both necessity and desire.	0.780		
CC3	I believe I have very few options to consider leaving this institution.	0.770		
CC4	It would be very difficult for me to leave my institution right now, even if I wanted to.	0.814		
	Organizational performance (RO)		**0.957**	**0.949**
RO1	Our institution is successful.	0.833		
RO2	Institutional objectives are fully achieved.	0.823		
RO3	Administrative staff and civil workers are generally satisfied with working at the institution.	0.663		

RO4	The institution is respected by the external community.	0.717
RO5	Our institution understands the needs of its clients.	0.807
RO6	Our institution's future performance is secure.	0.785
RO7	Our institution is capable of reinventing itself.	0.821
RO8	Our institution evolves faster than other universities.	0.723
RO9	Our institution is a model of good coordination.	0.790
RO10	Our institution reacts quickly to changes in the environment.	0.776
RO11	Our institution responds quickly to decision-making in a proactive and informed manner.	0.790
RO12	Our institution is a results-oriented entity.	0.705
RO13	Our institution's resources are used efficiently.	0.734

Note. Prepared by the authors based on results obtained using Smart PLS and the cited authors.

To assess discriminant validity, the Heterotrait-Monotrait (HTMT) criterion was used. As shown in Table 3, the HTMT values obtained fall within the thresholds recommended in the literature (Henseler *et al.*, 2015), which supports the discriminant validity among the constructs analyzed.

Table 3

First-order discriminant validity (HTMT)

	COMP	CC	INCT	INST	INVT	RO	SL
Continuity commitment (CC)	0.226						
Technological uncertainty (INCT)	0.271	0.125					
Technological insecurity (INST)	0.699	0.188	0.340				
Technological invasion (INVT)	0.425	0.304	0.122	0.465			
Organizational performance (RO)	0.088	0.319	0.245	0.123	0.093		
Job satisfaction (SL)	0.106	0.350	0.085	0.203	0.058	0.396	
Technological overload	0.380	0.201	0.206	0.244	0.528	0.130	0.125

Nota. Prepared by the author based on the results of the Smart PLS software.

Second-order measurement model

The results of the evaluation of the second-order measurement model are presented in Tables 4 and 5. Table 4 shows adequate internal consistency and convergent validity of the constructs. However, the "Technological Uncertainty" dimension was removed because it had a factor loading lower than the values recommended in the literature.

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Table 4
Factors, composite reliability, and second-order AVE

Construct/Item	Loadings	Composite Reliability	Extracted Variance Mean (AVE)
Technostress		0.751	0.822
Technological overload	0.648		
Technological invasion	0.815		
Technological complexity	0.754		
Technological insecurity	0.706		
Job satisfaction		0.885	0.927
SL1	0.913		
SL2	0.900		
SL3	0.886		
Commitment to continuity		0.838	0.878
CC1	0.841		
CC2	0.773		
CC3	0.774		
CC4	0.819		
Organizational performance		0.957	0.949
RO1	0.832		
RO2	0.823		
RO3	0.663		
RO4	0.717		
RO5	0.807		
RO6	0.785		
RO7	0.821		
RO8	0.723		
RO9	0.790		
RO10	0.776		
RO11	0.790		
RO12	0.705		
RO13	0.734		

Note. Prepared based on the results obtained in Smart PLS.

As shown in Table 5, the HTMT values obtained meet the quality criteria recommended in the literature (HTMT < 0.85), confirming the discriminant validity among the constructs of the second-order model.

Table 5

Second-order discriminant validity

	CC	RO	SL
Commitment to Continuity (CC)			
Organizational Performance (RO)	0.319		
Job satisfaction (SL)	0.350	0.396	
Technostress	0.367	0.125	0.137

Note. Prepared by the author using Smart PLS.

Structural model

The evaluation of the structural model includes explained variance (R^2), path coefficients (path coefficients ≥ 0.20), and predictive relevance (Q^2). Statistical significance, estimated using the bootstrapping technique (Hair *et al.*, 2017), was used to validate the hypotheses.

The results are presented in Table 6, showing that all proposed relationships are statistically significant, which supports the formulated hypotheses. Regarding the model's explanatory power (R^2), 18.4% of the variance in continuity commitment and 19.5% of organizational performance were explained by technostress and job satisfaction. These values reflect moderate explanatory power according to Cohen (1988), making them suitable for exploratory research and in complex organizational contexts such as higher education institutions (Bueno-Broterson *et al.*, 2025). Regarding predictive power, the values are positive (Q^2predict), confirming that the model adequately predicts out-of-sample data.

Table 6

Path coefficients, statistical significance, and predictive relevance

Relationship	Path Coefficient	Standard Deviation	t-statistics	Statistical significance (p-values)	Response
H1: Technostress -> Commitment to continuity	0.300	0.058	5.190	0.000	Se soporta
H2: Job satisfaction -> commitment to stay	0.309	0.068	4.562	0.000	Se soporta
H3: Job satisfaction -> Organizational Performance	0.338	0.061	5.532	0.000	Se soporta
H4: Commitment to continuity -> Organizational performance	0.198	0.068	2.928	0.003	Se soporta
	R^2	R^2 adjusted	Q^2predict		
Continuity constraint	0.184	0.177	0.155		
Organizational Performance	0.195	0.188	0.148		

Note. Prepared using the results of Smart PLS (p-value <0.05).

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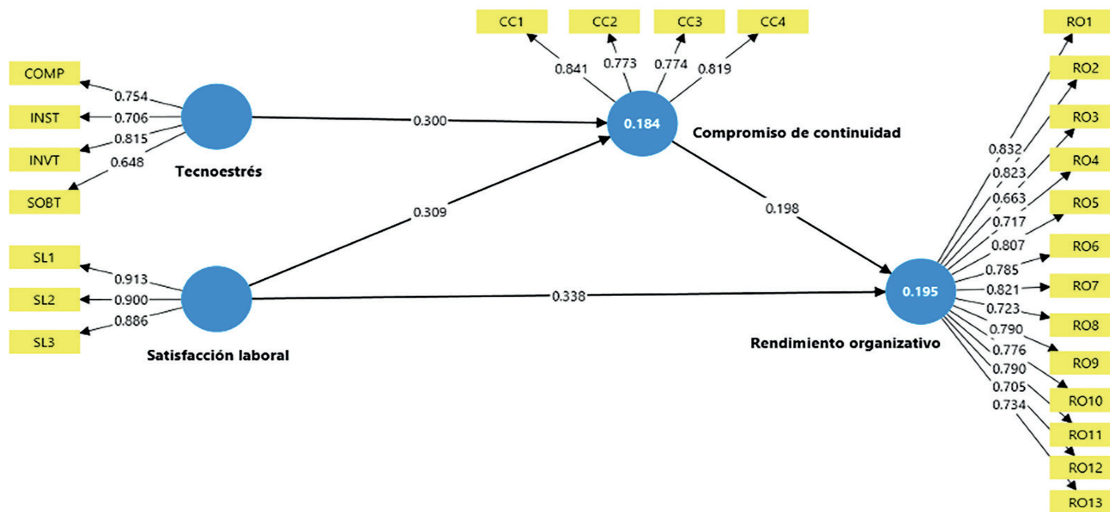
The results of the structural model are shown in Figure 2.

Figure 2
Structural model



Note. Prepared using Smart PLS SEM (version 4.0).

The results obtained provide insight into the impact of technostress and organizational commitment in work contexts characterized by increasing digitalization. A relevant finding is the positive and significant effect of technostressors on continuance commitment, which contrasts with the classical literature, which has generally reported negative effects of technostress on the various dimensions of organizational commitment (Molino *et al*., 2020; Kot, 2022; Tarafdar *et al*., 2019). However, previous studies have noted that certain technological demands can act as challenging stressors, promoting adaptation and learning processes at work (Kumar, 2024; Saavedra, 2023; Cuervo-Carabel *et al*., 2020). In this line, Mujtaba and Reis (2013) argue that technostress in educational contexts may reflect problem-solving efforts and the development of creative solutions aimed at improving professional performance. From this perspective, the effects of technostress are not uniform but depend on the organizational context, available resources, and worker characteristics (Califf *et al*., 2015). This finding suggests that administrative staff in Chilean universities develop adaptive responses to growing digital demands, reinforcing their decision to remain at the institution. It is important to note that this effect should not be interpreted as a strengthening of affective commitment, but specifically of continuance commitment, which is based on the perception of costs associated with leaving the organization (Santiago-Torner, 2023).

From this perspective, contextual and institutional factors become significant. According to Hessari *et al.* (2024), under certain conditions, employees can respond proactively to technostress, transforming it into a stimulus for commitment and improved performance. For Kumar (2024), when support mechanisms and effective organizational management are in place, technostress can promote adaptive learning processes that strengthen the worker's bond with the organization. Likewise, Tarafdar *et al.* (2019) argue that the use of information systems under positive or motivating pressures can increase efficiency (for example, by working faster, reducing time, effort, and errors) and improve individual performance by generating perceptions of stability and continuity.

The descriptive results of the study reinforce this interpretation, as respondents positively value aspects associated with the use of technologies, such as the exchange of technological knowledge among coworkers, the speed of task execution, and involvement in technology optimization processes. These adaptive responses can be interpreted as prerequisites for stability and professional development in highly digitized university contexts, explaning the positive effect of technostress on commitment to continuity.

On the other hand, job satisfaction and commitment to continuity show a positive and significant relationship. This result is consistent with previous studies, demonstrating that satisfied employees develop more favorable attitudes toward their organization and tend to remain with it, especially in the university setting where job stability and satisfaction influence the decision to stay (Wang and Rashid, 2022; Pedraza *et al*., 2021; García-Tamariz *et al.*, 2024). Continuance commitment showed a positive and significant effect on organizational performance, a finding consistent with that reported by Arce and Rojas (2020) in educational contexts, where staff retention is linked to higher levels of institutional performance. Job satisfaction also showed a positive and significant effect on organizational performance, in line with previous research, highlighting its influence on productivity and organizational outcomes (Magno *et al.,* 2020; Hernández *et al.,* 2024; Pedraza, 2020; Pedraza *et al.,* 2021). These results reinforce the idea that job satisfaction is important for the retention of administrative staff and the achievement of organizational objectives in Chilean universities.

Conclusions

The objective of this research was to analyze the effect of technostress and job satisfaction on commitment to continuity and organizational performance among administrative staff at Chilean universities. The results suggest that technostress can coexist with attitudes of adaptation and continuity in the face of growing digital demands. This phenomenon does not always act as a dysfunctional factor; rather, it can even strengthen employees' commitment to the organization under appropriate conditions of institutional support, training, and participation.

From the perspective of the university context, technological demands can be interpreted as functional challenges associated with job stability and continuity, particularly in higher education institutions characterized by relatively stable labor relations and progressive digitization processes. This finding is especially relevant for university management, as it demonstrates that the way in which digital transformation processes are designed and supported directly impacts staff loyalty to the institution.

Regarding the proposed research model, while it captures part of the dynamics of commitment to continuity and organizational performance, there are other contextual and individual factors not incorporated into the model (e.g., leadership, organizational climate, institutional culture) that could increase its explanatory power (R2). Hence, future research could delve deeper into the analysis of moderating effects such as length of service, type of institution, and level of digital experience.

From a theoretical perspective, this research reinforces the need to revise classical theoretical models of technostress in light of current digital transformation processes, especially in education. The findings challenge the traditional view of technostress as exclusively a negative antecedent, showing that, under certain organizational conditions, it can become a catalyst for commitment to continuity and job retention.

From a practical perspective, the results offer useful guidance for human resource management in higher education institutions, highlighting the importance of designing digitalization strategies accompanied by organizational support, continuous training, and opportunities for participation. Within this framework, the findings suggest that technostress can be managed institutionally in a way that it fosters adaptation and job retention. The controlled activation of such demands, accompanied by support policies and training, allows for addressing the high-pres-

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sure environments inherent to digital transformation without compromising the well-being of administrative staff. Thus, the results reinforce the need for university management to address technostress as an adaptive resource that contributes to strengthening commitment to continuity and institutional performance.

Finally, among the study's limitations are the use of non-probability sampling, participant selection, and the focus on universities in southern Chile, which limits the generalizability of the results. However, this geographical limitation opens opportunities for future comparative research in other regions of the country, as well as in different institutional contexts and levels of digital maturity, especially given the atypical result observed in the main hypothesis.

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Author Declaration - CRediT Taxonomy

Authors	Contributions
Sergio Araya-Guzmán	Conceptualization, methodology, formal analysis, original draft, writing.
Yarisel Bueno-Broterson	Methodology, writing, data management, original draft. Review and editing.
Marcela Guiñez-Pérez	Writing, research. Review and editing.
Cristian Salazar Concha	Conceptualization, methodology, formal analysis. Review and editing.

Statement on the use of artificial intelligence

The authors **DECLARE** that, in the preparation of the article titled: "Effects of technostress on commitment to continuity and organizational performance in Chilean higher education institutions," artificial intelligence (AI) was not used at any stage of the process.

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Entrepreneurial education and well-being in nascent university entrepreneurship

Educación emprendedora y bienestar en los emprendimientos nacientes universitarios

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Abstract: the development of entrepreneurial activity among students is key to reducing unemployment rates and shaping regional development. This study explores the impact of students' perceived well-being; the extent to which they perceive that the university is oriented towards achieving the Sustainable Development Goals (SDGs); and education as a moderator of nascent entrepreneurship. A quantitative cross-sectional approach was adopted, performing a binary regression analysis on a sample of 3,849 university students, A structured questionnaire based on the international GUESSS project, adapted for Latin-American, was used. Dependent variable was nascent entrepreneurship (NES), measured as a dichotomous variable. Independent variables corresponded to perceptions of: (1) student well-being (PWb) and (2) institutional perception of the SDGs, while (3) entrepreneurial education (EDU) was incorporated as a moderating variable. The results show a predominance of women (56,1 %), self-employed parents (52,4 %), and entrepreneurial training activities (22,8 %). Counterintuitively, perceived well-being and institutional perception of the SDGs have a negative and significant effect on nascent entrepreneurship. However, entrepreneurial education positively moderates the relationship between well-being and entrepreneurship, attenuating this effect and increasing the likelihood of entrepreneurial action. It can be concluded that education in nascent entrepreneurship improves the relationship between personal and contextual factors, increasing the likelihood of students becoming emerging entrepreneurs.

Keywords: business, education, well-being, sustainable development, university, entrepreneurial behavior, achievement motivation.

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Resumen: el desarrollo de la actividad emprendedora entre estudiantes es clave para reducir las tasas de desempleo y configurar el desarrollo regional. Este estudio explora el impacto del bienestar percibido por los estudiantes; el grado en que perciben que la universidad está orientada a la consecución de los Objetivos de Desarrollo Sostenible (ODS); y la educación como moderadora del emprendimiento naciente. Se adoptó un enfoque cuantitativo transversal, realizando un análisis de regresión binaria en una muestra de 3849 estudiantes universitarios, utilizando un cuestionario estructurado basado en el proyecto internacional GUESSS, adaptado para Latinoamérica. La variable dependiente fue emprendimiento incipiente (NES), medida como variable dicotómica. Las variables independientes correspondieron a percepciones de: (1) bienestar estudiantil (PWb) e (2) institucional de los ODS, mientras que (3) la educación emprendedora (EDU) se incorporó como moderadora. Los resultados muestran predominancia de mujeres (56,1 %), padres trabajadores independientes (52,4 %) y actividades de formación emprendedora del 22,8 %. Asimismo, se evidencia de manera contraintuitiva, que el bienestar percibido y la percepción institucional de los ODS tienen un efecto negativo y significativo sobre el emprendimiento naciente. Sin embargo, la educación emprendedora modera positivamente la relación entre bienestar y emprendimiento, atenuando dicho efecto e incrementando la probabilidad de acción emprendedora. Concluyéndose que la educación en emprendimiento naciente mejora la relación entre factores personales y contextuales, aumentando la probabilidad de los estudiantes en ser emprendedores emergentes.

Palabras clave: empresa, educación, bienestar, desarrollo sostenible, universidad, comportamiento emprendedor. voluntad de realización.

Introduction

Research in the field of entrepreneurship has experienced remarkable growth (Leiva *et al.*, 2021), becoming a priority for academic and government institutions in Latin-American, given that the professional decisions made by university students significantly influence their life trajectories, affecting not only their individual well-being but also the social and economic development of their communities. Therefore, it is necessary to encourage the creation of successful entrepreneurs with the aim of improving the socio-economic conditions of the population (Arce & Gordillo, 2023) contributing to the development of countries (Amorós, 2024) and mitigate the instability facing the region by encouraging entrepreneurial spirit among university students (Vallejo & Robalino, 2025).

Entrepreneurial behavior, from a behavioral perspective, encompasses individual factors such as self-efficacy, opportunity perception, and subjective well-being (Lent *et al.*, 2000). It also addresses environmental demands related to innovation and sustainability within the university context (Steira *et al.*, 2024). Theoretically, subjective well-being is traditionally defined as individuals' cognitive and affective evaluations of their lives, including life satisfaction and emotional balance (Diener *et al.*, 1999). Similarly, fundamental research on entrepreneurship education emphasizes its importance in generating entrepreneurial visions and mindsets, identifying opportunities, and learning processes that go beyond the acquisition of technical skills (Fayolle, 2013). Together, these perspectives highlight the role of higher education institutions in promoting entrepreneurial skills through educational practices that transform personal behaviors into more meaningful and viable actions.

Previous studies have shown that entrepreneurship education is pivotal life-long skills development, namely: problem solving, creativity, intrinsic motivation, and risk tolerance (Steira *et al.*, 2024). Moreover, research findings, such as those of Shir *et al.* (2019), demonstrate that these skills should be integrated into entrepreneurship training programs from the outset to foster transformative learning experiences. Likewise, authors such as Montes *et al.* (2023) argue that entrepreneurship is a higher education interdisciplinary field.

Despite these achievements, a significant gap endures in Latin America regarding entrepreneurial intention and the successful creation of businesses (Amorós *et al.*, 2016). This is due to limited training opportunities and poor institutional support for entrepreneurship in academic programs. Hence, it limits the development of effective and efficient support networks for business practice. For this reason, universities that endorse business-strengthening activities, practical training, extracurricular initiatives, and interaction with prominent entrepreneurs stand out in the region.

Accordingly, this study has focused more on integrative approaches that articulate individual competencies, educational environments,

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and social factors (Holienka *et al.*, 2017). The literature shows that the decision to become an entrepreneur is the result of the interaction among internal motivations and institutional, social, and cultural conditions. This supports regional development processes (Zancanaro *et al*., 2024) and is evident in variables such as creativity (Amorós *et al*., 2021), entrepreneurial skills (Steira *et al*., 2024), social commitment (Lechuga *et al.*, 2024), entrepreneurial culture (Shir *et al.*, 2019), experiential learning (Hassan *et al.*, 2021), and institutional support mechanisms (Borsi & Dőry, 2020), all of which are closely linked to education (Lechuga *et al.*, 2024).

However, a large proportion of the literature continues to approach entrepreneurial education from a predominantly technical perspective, emphasizing skills training and resilience strategies (Steira *et al*., 2024). From this perspective, while planning, innovation, and impact generation are identified as pivotal elements for business success, entrepreneurial education should also aim to generate social, economic, and cultural value through meaningful learning and experimentation. For this reason, entrepreneurship education should be systematically incorporated into university curricula (Guerrero & Lira, 2023).

Consequently, HEIs have been encouraged to align their educational strategies with the Sustainable Development Goals (SDGs), promoting entrepreneurship as a mechanism for social and economic development. In other words, societal demands have led academic programs to incorporate entrepreneurship as a transversal and binding component of development processes (Valencia *et al.*, 2025). Despite these efforts, current entrepreneurship training practices have not fully succeeded in motivating graduates to engage in entrepreneurial action (Lyu *et al*., 2023), raising questions about both individual factors such as personal motivations (Shirokova *et al.*, 2021) and risk aversion (Tsaknis *et al*., 2025), and contextual factors related to the university, family, and broader social environment (Shirokova *et al.*, 2017; Edelman *et al.*, 2016; Taneja *et al.*, 2023).

This study analyzes the direct effects and the moderating role of entrepreneurial education in the relationship between personal factors, such as perceived well-being, and contextual factors, such as institutional perceptions of the SDGs, on nascent entrepreneurship. Although entrepreneurship is widely recognized as a driver of economic growth and job creation, prior research has identified both positive and negative effects of entrepreneurial education across different contexts (Nabi *et al.*, 2017). Given the potential of entrepreneurial education to stimulate self-confidence, self-efficacy, and business viability (Steira *et al*., 2024; Amorós *et al.*, 2021), this study examines its differential role in facilitating the transition from entrepreneurial intention to action.

Drawing on previous evidence highlighting the differential effects of entrepreneurial education on entrepreneurial outcomes (Amorós *et al.*, 2021), this research is based on data from the Global University Entrepreneurial Spirit Students' Survey (GUESSS), which measures entrepreneurial intentions and activities among university students. Using hierarchical regression analysis, the relationships between perceived well-being, perceptions of the SDGs, and entrepreneurial education in relation to nascent entrepreneurial action are examined.

The findings indicate a negative and statistically robust effect of both perceived well-being and the SDGs on nascent entrepreneurship. Entrepreneurial education demonstrates a positive moderating effect on the relationship between well-being and entrepreneurial action, thereby mitigating its negative impact. No significant moderating effect is observed between SDGs and nascent entrepreneurship, suggesting that entrepreneurial education is more effective in facilitating the transition from entrepreneurial intention to action than in influencing sustainability-oriented perceptions. This article presents the theoretical background, describes the materials and methods, reports the empirical findings, discusses the results and their implications, outlines future research directions, and concludes with final remarks.

Theoretical framework and hypotheses

Hypothesis 1 (H1). Students' perceptions of subjective well-being affect their likelihood of participating in a new initiative.

Subjective well-being, from a psychological perspective, influences self-perception of abilities, risk-taking capacity, and orientation toward long-term goal achievement (Ryff, 1989). Within the university context, satisfaction in academic and personal life has been shown to increase the likelihood of translating entrepreneurial intentions into action (Laspita *et al.,* 2024). Promoting autonomy, self-confidence, and student well-being can therefore foster individuals capable of initiating and advancing entrepreneurial initiatives (Shir *et al.,* 2019). Furthermore, entrepreneurial behavior is shaped by initiative and creativity, both of which are influenced by students' emotional well-being (Amorós *et al.*, 2021).

Hypothesis 2 (H2). SDGs affect the probability of participating in a start-up.

The second factor of analysis concerns the role of the SDGs as a driver of entrepreneurship. Specifically, this factor examines the orientation toward launching initiatives with social and environmental impact, which characterizes sustainable entrepreneurship and its connection to university education in Latin-American (Guerrero & Lira, 2023). In this context, entrepreneurship serves as a transformative tool grounded in principles of equity, sustainability, and social justice (Valencia et al., 2025). When the SDGs are viewed as a commitment to sustainable development and social innovation, entrepreneurship is positioned as an instrument for addressing social challenges.

Hypothesis 3 (H3). Entrepreneurial education moderates the relationship between individual perceptions (well-being) and nascent entrepreneurship.

Entrepreneurial education moderates the relationship between subjective well-being and nascent entrepreneurship by enhancing the influence of personal factors. When personal resources interact with an educational environment that fosters creativity, innovation, and leadership, the likelihood of entrepreneurship increases significantly (Shir *et al*., 2019; Lechuga *et al*., 2024). Therefore, business education emphasizes the development of individual resources, such as self-efficacy and strategic thinking (Steira *et al*., 2024), which can be a key factor in ensuring that subjective well-being translates into entrepreneurial action.

Hypothesis 4 (H4). Entrepreneurial education moderates the relationship between individual perceptions (SDGs) and nascent entrepreneurship.

Entrepreneurial education can influence institutional perceptions of the SDGs in relation to entrepreneurial initiatives. An environment that encourages collaborative and experiential learning supports the transition from intention to entrepreneurial action (Guerrero & Lira, 2023). Through entrepreneurial training, students can develop initiatives that advance the SDGs, foster social commitment, and reinforce the connection between sustainable values and action. University entrepreneurial education thus plays an important role in promoting entrepreneurial behavior.

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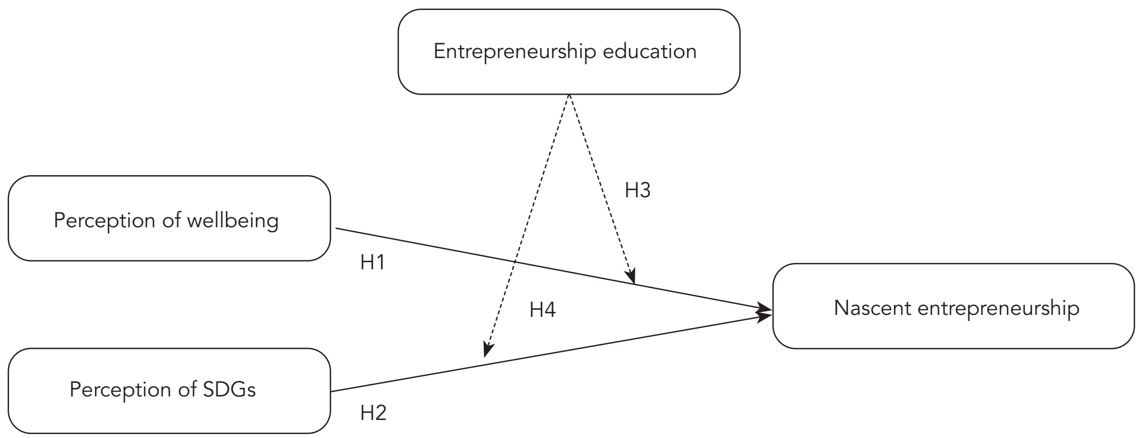
Figure 1
Theoretical Model



Nota. The theoretical model depicts the relationships between perceived well-being, perception of the SDGs, and nascent entrepreneurship, considering the moderating role of entrepreneurial education.

Materials and methods

Research with students is particularly useful for measuring nascent entrepreneurship, as it has been shown that university students with emerging ventures are very similar to true entrepreneurs. Based on this, interest in highlighting the role of entrepreneurial education in promoting entrepreneurship (Laspita *et al.*, 2024) has grown. Therefore, this quantitative cross-sectional study uses the questionnaire applied in the GUESSS project for the Colombian context, yielding a sample of 3,849 Colombian university students enrolled in undergraduate programs.

The dependent variable was nascent entrepreneurship (NES), with response options set as (1) yes, trying to start a business; and (0) no. The definition of the variable falls between entrepreneurial intention and behavior (Lyu *et al.*, 2023). The independent variables studied were: (1) perception of well-being (PWb) in university contexts (Jin & Ye, 2022) measured using a seven-point Likert scale; (2) institutional perception of the SDGs, constructed from the university's support for sustainability goals, social responsibility, and commitment to the environment (Núñez *et al.*, 2024); and as a moderating variable (3) entrepreneurial education (EDU), to identify whether formal training in entrepreneurship was received (Laspita *et al.*, 2024; Leiva *et al.*, 2021).

PWb and institutional perception of the SDGs were operationalized using composite indices from the GUESSS database. These indices are derived from multiple items and standardized by the GUESSS research consortium using rigorous psychometric procedures. Because the dataset comprises secondary data, only aggregated scale scores were accessible, which prevented the estimation of internal consistency coefficients, such as Cronbach's alpha, for the current sample.

Previous GUESSS-based studies and related research, including work in Latin-American universities, have shown that these scales are reliable and valid. Earlier studies report good internal consistency for both subjective well-being and sustainability perception scales, with Cronbach's alpha values above 0.70 (Shirokova *et al.*, 2017; Laspita *et al.*, 2024). Using these composite measures ensures strong psychometric quality and supports their use in studying new entrepreneurship in Colombia. These variables were chosen because they are important in student entrepreneurship research: perceived well-being is linked to entrepreneurial self-efficacy (Contreras *et al.*, 2022), and institutional commitment to the SDGs shows a prosocial focus that is becoming more common in university entrepreneurship (Guerrero & Lira, 2023). Entrepreneurial education is also seen as a key factor in developing entrepreneurial skills and attitudes (Alakaleek *et al.*, 2023).

Given the dichotomous nature of the dependent variable NES, coded as 1 for attempting to start a business and 0 otherwise, a binary regression model was selected as the most appropriate analytical strategy. Although logistic regression is commonly applied to binary outcomes, the term binary regression is used here to emphasize the probabilistic modeling of a dichotomous response within the generalized linear modeling framework. This approach enables the estimation of individual, contextual, and interaction effects, as well as the direct assessment of their influence on the probability of engaging in nascent entrepreneurial activity. The definition of the hierarchical model allows for the assessment of incremental explanatory power as main effects and interaction terms are sequentially added, in line with the theoretical aims of the research.

During the study, hierarchical block regression was applied for analysis. Model 1 included only control variables, model 2 added the main predictors (PWb, SDGs, and EDU), and model 3 defined the interaction terms EDU*PWb and EDU*SDGs to assess the moderating role of entrepreneurial education (Laspita *et al*., 2024). The robustness of the estimated coefficients was evaluated using bootstrap procedures with 10,000 random replicates, accounting for possible deviations from normality and heteroscedasticity. The emmeans package in R was used for marginal effects. Likewise, the research complied with ethical standards, ensuring informed consent, participant anonymity, and confidentiality.

Results and discussion

The main objective of the study was to understand the factors influencing early-stage entrepreneurship, linking individual, educational, and contextual variables. The study focused on understanding the factors that influence early-stage entrepreneurship, integrating individual, educational, and contextual variables. Educational level and NES, as well as EDU, emerged as factors that enhance entrepreneurs' individual resources. At the structural level, SDGs 4 (education), 5 (gender), 10 (inequality), 9 (innovation), 8 (work) and 11 (sustainability) are analyzed, given their impact on social and economic action. The family environment is analyzed as a variable that influences entrepreneurial decisions. PWb as an indicator of personal perception of entrepreneurship. Finally, sociodemographic variables focused on the age and gender of the study subjects, which allowed for a better characterization of their progress toward entrepreneurship.

Table 1

Descriptive statistics

			Asymmetry		Kurtosis	
	Mean	**SD**	**Parameter**	**SE**	**Parameter**	**SE**
Age	25.536	6.292	1.9801	0.0395	4.551	0.0789
Gender	0.561	0.496	-0.2446	0.0395	-1.941	0.0789
Self-employed parents	0.524	0.499	-0.0963	0.0395	-1.992	0.0789
Level of education	1.217	0.413	1.3704	0.0395	-0.122	0.0789
EDU	0.228	0.42	1.2982	0.0395	-0.315	0.0789
NES	0.455	0.498	0.1801	0.0395	-1.969	0.0789
ODS	5.731	1.123	-1.1143	0.0395	1.227	0.0789
PWb	5.013	1.34	-0.6211	0.0395	-0.102	0.0789

Nota. The table presents descriptive statistics (mean, standard deviation, asymmetry, and kurtosis) that summarize the distribution of the analyzed variables.

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The use of descriptive statistics allowed for the characterization of the sample and the assessment of the assignment of the variables linked in the model. The analysis focused on measures of central tendency, dispersion, and distribution shape to support an accurate interpretation of the results and identify possible biases or atypical data patterns. Table 1 shows the descriptive statistics for each variable. The mean age of the participants was 25.536 years (SD=6.292), with a marked positive asymmetry (1.98), showing a concentration of younger participants and a few older participants. The kurtosis value (4.551) indicates a leptokurtic distribution, which is more pronounced than a normal distribution. Gender, coded as a binary variable (mean=0.561), indicates that 56.1% of the sample is represented by the group coded as 1 (women). The negative skewness (-0.2446) and kurtosis (-1.941) suggest a relatively symmetrical distribution with a reduced central concentration (platykurtic). Regarding parental self-employment, approximately 52.4% of students have at least one self-employed parent. The distribution is almost symmetrical (skewness=-0.0963) and has a negative kurtosis (-1.992), indicating a flatter bell shape.

The predominant level was undergraduate with a mean of 1.217 (SD=0.413). Likewise, the positive asymmetry (1.3704) suggests lower educational levels for a considerable number of participants, while revealing few at the postgraduate level. The kurtosis (-0.122) is close to zero, indicating a moderately normal distribution. In EDU, only 22.8% have received training in entrepreneurship. The positive skewness (1.2982) and negative kurtosis (-0.315) show a biased distribution towards the absence of entrepreneurial education, as is common in general samples.

In relation to the main variables of the model, it was identified that 45.5% are starting a business. The positive asymmetry (0.1801) and kurtosis (-1.969) indicate a slight concentration towards lower values, although the distribution remains relatively symmetrical. The perception of the SDGs is high average (5.731/7) with slight negative asymmetry (-1.1143), indicating a generally positive perception of institutional commitment to the SDGs. The kurtosis (1.123) reflects a somewhat pointed distribution. The perception of well-being also has a high meaning (5.013/7), with negative skewness (-0.6211), reflecting a majority perception of subjective well-being. The kurtosis (-0.102) indicates a normal bell-shaped distribution.

With the above, it can be noted that the variables show expected trends in the university population: high perception of well-being and institutional commitment, but low entrepreneurial training. Additionally, most distributions are not normal, which justifies the use of robust techniques (such as the Bootstrap), and extreme asymmetric and kurtosis in variables like age and educational level must be considered when interpreting subsequent inferential models.

A Pearson correlation analysis allowed us to explore the bivariate relationships between the study variables, identify the strength and direction of the linear associations between the constructs involved, and provide a preliminary assessment of the links that underpin the theoretical model. Table 2 presents the correlations between the dependent variable (nascent entrepreneurship) and the independent variables (perception of well-being, perception of the SDGs, and entrepreneurial education), as well as the sociodemographic variables used as controls.

Table 2

Correlation matrix of the focal variables

	1	2	3	4	5	6	7	8
1 NES	—							
2 SDGs	-0.083***	—						
3 PWb	-0.047**	0.377***	—					
4 EDU	0.003	0.170***	0.119***	—				

5 Level of education	0.004	0.041*	0.076***	0.015	—			
6 Self-employed parents	0.072***	-0.018	0.040	0.024	-0.022	—		
7 Gender	-0.050**	0.032*	0.025	-0.036*	0.066***	-0.050**	—	
8 Age	-0.067***	-0.050**	0.034*	0.01	0.222***	-0.109***	-0.070***	—

Note. The table shows the correlations between the study variables; asterisks indicate statistical significance ($p < .05$, $p < .01$, $p < .001$).

There is a negative correlation between NES and the perception of the SDGs ($r=-0.083$, $p< .001$), which could indicate that a higher institutional valuation of the SDGs is not necessarily associated with greater involvement in nascent ventures. The perception of well-being also shows a negative correlation with NES ($r=-0.047$, $p<.01$), although to a lesser extent. As for the EDU variables, educational level, autonomous parents and gender have positive but not significant associations with NES, suggesting a weaker or indirect relationship.

Similarly, a strong positive correlation was identified between SDGs and PWb ($r=0.377$, $p<.001$), suggesting that students with a higher institutional perception of SDGs also report higher subjective well-being. EDU correlates positively with both PWb ($r=0.119$, $p<.001$) and SDGs ($r=0.170$, $p<.001$), indicating that those who receive entrepreneurial training also tend to have more favorable perceptions of institutional well-being and sustainability.

Likewise, relationships with control variables show that age has statistically supported correlations with several variables: a negative correlation with NES ($r=-0.067$, $p<.001$), indicating that younger students tend to be more entrepreneurial; and a positive correlation with Educational Level ($r=0.222$, $p<.001$), as expected due to academic advancement. Gender correlates negatively with Educational Level ($r=-0.036$, $p<.05$) and with Autonomous Parents ($r=-0.050$, $p<.01$), although these associations are of low magnitude. Autonomous parents have a positive correlation with NES ($r=0.072$, $p<.001$), suggesting a possible family influence on the decision to become an entrepreneur.

On the other hand, Tables 3 and 4 showcase the goodness-of-fit statistics, showing a modest but steady improvement in the model's performance as theoretically relevant variables are linked. Specifically, the increases in McFadden's pseudo-R^2 and log-likelihood values reflect greater explanatory power and a better fit of the model relative to the reference models, thus supporting the hierarchical modeling strategy. However, the pseudo-R^2 values in the binary regression remain lower than the R^2 values in the linear models. To assess the effect of perceived PWb on NES, two hierarchical regression models were estimated. Model 1 included control variables and PWb, while model 2 incorporated the interaction term PWb*EDU to determine whether entrepreneurial education moderates the relationship between well-being and the decision to start a business. These results confirm the relevance of the proposed predictors.

Table 3

Effect of Perceived well-being

Predictor	Estimator	p	Estimator	p
EDU	0.00703	0.714	-0.00236	0.977
Gender	-0.04558	0.005	-0.04559	0.005
Level of education	0.01464	0.452	0.01463	0.453

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Self-employed parents	0.07164	<0.001	0.07167	<0.001
PWb	-0.01876	0.002	-0.01911	0.005
PWb*EDU			0.0179	0.046
Constant	0.51781	<0.001	0.51955	<0.001
McFadden pseudo-R^2	0.0104		0.0104	
Log-likelihood	-2624.867		-2624.853	

Note. The table shows the regression coefficients and p-values, along with model fit statistics (McFadden's pseudo-R^2, log-likelihood, and AIC), which indicate relative improvements in model fit.

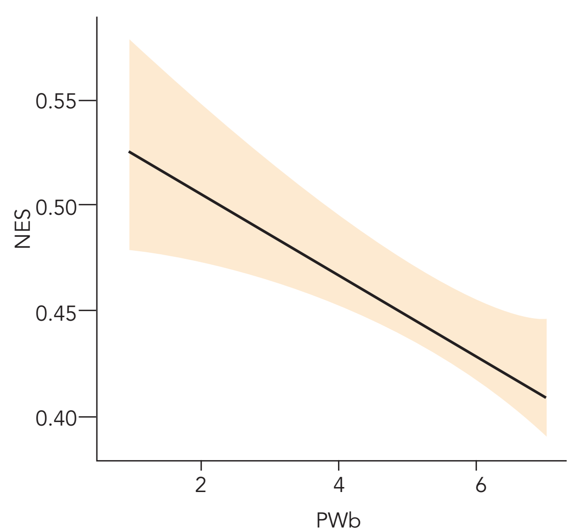
In Model 1, PWb has a negative and statistically supported effect on nascent entrepreneurship (β=-0.01876, p=0.002). This indicates that the lower the subjective well-being, the greater the probability of entrepreneurship. In Model 2, the PWb coefficient remains negative and statistically robust (β=-0.01911, p=0.005), although its magnitude is slightly greater. The interaction yields a positive and inferentially supported result (β=0.0179, p=0.046), confirming that entrepreneurship training moderates the relationship between well-being and early-stage entrepreneurship. This indicates that entrepreneurial training reorients well-being to increase the probability of entrepreneurship.

Regarding the control variables, gender was found to be a negative predictor in both models (β=-0.04558, p=0.005), suggesting that women (coded as 1) are less likely to be involved in a nascent venture. Self-employed parents show a positive and highly statistically robust effect ($\beta \approx 0.0716$, p<0.001), confirming family influence as a relevant factor in entrepreneurial orientation. Finally, neither educational level nor entrepreneurial education alone are significant in any of the models, indicating that their direct effects on NES are marginal in this sample.

These findings suggest that greater well-being does not necessarily drive entrepreneurship in university students, but that entrepreneurial education can modify this pattern. Thus, the role of training as a facilitator that converts subjective well-being into a mobilizing resource for entrepreneurial action is reinforced.

Figure 2

Marginal effect of PWb on NES



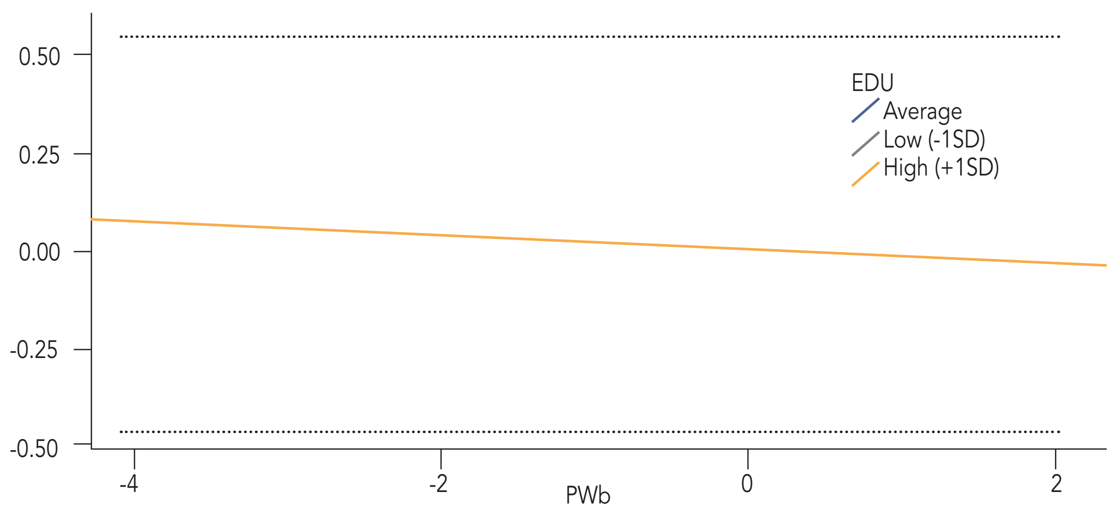
Note. The figure shows the marginal effect of perceived well-being on nascent entrepreneurship; the gray band indicates the confidence interval.

The higher the perception of well-being, the lower the level of nascent entrepreneurship, which is logical in emerging economies, given the relative situation of the middle and lower classes. Considering that they do not require greater resources for vital development, these individuals do not perceive the added value of entrepreneurship as a viable path. Using the R emmeans package, the predictive effects of the moderation of entrepreneurship education on the marginal effect of PWb on NES are estimated for high, medium and low levels. The estimation mechanism used was random resampling with replacement, Also Known as Bootstrapping, which involved calculating 10,000 random subsamples.

The figure shows that, in general, regardless of the level of entrepreneurship education in this case study, the perception of well-being has a negative effect on nascent entrepreneurship.

Figure 3

Moderating effect of entrepreneurial education on the relationship between PWb and NES



Note. The figure shows the moderating effect of entrepreneurial education on the relationship between perceived well-being and nascent entrepreneurship at low, medium, and high levels of the moderator.

To explore the impact of institutional perceptions of the SDGs on NES, two hierarchical models were estimated. Model 3 includes the main effects of the independent and control variables, incorporating the perception of the SDGs as a predictor. In Model 4, the interaction between the perception of SDGs and entrepreneurial education (SDGs*EDU) is added, allowing us to examine whether entrepreneurship training conditions the effect of institutional orientation towards sustainability on the decision to become an entrepreneur.

Table 4

Effect of the Sustainable Development Goals

	Model 3		Modelo4	
Predictor	**Estimator**	**p**	**Estimator**	**p**
EDU	0,0169	0,382	-0,0698	0,541
Gender	-0,044	0,006	-0,0441	0,006
Level of education	0,0138	0,477	0,0136	0,485
Self-employed parents	0,068	<0,001	0,0684	<0,001
SDGs	-0,0369	<0,001	-0,0395	<0,001
SDGs*EDU			0,0144	0,441
Constant	0,6349	<0,001	0,6496	<0,001

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McFadden pseudo-R²	0,01414	0,01427
Log-likelihood	-2614,935	-2614.601
EDU	5243,87	5245,202

Note. The table shows the regression coefficients and p-values, along with model fit statistics (McFadden's pseudo-R², log-likelihood, and AIC), which indicate relative improvements in model fit.

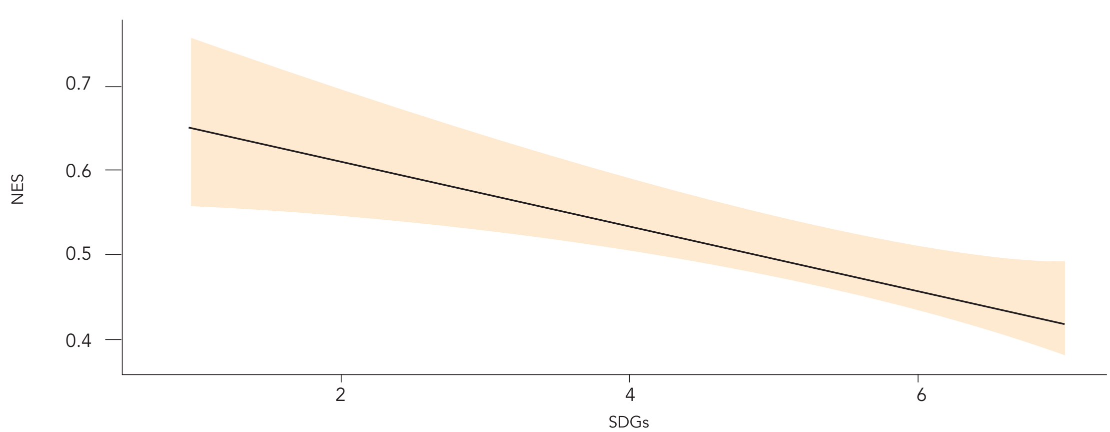
In both models in Table 4, perception of the SDGs has a negative and statistically meaningful effect on nascent entrepreneurship: Model 3: β=-0.0369, p<0.001 and Model 4: β=-0.0395, p<0.001. This suggests that the greater the institutional perception of commitment to the SDGs, the less likely students are to start a business. This finding contrasts with studies linking prosocial orientation to entrepreneurial intention and may be due to a perceived lack of connection between sustainability and business viability in educational contexts. The interaction between SDGs and EDU is not statistically significant (β=0.0144, p=0.441), indicating that entrepreneurial training does not moderate the relationship between institutional perceptions of sustainability and students' entrepreneurial activity.

In the control variables, it is identified that self-employed parents have a positive and statistically supported effect in both models ($\beta\approx$0.068, p<0.001), which reinforces the hypothesis that the family environment influences the decision to become an entrepreneur. Gender has a negative effect ($\beta\approx$-0.044, p=0.006), as observed in previous models, indicating that the female group (presumably coded as 1) participates less in nascent ventures. Finally, neither educational level nor EDU alone has a statistically robust effect on NES.

The results demonstrate that a stronger institutional perception of the SDGs is negatively associated with the likelihood of entrepreneurship, and that entrepreneurial education does not significantly moderate this relationship. This outcome may suggest a disconnect between institutional narratives on sustainability and students' perceptions of the practical relevance of these principles within entrepreneurial contexts. Collectively, the four models suggest that nascent entrepreneurship is influenced by the interplay among individual resources, institutional contexts, and entrepreneurial education. Although entrepreneurial education can reduce the negative effects on well-being, its ability to advance institutional agendas, such as the SDGs, appears limited during the initial stages of the entrepreneurial process.

Figure 4

Marginal effect of the SDGs on NES

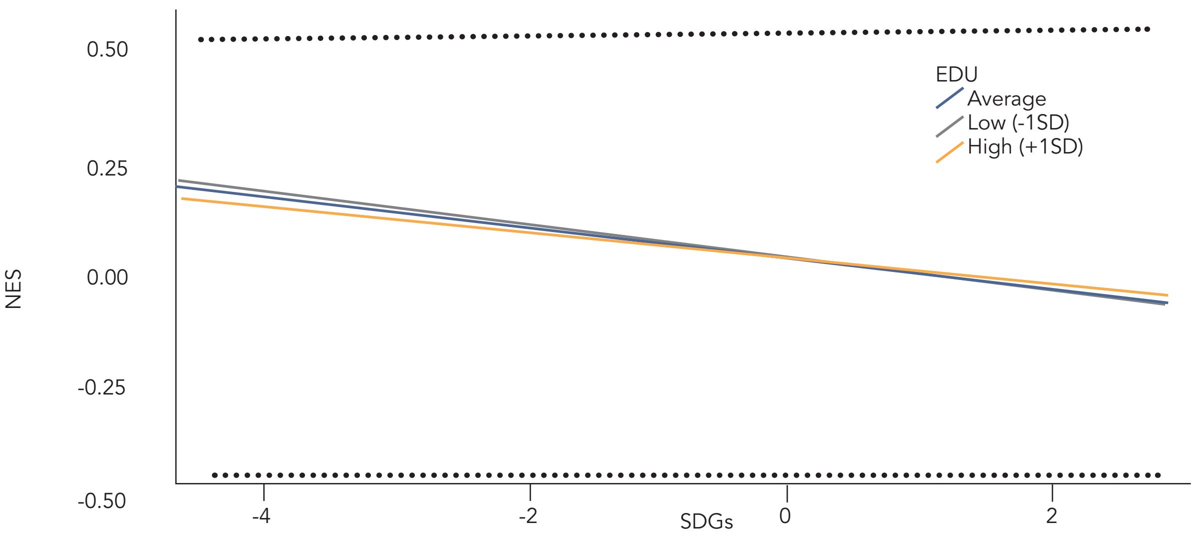


Note. The figure shows the marginal effect of the perception of the SDGs on nascent entrepreneurship; the gray band represents the model's confidence interval.

Finally, to examine the predictive effects of moderator education in entrepreneurship on the marginal effect of SDGs on NES, bootstrapping is employed using 10,000 random subsamples. The results are shown in Figure 5.

Figure 5

Moderating effect of entrepreneurial education on the marginal effect of the SDGs on NES



Nota. The figure shows the moderating effect of entrepreneurial education on the relationship between perceptions of the SDGs and nascent entrepreneurship at low, medium, and high levels of the moderator.

The results obtained in the research allow us to understand the factors that influence emerging university entrepreneurship in Colombia. They show that individual resources and environmental demands interact significantly, explaining entrepreneurial intentions and behaviors, supporting the work of Laspita *et al.* (2012) in maintaining subjective well-being and perception of the SDGs as predictors with differentiated effects, while entrepreneurial education appears to partially moderate these relationships.

However, the fact that the PWb variable has a statistically detectable negative effect on nascent entrepreneurship is a result that can be seen in emerging economies, which contrasts with studies that associate PWb with a greater preference for entrepreneurship (Baldacchino & Sassetti, 2025), suggesting that environments with adversities for the individual encourage the drive to create new businesses. These findings confirm the argument advanced by Laspita *et al.* (2012) regarding the influence of personal background on entrepreneurial motivation when it is driven by economic or psychological pressure associated with needs or opportunities. This aligns with the findings of Galindo *et al.* (2020), who assert that entrepreneurship is a priority when viewed as a strategy for either improvement or survival. Therefore, it can be inferred that the greater the well-being, the less the need to take risks and seek opportunities, which reaffirms that other factors of change, such as environmental and academic aspects, determine the decision to take on the entrepreneurial challenge in Latin American contexts.

The perception of university support for the SDGs also has a significant negative effect on nascent entrepreneurship. This may be due to students' perception that the SDGs are more closely associated with the state than with opportunities to start their own businesses. This situation is like that found by Laspita *et*

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al. (2012), in that social pressures and bureaucratic processes can hinder entrepreneurship. In other words, it confirms that in Latin-American, sustainability is still understood as an ethical obligation rather than a competitive advantage (Espinoza *et al.*, 2023).

The entrepreneurial education positively moderates the relationship between PWb and NES, thereby affecting subjective well-being by promoting entrepreneurship and self-confidence. This reaffirms that entrepreneurial education has a positive impact on self-efficacy, creativity and control over opportunities (Nabi *et al.*, 2017). Thus, education can transform an intention into entrepreneurial action by offering tools that strengthen individuals' resources, enabling them to cope with the demands of their environment (Laspita *et al*., 2012). In other words, entrepreneurial education reorients well-being toward value creation and sustainable innovation (Mahfud & Nur, 2025).

On the other hand, entrepreneurial education does not significantly moderate the relationship between SDGs and NES, which may be because education still fails to make students understand how to connect SDGs with entrepreneurship, beyond ethical obligation. This implies that learning scenarios that promote sustainable values and solutions are needed so that, when transferring knowledge through content, entrepreneurship can be influenced and enhanced (Laspita *et al.*, 2012). However, the moderating absence of education in this relationship reveals that it is assuming an informative rather than a transformative role, highlighting the need to address more experiential activities based on projects and business laboratories that facilitate effective commercial actions (Di Paola *et al.*, 2023).

Family and personal background also play an important role in entrepreneurship (Laspita *et al*., 2012). The study finds that students with self-employed parents are more likely to take part in entrepreneurial activities. This suggests that family experience alongside entrepreneurship redefines attitudes, values, and self-efficacy (Aragón *et al.*, 2024), providing students with real experiences of management, resilience, and risk, and strengthening the entrepreneurial mindset from university to real life.

According to the results, gender is shown to be a negative and statistically significant predictor, indicating that females are less likely to have access to support networks that foster self-confidence. Another noteworthy element is the influence of social pressure on risk-taking decisions (Laspita *et al.*, 2012), regardless of gender. In the national university context, these social and family pressures often make formal employment more attractive than starting a business.

This research also showed that young new undergrad students are increasingly involved in entrepreneurship. This aligns with Nabi *et al*. (2017) findings that state that young students are more willing to take risks and stand out as more creative and innovative, mainly because they have fewer family commitments and responsibilities. According to Laspita *et al*. (2012), factors such as specialized training, university resources, and institutional support shape youth entrepreneurship and the potential for change among younger generations.

Consequently, it is important to note that the model is partially based on the Colombian model, thus demonstrating that individual resources and environmental demands have a important impact on entrepreneurs' practices. However, in the university and educational sphere, there is still a lack of motivation for students to train as employees rather than entrepreneurs. Thus, this constant relationship between personal and structural factors confirms the statements of Laspita *et al*. (2012) on the need to understand the background of entrepreneurs in relation to the social and educational pressures that strengthen the entrepreneurial spirit of university students.

When considering the institutional and contextual stance, this negative link between students' perceptions of the Sustainable Development Goals (SDGs) and early-stage entrepreneurship extrapolates the low alignment. Previous studies show that sustainability orientations promoted by HEIs are often more effective when framed as formal institutional frameworks that set expectations and standards, rather than when they are used directly to encourage entrepreneurial opportunities (Guerrero & Lira, 2023; Valencia *et al*., 2025). Within the intention-action framework, early entrepreneurial behavior is mainly determined by perceptions of feasibility and contextual constraints rather than by normative or aspirational agendas (Shirokova *et al*., 2017). Accordingly, discourses on sustainability may introduce perceived complexity or legitimacy requirements for students who are taking entrepreneurial action. At the same time, early-stage entrepreneurs tend to prioritize access to resources and risk reduction over more global institutional logics, such as sustainability agendas (Lyu *et al*., 2023). This view largely explains the rationale for entrepreneurial education, which moderates the relationship between well-being and entrepreneurial action, but does not significantly explain the link between the SDGs and early-stage entrepreneurship. Pedagogical strategies can strengthen personal capacities without explicitly highlighting the institutional logic of sustainability in immediate entrepreneurial behavior (Nabi *et al*., 2017; Amorós *et al*., 2021).

Overall, these results are consistent with studies on entrepreneurship that emphasize the context-dependent nature of early entrepreneurial behavior, particularly in rapidly growing economies. However, previous studies show that structural conditions, institutional support, and perceived opportunity costs determine initial entrepreneurial decisions, often outweighing value-based regulatory or statutory rigidity during the early stages (Amorós *et al.,* 2021; Guerrero & Lira, 2023). Accordingly, the adverse effects associated with perceived well-being and institutional sustainability agendas do not condition entrepreneurship theory but rather highlight the conditional nature of these relationships during the development of each stage. Thus, entrepreneurship education emerges as a mechanism that translates resources into action, as sustainability commitments require structural policies to promote entrepreneurship.

The findings discussed above highlight the complex relationships among individual perceptions, institutional contexts, and entrepreneurial education when influencing nascent entrepreneurial behavior among university students. Additionally, statistical analysis reveals patterns with notable theoretical and practical implications for HEIs and public policy makers regarding entrepreneurship. The next section analyzes the implications in detail, relating the empirical evidence to established theoretical frameworks and outlining practical guidelines for entrepreneurial education and university strategies focused on sustainability.

Theoretical and practical implications

This research adds to the existing literature on university entrepreneurship. It provides a new vision and theoretical analysis of how subjective well-being and the perception of the SDGs as antecedents of incipient entrepreneurship in HEIs and entrepreneurial education affect entrepreneurial action. This means that, considering the models focused on entrepreneurial intention (Mahfud & Nur, 2025), emphasis is placed on linking well-being variables with sustainability and education. Thus, entrepreneurship cannot be understood in isolation from the social and educational contexts in which students interact. Rather, it involves a strategic approach focused on training ecosystems, supporting infrastructure, and strengthening university students' individual resources.

The limited explanatory power of the models highlights the complex and multifactorial nature of nascent entrepreneurship, which is defined by the interplay of personal, contextual, and institutional factors. Incremental improvements across hierarchical models indicate that subjective well-being, institutional orientation toward the SDGs, and entrepreneurial education each contribute significantly to explaining entrepreneurial engagement. However, a considerable proportion of variance remains due to unobserved factors.

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Therefore, Colombian universities must recognize that subjective well-being is not a factor that drives entrepreneurial decision-making, unless there is a real need for students to become entrepreneurs. It is in this context that entrepreneurial education must raise awareness that entrepreneurship is not a practice exercised only in times of need or opportunity, but can be a social practice, thereby orienting entrepreneurial training programs from both individual (personal and technical skills) and contextual perspectives.

On the other hand, the lack of moderation of EDU in the relationship between the SDGs and the NES, coupled with the direct negative effect of the SDGs, suggests a disconnect between the discursive institutional commitment to sustainability and students' perceptions of the practical applicability or business viability of these principles. HEIs must integrate the SDGs more effectively into entrepreneurial education so that sustainability values translate into concrete and viable projects. Therefore, HEIs must address the SDGs in various ways to integrate them into business education and to examine the influence of the family environment, with a view to undertaking specific, viable projects that can have a positive impact on regional development.

Theoretically, these findings advance entrepreneurship research by emphasizing the stage-dependent nature of entrepreneurial processes in emerging economies. The results refine intention–action models by demonstrating that subjective well-being and sustainability-oriented institutional logics do not serve as universal drivers of entrepreneurial behavior; instead, they exert conditional effects that differ across stages of venture emergence. This study brings together the variables of well-being, institutional sustainability agendas, and entrepreneurial education, thus providing a unified normative framework for nascent entrepreneurship. In practical terms, the findings suggest that educational institutions should go beyond general commitments to sustainability and develop entrepreneurial education that translates the SDGs into viable business opportunities. Project-based learning, innovation spaces, mentoring systems, and university-industry links are paramount for translating sustainability values into practice, especially in environments marked by economic uncertainty and structural constraints.

Conclusions

Finally, this study confirms the relevance of entrepreneurial education in strengthening the nascent entrepreneurial spirit at the university, when the interrelationship between different individual and contextual factors is balanced and improved, which increases the likelihood of students developing entrepreneurial activity. The findings reveal that higher levels of perceived well-being and economic or social stability are associated with a lower propensity to start entrepreneurial projects. However, entrepreneurial training can shift this sense of well-being toward the entrepreneurial spirit, reinforcing self-efficacy and turning personal satisfaction into entrepreneurial motivation.

From an applied perspective, the findings suggest that universities should enhance entrepreneurship education programs by explicitly linking sustainability agendas, such as the SDGs, with business viability and opportunity recognition. To achieve this goal, it is necessary to move from symbolic commitments to experiential teaching-learning strategies, project-based courses, and business laboratories that enable students to translate sustainability principles into viable initiatives. In addition, social effects such as gender, age, and social pressures indicate that differential support mechanisms are needed to address the structural and cultural barriers that limit entrepreneurial practice.

In conclusion, it is important to mention that future studies should address limitations related to factors not considered in this research, such as economic variables that may influence the development of start-ups among university students. Individual personality traits related to social trust, work obsession, risk-taking, innovation, and proactivity, which may

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be essential to understanding entrepreneurial behavior, were also not addressed. Likewise, contextual demands, such as workplace social pressures, were not addressed. From an academic perspective, it would be important to examine the depth of training courses and determine whether they increase the likelihood of entrepreneurship, given that this study did not distinguish between compulsory, optional, or continuing education courses.

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Author Declaration - CRediT Taxonomy

Autores/as	Contribuciones
Daniel Yiwady Ordoñez- Abril	Drafting of the original manuscript, research, formal analysis, writing, review, and editing. Data analysis and discussion.
Guillermina Tormo Carbó	Conceptualization, research, methodology, and supervision.
Gabriel García-Martínez	Introduction, research, data analysis, and discussion.
María Erika Narváez-Ferrín	Writing, review, and editing. Review of the bibliography and discussion.

Statement on the use of artificial intelligence

The authors **DECLARE** that, in the preparation of the article titled: "Entrepreneurial Education and Well-being in Emerging University Startups," artificial intelligence (AI) was used to assist with the translation and linguistic review of the manuscript. The authors declare that they reviewed and validated the content and assume full responsibility for the final version of the article.

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Infographics

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CIRCULAR ECONOMY PRACTICES AND ECO-INNOVATION: AN APPROACH TO SUSTAINABLE DEVELOPMENT

Authors: Gonzalo Maldonado-Guzmán Sandra Yesenia Pinzón-Castro Vianney Judith Robledo-Herrera

JUSTIFICATION

The growing number of environmental problems, the depletion of natural resources, and ecological imbalance are raising consumer awareness and increasing demand for environmentally friendly products.

To analyze the effects of the circular economy on eco-innovation practices from a sustainable development perspective in Mexican manufacturing companies.

METHODOLOGY

A survey was administered to a sample of 410 Mexican manufacturing companies, and the data were analyzed using the PLS-SEM statistical technique with the support of SmartPLS software.

RESULTS

1. Manufacturing companies in Mexico can achieve a higher level of eco-innovation in their products, processes, and management systems if they implement circular economy practices (reuse, recycling, remanufacturing).

2. The adoption and implementation of circular economy and eco-innovation practices is an issue that is still very new in most developing countries, particularly in Latin America.

CONCLUSION

1. Manufacturing companies in Mexico that have applied circular economy practices in their production processes have generated more environmentally friendly eco-products and, as a result, achieved greater sustainable development.

2. The adoption and implementation of circular economy and eco-innovation practices is an issue that is still very new in most developing countries, particularly in Latin America.

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WOMEN AND SUSTAINABLE CONSUMPTION IN EMERGING MARKETS: IMPLICATIONS FOR MANAGEMENT

Author: Sebastián Araya-Pizarro

JUSTIFICATION

This study addresses the gap between intention and action in sustainable consumption in emerging markets, focusing the analysis on women—a segment with consistent patterns of environmental awareness—to provide empirical evidence for designing more effective strategies.

OBJECTIVE

To analyze the attitudes, practices, and preferences regarding eco-friendly consumption among Chilean women, identifying factors that influence their green identity and willingness to pay for sustainable products.

METHODOLOGY

A non-experimental, cross-sectional quantitative approach was adopted, with data collected via a survey (n=391). Descriptive techniques, cluster analysis, and logistic regression were applied to test three hypotheses regarding attitude-behavior gaps, identity legitimation, and consumption profiles.

RESULTS

1. An "identity legitimation gap" was identified: although most women hold pro-environmental attitudes, only one in four perceives herself as a "green consumer," reducing the consistency of their eco-friendly habits.

2. The market is divided into Green Core, Economical, and Pragmatic segments. The pragmatic segment (67.3%) is the predominant one, characterized by a balanced approach between quality and price, with a willingness to pay up to a 25% premium.

CONCLUSION

1. The expansion of the sustainable market requires moving beyond the pursuit of "ecological perfection," validating partial but consistent actions that allow more people to identify with the green identity.

2. The commercial success of sustainable products depends on strategies focused on the pragmatic segment, offering alternatives that strike a balance between environmental responsibility, economic rationality, and accessibility.

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COMMUNICATION MODELS FOR SUSTAINABILITY: A COMPARATIVE STUDY IN CHILE, COLOMBIA, AND ECUADOR

Authors: Melita Vega Lorena Solange Retamal-Ferrada Jaime Alberto Orozco-Toro Caroline Ávila

JUSTIFICATION

Sustainability is a strategic priority for organizations, but its impact depends on how it is communicated. Understanding communication models for sustainability allows us to identify whether organizations generate genuine dialogue or merely bolster their reputation.

OBJECTIVE

To conduct a comparative analysis of how large organizations in Chile, Colombia, and Ecuador manage their sustainability communication, identifying their strategic orientations and structural differences.

METHODOLOGY

A questionnaire was administered to 75 large organizations in the three countries based on the Convergence Model between Communication and Sustainability. Subsequently, the collected data were analyzed using non-parametric statistical tools.

RESULTS

1. In Chile and Colombia, an orientation toward the Common Good predominates, with a more participatory communication style aligned with the organizational purpose.

2. In Ecuador, a more instrumental orientation is observed, centered on business and reputation, with primarily one-way communication strategies.

CONCLUSION

1. Communication for sustainability reaches its transformative potential when integrated into organizational culture through two-way practices and authentic dialogue with stakeholders.

2. It is not enough to simply communicate sustainability: it is also necessary to strengthen ethical, regulatory, and strategic frameworks that enable the generation of legitimacy and sustained social commitment.

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ENVIRONMENTAL AWARENESS, RESILIENCE, AND TECHNOLOGY: KEY STRATEGIES FOR PROMOTING GREEN EMPLOYMENT IN BUSINESS

Autores: Alfonso Jesús Gil-López · Diego Sesma-Martín · Claudia Tobías-Marín · Begoña Berges-Cordón

JUSTIFICATION

Sustainability is now a strategic priority, and the green transition requires that environmental guidelines be translated into daily routines. Understanding which individual factors drive this implementation helps promote green jobs and behaviors within the company.

OBJECTIVE

To analyze how green awareness relates to the adoption of green jobs/behaviors, how resilience is associated with green awareness, and whether technological acceptance (partially) mediates this relationship between green awareness and green jobs.

METHODOLOGY

A cross-sectional study involving 302 workers in Spain. Validated scales (1–7 Likert) were used, and a PLS-SEM model was estimated using SmartPLS to test hypotheses.

RESULTS

1. Employee green consciousness is positively and significantly associated with green job performance and behaviors (more pro-environmental orientation, greater job performance).

2. Resilience is positively and significantly related to green consciousness; furthermore, technological acceptance partially and significantly mediates the relationship between green consciousness and green jobs, increasing the model's explanatory power.

CONCLUSION

1. To accelerate the sustainable transition, it is advisable to select and develop resilient talent with ecological values, fostering the consolidation and maintenance of green awareness in the face of cost and time pressures.

2. Designing user-centered green tools and training (utility and ease of use) helps bridge the attitude-behavior gap and convert environmental awareness into verifiable performance, especially in roles with limited scope for action.

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ADOPTION OF MICROMOBILITY APPS IN CHILE: TAM AND SHARING ECONOMY

Aurthors: Katherine Mansilla-Obando Gonzalo R. Llanos

JUSTIFICATION

Urban transportation is one of the main sources of air pollution in Chile, especially in Santiago. Micromobility apps are emerging as a sustainable alternative, but their success depends on understanding what truly motivates people to adopt them.

OBJECTIVE

To identify the factors that explain the intention to use electric bicycle and scooter apps in Chile, integrating the Technology Acceptance Model (TAM) with sharing economy variables and environmental conditions.

METHODOLOGY

A quantitative study was conducted with 168 users in Santiago, using a survey based on validated TAM scales. The data were analyzed using structural equation modeling (CB-SEM) to assess causal relationships between the variables.

RESULTS

1. Perceived utility and enjoyment are the most influential factors on usage intention. Users adopt these apps when they perceive practical benefits and, at the same time, an enjoyable experience.

2. Enabling conditions (infrastructure and support) do not directly influence usage intention, but they do improve the perception of utility and enjoyment. Ease of use acts primarily indirectly.

CONCLUSION

1. Adoption is driven by a dual logic: functional efficiency and experiential value. Platforms must be managed not only as transportation services but as digital services centered on the user experience.

2. The urban environment plays a key facilitating role. Public policies that reduce friction and invest in infrastructure indirectly strengthen the adoption of sustainable mobility solutions.

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BOYCOTT REACTIONS TO GREENWASHING BY CONSUMER PROFILE: A SURVEY IN BRAZIL

Authors: Taís Pasquotto Andreoli, Isabela Marques Kumer

JUSTIFICATION

In the current context of the proliferation of greenwashing—a deceptive communication strategy in which organizations exaggerate their environmental practices—compounded by the continued absence of effective regulatory mechanisms, the responsibility for regulation falls on consumers.

OBJECTIVE

To understand consumer reactions in greenwashing, particularly in terms of knowledge, judgment, and boycott-motivated behavior, investigating differences derived from consumer profiles.

METHODOLOGY

A quantitative survey was conducted with a sample of 1,251 Brazilian consumers.

RESULTS

1. The sample demonstrated a high level of criticality when judging greenwashing practices, with a considerable predisposition toward boycott-motivated behavior.

2. Differences were identified across all consumer profile variables, with a stronger reaction observed among female consumers, those with higher income and educational levels, older consumers, and individuals with management experience.

CONCLUSION

1. This study highlights the role of consumers as potential market regulators and their ability to exert pressure through the active rejection of brands that engage in deceptive environmental practices.

2. The reaction to greenwashing is not distributed uniformly among consumers but is associated with specific sociodemographic characteristics, suggesting that the potential regulatory role of consumers in the context of greenwashing is socially structured and does not apply across the entire market.

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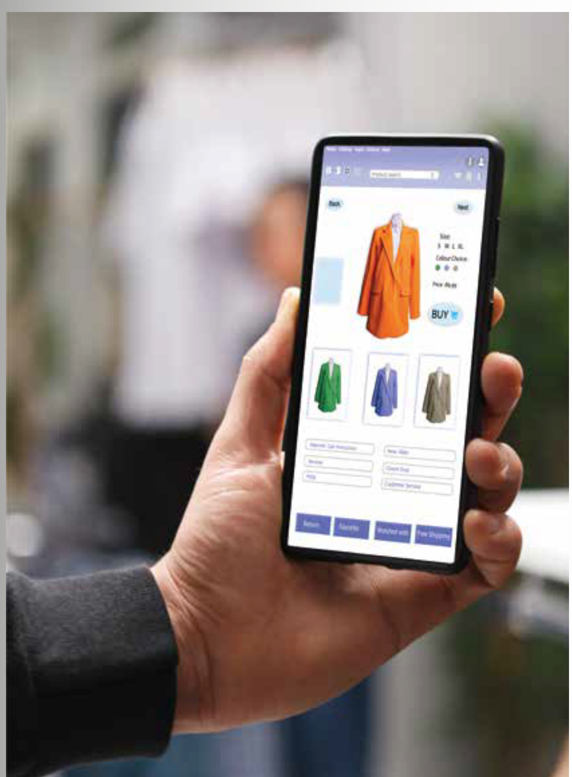
EMERGING TECHNOLOGIES TO OPTIMIZE ENVIRONMENTAL SUSTAINABILITY IN THE TEXTILE INDUSTRY: A SYSTEMATIC REVIEW

Authors: Sebastián Cardona-Acevedo Alejandro Valencia-Arias Jackeline Valencia



JUSTIFICATION

The textile industry is one of the most polluting sectors due to its high consumption of water, energy, and chemicals, which generates significant environmental impacts. Analyzing sustainable technologies is key to reducing these effects and strengthening the sector's competitiveness.

OBJECTIVE

To systematically analyze technological innovations applied in the textile industry aimed at mitigating environmental impacts.

METHODOLOGY

A systematic literature review was conducted following the PRISMA 2020 guidelines, supplemented by a descriptive bibliometric analysis based on the frequencies of coded variables derived from studies indexed in Scopus and Web of Science.

RESULTS

1. The most frequent innovations include digital platforms, clean technologies, recycling systems, and advanced materials, which improve resource efficiency, reduce waste, and optimize energy performance.

2. Significant barriers to technology adoption persist, primarily high implementation costs, regulatory restrictions, and financial constraints within supply chains.

CONCLUSION

1. Technological innovation is an essential driver for achieving a more sustainable textile industry, although its impact depends on organizational capabilities, corporate culture, and appropriate strategic frameworks.

2. True sustainability requires systemic approaches that integrate technology, governance, business strategies, and collaboration among sector stakeholders to consolidate circular and responsible production models.

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SLOVAK GDP PREDICTION BASED ON METAL PRICES AS A TOOL FOR POLICYMAKERS

Autores: Marek Vochozka, Robin Kunju Mol Ra, Veronika Šanderová, Libuše Turinská

JUSTIFICATION

This article responds to the demand of the European market, where it is necessary to predict economic development in relation to stable variables.

OBJECTIVE

To address the important problem of predicting the macroeconomic indicator of GDP in relation to the stable development of metal prices.

METHODOLOGY

The article focuses on the economic situation in Slovakia, and neural network tools were used for the prediction.

RESULTS

1. A key finding is the high accuracy of Slovakia's GDP prediction based on the price trends of certain metals.

2. When comparing the impact of the selected metals, it was found that the evolution of aluminum prices has the greatest impact on the prediction of Slovakia's GDP.

CONCLUSION

1. This article helps public policymakers in Slovakia identify the relationship between the prices of certain metals and the country's GDP.

2. The relationship between the prices of the selected metals and Slovakia's GDP macroeconomic indicator is considered the main contribution, as other countries can plan their budgets based on the methodology used. Thanks to the use of neural networks, the prediction incorporates all influences, including extraordinary ones, that affect metal prices.

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THE EFFECTS OF TECHNOSTRESS ON CONTINUITY COMMITMENT AND ORGANIZATIONAL PERFORMANCE IN CHILEAN HIGHER EDUCATION INSTITUTIONS

Authors: Sergio Araya-Guzmán, Yarisel Bueno-Broterson, Marcela Guiñez-Pérez, Cristian Salazar-Concha

JUSTIFICATION

The growing digitization in universities has transformed institutional management and the working conditions of administrative staff, generating new technological demands that may affect their well-being and performance.

OBJECTIVE

To analyze the effect of technostress and job satisfaction on commitment to continuity and organizational performance among administrative staff at Chilean universities.

METHODOLOGY

A quantitative study was conducted with 240 administrative staff members from universities in southern Chile, using structural equation modeling (PLS-SEM) to analyze the relationships between the variables.

RESULTS

1. Technostress had a positive and significant effect on commitment to stay, indicating that technological demands do not always reduce job retention.

2. Job satisfaction among administrative staff promotes retention within the institution and improves organizational performance.

CONCLUSION

1. In university settings with job stability, technostress can be interpreted as an adaptive challenge rather than a threat to retention within the organization.

2. Institutional management should accompany digitization processes with organizational support and training, promoting the commitment and performance of administrative staff.

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ENTREPRENEURSHIP EDUCATION AND WELL-BEING IN EMERGING UNIVERSITY STARTUPS

Authors: Daniel Yiwady Ordoñez-Abril, Guillermina Tormo-Carbó, Gabriel García-Martínez, María Erika Narváez-Ferrín

JUSTIFICATION

University entrepreneurship is key to reducing unemployment and strengthening regional development in Latin America. Understanding which personal and contextual factors influence entrepreneurial action allows designing better educational strategies and institutional policies.

OBJECTIVE

To analyze how perceived well-being and the institutional perception of the SDGs influence nascent entrepreneurship, and to assess whether entrepreneurial education moderates these relationships.

METHODOLOGY

A quantitative study was conducted with 3,849 Colombian university students, using data from the international GUESSS project and hierarchical binary regression models.

RESULTS

1. Counterintuitively, higher levels of perceived well-being are associated with a lower probability of starting a business.

2. Institutional perception of commitment to the SDGs also has a negative effect on nascent entrepreneurship and is not significantly moderated by entrepreneurial education.

CONCLUSION

1. Entrepreneurship education does positively moderate the relationship between well-being and entrepreneurship, transforming well-being into a resource that mobilizes action.

2. Universities should integrate sustainability with real business opportunities, strengthening experiential methodologies that connect the SDGs with business viability.

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Basic writing rules

Universidad Politécnica Salesiana del Ecuador

General information

"Retos" is a bilingual scientific publication by the Universidad Politécnica Salesiana de Ecuador, which has been edited on a bi-annual basis since January 2011. The journal focuses on Development and transdisciplinary issues including Public Administration, Social Economics, Marketing, Tourism, Entrepreneurship, Management, Administrative and Economic Science, etc.

It is an arbitrated Scientific Journal that uses an external evaluation system known as *peer-review*, employing *double-blind review*, in accordance with the American Psychological Association (APA) style rules. By using this system, the authors have access to an objective, impartial and transparent review process, which facilitates their publication being included in databases, repositories, and international indexed references.

"Retos" is indexed in the selective directory and catalog of the Online Regional Information System for Scientific Journals in Latin America, the Caribbean, Spain, and Portugal (Latindex), in the REDALYC Scientific Information System, the Directory of Open Access Journals in repositories, libraries, and specialized catalogs in Ibero-America.

The Journal is published with two different editions: printed (ISSN: 1390-62911) and electronic (e-ISSN: 1390-8618), in Spanish and English, and each article is identified with a DOI (Digital Object Identifier System).

Scope and policies

Themes

Original contributions in Development issues, as well as related fields: Public Administration, Social Economics, Marketing, Tourism, Entrepreneurship, Management...and all other disciplines related to the central thematic issue.

Contributions

"Retos" preferably publishes the results of empirical research about Development, written in Spanish and/or English, while reports, studies, and proposals are also accepted, as well as reviews of state-of-the-art literature.

All of the publications must be original, never have been published in any other journal, and not be undergoing any arbitration or publication processes. Contributions to the journal can include any of the following:

- **Research:** 5,000 to 6,500 words of text, including the title, abstracts, keywords, tables, and references.
- **Reports, Studies, and Proposals:** 5,000 to 6,500 words of text, including the title, abstracts, tables, and references.
- **Reviews:** 6,000 to 7,000 words of text, including tables and references. Justified, current, and selective references shall be evaluated, and should include around 70 publications.

"Retos" is published bi-annually (20 articles per year), in April and October, and each edition has two sections with five articles each, the first containing a **Monograph** theme edited by subject matter experts, and a second **Miscellaneous** section, made up of diverse contributions related to the publication's theme.

Presentation, structure, and submission of manuscripts

Papers are to be presented with Arial 10 typeface, single line spacing, all justified, without indentation or blank spaces between paragraphs. A space is only to be included between the major sections (title, authors, abstracts, keywords, credits, and epigraphs). All margins on each page must be 2 cm.

The papers are to be presented in Microsoft Word format (.doc or .docx), and the file is to be anonymous in the File Properties such that the author(s) is(are) not identified.

Manuscripts are to be submitted only through the OJS (Open Journal System), in which all authors must first register. Original papers sent via email or another interface are not accepted.

Manuscript Structure

For papers that are empirical research, the manuscripts are to follow IMRDC structure, while Notes and Contributions epigraphs are optional. Papers that constitute reports, studies, proposals, and reviews are afforded greater flexibility in terms of epigraphs, especially in relation to Materials and Methods, Analysis and Results, and Discussion and Conclusions. All types of papers are required to include References.

1. **Title (Spanish) / Title (English):** Concise but informative, the first line in Spanish and the second, in English. Maximum 80 characters are accepted, including spaces. The Editorial Board is allowed to propose changes to the author's title.
2. **First and last names:** of each of the authors, organized in order of priority. Maximum three authors are accepted per original paper, although justified exceptions may be allowed, based on the theme, complexity, and length. The names are to be followed by the professional category, workplace, each author's email address and ORCID number. It is mandatory to include whether the author has a doctorate degree (Dr. before the name).
3. **Abstract (Resumen, Spanish) / Abstract (English):** This section can contain a maximum of 230 words, first in Spanish and then in English. The abstract shall concisely contain the following, and in this order: 1) Justification of the theme; 2) Objectives; 3) Methods and sample; 4) Main results; 5) Main conclusions. It should be written impersonally "This paper analyzes..." In the abstract, automatic translation is not accepted due to its poor quality.
4. **Keywords (descriptores, Spanish) / Keywords (English):** Six keywords are to be included for each language, and must be directly related to the paper's theme. This requirement shall be scored based on whether the keywords can be found in the UNESCO Thesaurus.
5. **Introduction and State of the Question:** The section proposes the question, the context of the issue surrounding it, justification, basis, and proposal for the study, using bibliographic references, including the most important up-to-date literature on the theme, both nationally and internationally.
6. **Material and Methods:** This is to be composed in such a way that the reader can easily understand how the research was performed. As appropriate, describe the method, sample, sampling, and refer to the type of statistical analysis used. If it is an original method, present the reasons for applying it, and describe any possible limitations.

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7. **Analysis and Results:** This section should seek to highlight the most important observations, and without including any value judgments, describe the methods used. Throughout the text, essential tables and figures shall be included in a logical sequence, without repeating any data.
8. **Discussion and Conclusions:** This section summarizes the most important findings related to any observations from relevant studies, pointing out contributions and limitations, without repeating data from other sections. The discussion and conclusions paragraph is to include inferences and new lines of research for the future.
9. **Contributions and acknowledgment (optional):** The Science Editors Board recommends that the author(s) specify the financing source for their research. Priority shall be given to work endorsed by competitive national or international projects. Regardless, for the manuscript to be scientifically evaluated, it is to be anonymized with an XXXX only for the initial evaluation, in order to avoid identification of any of the authors or research teams, which are to be named in the Cover Letter and later, in the final manuscript.
10. **Notes** (optional) are included, only if necessary, at the end of the article (before the references). They are to be included manually, since the Word footnotes are not recognized by the layout systems. Note numbers are to be included using superscript, both in the text and in the final note. Notes including simple bibliographic references (without comments) are not allowed, since these are supposed to be included in the references.
11. **References:** Bibliographic references are to follow the text references. Under no circumstances should references be included that have not been cited in the text. There should be enough references in order to contextualize the theoretical framework, and be based on criteria of contemporary relevance and importance. They are presented alphabetically, according to the author's last name (if the last name has more than one word, based on the first word of the last name).

Rules for references

Periodical publications

Journal article (one author) Valdés-Pérez, D. (2016). Incidencia de las técnicas de gestión en la mejora de decisiones administrativas [Impact of Management Techniques on the Improvement of Administrative Decisions]. *Retos, 12*(6), 199-2013. https://doi.org/10.17163/ret.n12.2016.05

Journal article (up to six authors): Ospina, M.C., Alvarado, S.V., Fefferman, M., & Llanos, D. (2016). Introducción del dossier temático "Infancias y juventudes: violencias, conflictos, memorias y procesos de construcción de paz" [Introduction of the thematic dossier "Infancy and Youth: Violence, Conflicts, Memories and Peace Construction Processes"]. *Universitas, 25*(14), 91-95. https://doi.org/10.17163/uni.n25.%25x

Journal article (more than six authors): Smith, S.W., Smith, S.L. Pieper, K.M., Yoo, J.H., Ferrys, A.L., Downs, E.,... Bowden, B. (2006). Altruism on American Television: Examining the Amount of, and Context Surronding. Acts of Helping and Sharing. *Journal of Communication, 56*(4), 707-727. https://doi.org/10.1111/j.1460-2466.2006.00316.x

Journal article (with no DOI). Rodríguez, A. (2007). Desde la promoción de salud mental hacia la promoción de salud: La concepción de lo comunitario en la implementación de proyectos sociales. *Alteridad, 2*(1), 28-40. (https://goo.gl/zDb3Me) (2017-01-29).

Books and chapters of books

Complete books: Cuéllar, J.C., & Moncada-Paredes, M.C. (2014). *El peso de la deuda externa ecuatoriana*. Quito: Abya-Yala.

Chapters of a book: Zambrano-Quiñones, D. (2015). *El ecoturismo comunitario en Manglaralto y Colonche.* En V.H. Torres (Ed.), Alternativas de Vida: Trece experiencias de desarrollo endógeno en Ecuador (pp. 175-198). Quito: Abya-Yala.

Electronic media

Pérez-Rodríguez, M.A., Ramírez, A., & García-Ruíz, R. (2015). La competencia mediática en educación infantil. Análisis del nivel de desarrollo en España. Universitas Psychologica, 14(2), 619-630. https://doi.org.10.11144/Javeriana.upsy14-2.cmei

All reference that have a DOI (Digital Object Identifier System) must be included in the References (which can be obtained at http://goo.gl/gfruh1). All of the journals and books that do not have a DOI are to appear with a link (to the online version, if available, shortened using Google Shortener: http://goo.gl) and the date of query in said format.

Journal articles are to be listed in English, except for those that are available in Spanish and English, in which case, both languages are to be included in brackets. All internet addresses presented are to be shortened in the manuscript, except for the DOI, which are to be included in the established format (https://doi.org/XXX).

Epigraphs, Tables, and Graphs

The epigraphs in the article's body are in Arabic numbers. These are to avoid all capital letters, underlining, or bold text. Numbering should use maximum three levels: 1. / 1.1. / 1.1.1. A carriage return is to be used at the end of each epigraph.

Tables are to be included in the text in Word format, according to their order of appearance, with Arabic numbering and captioned with a description of their content.

Graphics or figures should be kept to a minimum and incorporated into the text, in accordance with their order of appearance, with Arabic numbers and captions with a short description. Quality should be no less than 300 ppp, if necessary, using TIFF, PNG, or JPEG formats.

Submission process

The papers are to be submitted in two files through the journal's OJS system:

1. **Cover letter and title page,** which includes the title in Spanish and English, first and last names of the authors (standardized format) with ORCID number, abstract in Spanish and English, keywords in Spanish and English, and a declaration that the manuscript constitutes an original contribution that has not been sent for evaluation in another journal, confirmation of the authorship, acceptance (as the case may be) of formal changes to the manuscript according to the rules, and partial transfer of copyright to the publishing house (use the official format).
2. **Completely** anonymized manuscript in accordance with the preceding rules.

All authors are to register on the OJS platform, even if only one of them will be in charge of correspondence. No author can submit two manuscripts simultaneously, with a penalty of not being able to participate in four consecutive editions (2 years).

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