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Article

Eco-innovation as an antecedent of environmental performance and sustainable competitive performance in the manufacturing industry

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Abstract: In recent years, the environment in the manufacturing industry has become strongly competitive, which is why companies have found it necessary to constantly adjust their strategies and take actions aimed at improving their performance and competitiveness in a sustainable way to grow and remain in the market. Therefore, this paper aims to present an analysis to explain the current situation in the manufacturing industry in Aguascalientes, Mexico, by means of a survey in which product eco-innovation (PEI), process eco-innovation (PrEI) and organizational eco-innovation (OEI) and its effect on environmental performance (EP) and sustainable competitive performance (SCP) were measured. The results show that (EP) is positively and significantly influenced by (PEI) and (PrEI), while no significant influence is found for (OE). Furthermore, it is confirmed that environmental performance positively and significantly influences (SCP). The findings obtained from this study point to the relevance of promoting eco-innovation activities in the manufacturing sector, as this will ensure sustainable competitiveness.

Keywords: product Eco-innovation; process Eco-innovation; organizational Eco-innovation; structural analysis; manufacturing industry

1. Introduction

Due to the constant evolution of the market, companies face challenges of instability and high competitiveness, therefore, it is necessary to develop capacities to their growth, through innovative practices to obtain competitive advantages.

Since the United Nations Environment Program (UNEP) (2010), the interest in EI has been growing, especially due to the global urgency to sustainable development and mitigate negative effects of traditional economies. The interest in EI arises in European countries and mainly from members of the Organization for Economic Cooperation and Development (OECD) who consider eco-innovation as a tool to provide solutions to critical problems to sustainable development (OECD, 2009).

In order to minimize negative effects on the environment and respond with actions to comply with the United Nations Agenda 2030 (2019), EI issues have become a key element for sustainable development. Within the literature there are discussions on the understanding of EI, but they commonly highlight the implementation of actions in such a way that positive environmental, social and economic results are obtained (UNEP, 2023; Vence and Pereira, 2019), however, it is still not known for sure what actions are developed in relation to sustainability (Tribaldos and Kortetmäki, 2022) in some regions or countries on the planet, such as the case of emerging countries, in which operating costs in materials and energy are

40 to 60% (UNIDO, 2009); or the case of some business sectors that contribute 60 and 70% of the planet's pollution (Simmou et al., 2023), among other things due to the barriers to joining the green market such as low awareness of the environmental problem, costs, training, among others.

Eco-innovation allows responding to the challenges faced by the industry (Tan et al., 2021), however, it is necessary to validate these benefits towards performance and competitiveness, as the benefits for the consumer are discussed in the literature, but not for producers (Hojnik et al., 2017), which has not yet been explored (Ying et al., 2019).

In the same order of ideas, in the context of Mexico there is a national strategy (2019–2024) for the implementation of the Agenda 2030 (2019) in which the actions to be carried out to monitor compliance with the objectives for sustainability are established. Even though Mexico is a precedent in the OECD (OECD, 2016) database of "development of green technologies", as the country that had patented the most this type of technologies in Latin America in the period 2010–2012 (Rovira et al., 2017), the diagnosis in the national strategy (2019–2024) indicates that producers have not become efficient in their operations that allow them to reduce the negative influence on the environment to carry out their activities, and that changes are needed in the infrastructure sustainable and the application of regulations in sustainable industrial development.

It is a fact that environmental regulations for industry have impacted the way of responding to market needs worldwide, in the case of Mexico the manufacturing industry takes relevance because it makes a significant contribution to the economy, since of the total economic units in the country, these types of companies contribute 32.0% to the added value (INEGI, 2019), however, despite the importance of this sector according to INEGI (2024), in the fourth quarter of 2023, a decrease was recorded of 2.09% of GDP compared to the previous quarter and a decrease of 0.99% compared to the same quarter of 2022.

It should be noted that the state of Aguascalientes contributes 0.66% of the total economic units of the country's manufacturing industries sector (INEGI, 2019) and 1.15% of jobs depend on these economic units, it is presented as one of the states with the highest concentration of industrial activities according to value added along with states such as Campeche, Tabasco, Coahuila and San Luis Potosí.

This investigation is a significant step toward understanding eco-innovation (EI) in the manufacturing sector, as well as some insights into its impact on environmental performance (EP) and sustainable competitive performance (SCP). The main contributions, which are crucial for advancing the field, can be summarized as an empirical validation of eco-innovation models, differential effects of eco-innovation, specification of the environmental performance role as a factor in competitiveness, and sector-specific insights.

This study presents an empirical analysis of how product eco-innovation (PEI), process eco-innovation (PrEI), and organizational eco-innovation (OEI) have explained the improvement of environmental performance, considering manufacturing industries located in Aguascalientes, Mexico. This distinction helps in understanding better how different types of eco-innovation impact performance. Eco-innovation is vital to maintaining competitive advantages over time. Enhanced environmental performance is grounded in operational capabilities and directly enhances sustainable competitive performance, enabling the preservation of such advantages. This investigation offers firm-level research in a developing-country context (Mexico) focusing on manufacturing. Consequently, it lends unique insights into how eco-innovation is positioned within locations abundant with industrial activity but scarce in academic attention.

Eco-innovation is essential for the manufacturing industry as a critical driver of sustainable competitive advantage. This is because of the regulatory and market pressures to improve environmental and economic performance and mitigate environmental damage. Besides, the manufacturing sector is criticized for contributing to environmental degradation. Therefore, as investigated in this research, manufacturing firms should develop eco-innovation strategies as they address environmental challenges and improve firm performance, thus balancing environmental sustainability with economic performance in a highly competitive and environmentally conscious marketplace. This research finding offers insights into how firms should redesign and focus their eco-innovative strategies. Compared to traditional pollution control to proactive eco-innovation strategies, manufacturers can positively impact sustainability goals (Janahi et al., 2021). Some of the main benefits of eco-innovation are that it promotes environmentally friendly products, intelligent use of natural resources, and optimizes production processes. Additionally, it leads to cost reductions, improvement of customer satisfaction, and positioning firms competitively in a market where regulatory, community and competitive pressures demand sustainable practices (Nasrollahi et al., 2020). Thus, based on this research, companies that adopt eco-innovation and see environmental performance as a resource can strengthen their market standing, brand perception, and general corporate sustainability performance.

Different from previous studies treating eco-innovation as a singular concept, this research separates into three dimensions: product eco-innovation (PEI), process eco-innovation, and organizational eco-innovation, providing a more detailed analysis of how each type of eco-innovation contributes to environmental and competitive outcomes. Thus, firms must continuously adapt and reconfigure their resources to meet changing environmental performance and competitiveness. Moreover, using a Structural Equation Modeling (SEM) approach strengthens the reliability of its findings.

First, the literature review is presented, to continue with the methodological design of the study, then the reader will find the results of the study to conclude with the conclusions.

2. Literature review

2.1. Eco-innovation and environmental performance

A diversity of definitions for EI prevails in the literature. Vence and Pereira (2019) conceptualize it as the "set of changes that aim to reduce environmental impacts". While UNEP defines it as "a new business approach that promotes sustainability throughout the life cycle of a product and increases the performance and competitiveness of a company" (UNEP, 2023, p. 1). The concept of EI emphasizes innovative actions focused on "reducing the negative impact on the environment" (Liao and Tsai, 2019), in addition to implications such as organizational changes, including technological ones, as pointed out by Carrillo-Hermosilla et al. (2009) defining EI as the implementation of new technologies in such a path that good economic and environmental results are obtained; which also implies including organizational and social changes that allow improving not only competitiveness, but also sustainability in accordance with its three pillars: social, economic and environmental.

The eco-innovation observatory (2010) in its simplified version states that "EI is any innovation that reduces the use of natural resources and reduces the emission of harmful substances throughout the entire life cycle" (p. 19).

Eco-innovation is crucial to align business operations and goals to sustainability goals, creating a competitive edge while addressing global environmental challenges.

Traditional innovation processes were considered linear, such as the technology-push and market-pull models (Meissner and Kotsemir, 2015). Today, modern approaches are more considered iterative and proactive, integrating sustainability into long-term corporate strategies (Fatma and Haleem, 2023). Also, these new approaches consider external drivers such as regulation (Degong et al., 2018) finance and experience from global networks, on sustainable competitive performance (Martínez-Falcó et al., 2024). Moreover, today's approaches to innovation integrate directly into the innovation process of environmental sustainability (Almeida and Wasim, 2023; Hojnik et al., 2017). Traditional innovation was not coupled with ecological policies; nowadays, eco-innovation governmental policies drive companies to adopt greener practices. The evolution of eco-innovation has been closely tied to shifts in regulatory frameworks, technological advancements, and the increasing global emphasis on sustainable practices.

In studies on the subject, three dimensions are identified: PEI, which is conceptualized as the introduction of new products or services or with significant improvements which must present characteristics that minimize the negative effect on the environment (Chiou et al., 2011; Rovira et al., 2017); the PrEI that according to Pereira and Vence (2012) involves actions to mitigate the negative effects of production and consumption activities using different means such as the reduction of CO_2 emissions, substitution of toxic substances, being more efficient in energy production, etc. and OEI, which is understood as new or updated management systems that support environmental issues throughout the value chain (Cheng and Shiu, 2012). On the other part, EP in the firm is the degree of effectiveness in which the firm engages in solving environmental problems (Cha et al., 2019) through environmental practices that provide benefits to organizations (Ong et al., 2019). EI is one of those practices in which companies benefit in economic, social and environmental terms (Marco-Lajara et al., 2023), since incorporating a green strategic orientation improves EP in companies (Graafland and Bovenberg, 2020). One of the challenges in the manufacturing industry is to analyze EI practices with an inclusive and non-fragmented vision, that is, to include in the studies EI strategies with environmental benefits and with an orientation towards resource efficiency and sustainability. The literature is still ambiguous regarding the practical objectives related to EI strategy in the manufacturing industry (Janahi et al., 2021).

According to López (2021), EI is related to EP and SCP through the development of new products or new processes, or new business, whose purpose is to maintain a low environmental impact during their life cycle.

The results obtained in various studies confirm the positive influence of EI practices in optimizing the use of resources or rationalizing waste management (Gąsior et al., 2022), and relate it to savings in energy consumption, pollution, use recycling and environmentally friendly product design (Tjahjadi et al., 2020). In Taiwan in research carried out by Weng et al. (2015) prove that EI improves EP. Chiou et al. (2011) develop a study about EI, the results indicate that it contributes significant benefits to EP. In the same vein, the results of a study applied in Brazilian companies show that the green business profile or orientation leads to green innovation processes and practices being one of the main drivers for the EP of companies (Frare and Beuren, 2022).

In the literature there are several studies with positive results on the influence of EI with EP results such as Sahoo et al. (2023), Rehman et al. (2021), Yurdakul and Kazan (2020), Abu Seman et al. (2019), Singh et al. (2022), by measuring EI separated by its dimensions, Almeida and Wasim (2023) and Wu et al. (2022); Wu et al. (2023) conclude that EI of products and processes are determinants of EP. In the same sense it is emphasized that through EI of products and processes can be radically transformed, as well as leading to the creation of new environmental strategies (Rehman et al., 2021), there is also specific evidence of the influence that OEI influences EP by promoting the changes required for its achievement, such as establishing eco-innovative management structures, cooperative behaviors, information exchange, cross-functional committee work, implementation of techniques and programmers, and the necessary staff training in all organizational units (Baeshen et al., 2021; Singh and Chakraborty, 2021). Previous literature has neglected the analysis of eco-innovation determinants (Xavier et al., 2017) and how different types of elements respond differently to performance at a granular level. Besides, there is a lack of a broad understanding of how geopolitical and cultural contexts affect the adoption and success of eco-innovation, as different countries might face different challenges and opportunities compared to developed ones. According to this empirical evidence, the following study hypotheses are indicated.

H1: PEI positively and significantly influences EP

H2: PrEI positively and significantly influences EP

H3: OEI positively and significantly influences EP

2.2. Environmental performance and sustainable competitive performance

The concept of sustainable competitive advantage refers to the creation of value for a company that pursues a high degree of innovation thus enhancing competition in the market (Kuncoro and Suriani, 2018), currently one of the main capabilities that provide competitive advantage to organizations is sustainability, this through the use of tools and strategies aimed at change in order to obtain business results in relation to their environment (Palafox, 2019).

SCP is defined according to Chen et al. (2006) as the position occupied by the company that allows competitors to not successfully copy its strategy, thereby obtaining sustainable benefits (Barney, 1991; Coyne, 1986; Porter, 1985). The EP achieved with EI practices increases productivity since there is an improvement in prices, image, the possibility of creating new markets by attending new business and achieves competitive advantages (Chen et al., 2006).

By satisfying the market of green customers who demand green products, companies increase the EP of the company, as they focus on reducing negative impacts on the environment, which achieves both financial and non-financial performance (Costantini et al., 2017).

The effects that happen in organizations that achieve capabilities for EP improvement are among others, a positive influence on production cost reduction (Chen et al., 2016; Rehman et al., 2021), facilitation of public funding (Arranz et al., 2019) and competitive advantage (Gąsior et al., 2022); organizational growth (Leisen et al., 2019) and performance improvement (Weng et al., 2015). It is also identified that the increasing incorporation of environmental regulations allows the development of EI with a positive influence on growth and competitiveness in companies (Leisen et al., 2019).

For SCP efficient resource management is important (Rehman et al., 2021; Ying et al., 2019), strong networking collaboration with public and private organizations (Alkahtani et al., 2020; Arsawan et al., 2022; Makhloufi et al., 2021), with new processes or services with low environmental impact, which provides value to customers and the company. Creating knowledge and internalizing efforts in improving EP and competitive advantage enables SCP (Yadav et al., 2017).

In the same sense, Tjahjadi et al. (2020) in a study carried out in Indonesia confirms that competitive advantage is achieved through improving EP in the company with EI practices. For his part, Uddin (2021) argues after conducting a study of manufacturing companies that green management in the supply chain contributes to making organizational operations greener, which increases competitive advantage.

Mady et al. (2023) also in a study of manufacturing companies demonstrates that, by integrating environmental capabilities into their operations, they take advantage of emerging market opportunities in the demand for green products. Some findings on the subject also indicate that investing in green initiatives to improve EP increases confidence and helps achieve a competitive advantage in the market (Bag et al., 2022; Jiao et al., 2023; Le and Ikram, 2022). It is clear that there is a lack of a broad understanding of how geopolitical and cultural contexts affect the adoption and success of eco-innovation, as different countries might face different challenges and opportunities compared to developed ones (Xavier et al., 2017).

This research supports comprehension of the multifaced significance of integrated environmental performance and sustainable competitive performance. For instance, compared to traditional perspectives, integrated ecological performance and sustainable competitive performance promote firms that focus not only on financial outcomes but also their environmental impacts. At the same time, sustainable competitive performance aims to pursue environmentally friendly practices as well as maintaining its competitive edge (Habib et al., 2020). Besides, a synergistic approach to these techniques allows them to respond to today's market demands for sustainable products and services, enhancing their competitive positioning. The above allows us to propose the following hypothesis:

H4: EP positively and significantly influences SCP

Figure 1 presents the conceptual model to be empirically evaluated in the manufacturing industry sector, in which PEI, PrEI and OEI are presented as antecedents of environmental performance and how environmental performance in turn impacts sustainable competitive performance.

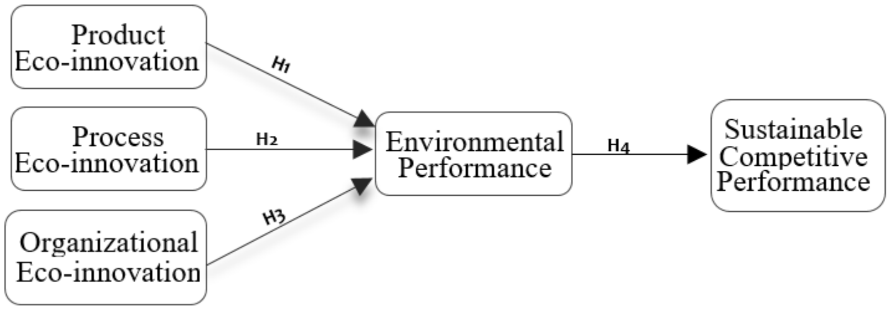

Figure 1. Graphical representation model of measurement.

3. Materials and methods

The design for the present study is quantitative, non-experimental with cross-sectional analysis. For the population, companies from the manufacturing industry were selected, corresponding to the state of Aguascalientes, Mexico. A sample of manufacturing companies located in the state of Aguascalientes was obtained from the database of the National Statistical Directory of Economic Units (DENUE) of the National Institute of Statistics and Geography (INEGI).

According to DENUE information, the population of manufacturing companies is 924 firms that have between 11 and 250 employees, the sample size was determined at 203 firms, a response rate of 21.96 % was obtained, which according to the literature does not represent a problem, since the threshold for common bias is 70 % or more in data collection to consider that it had no effect on the survey results (Fuller et al., 2016).

The instrument used for data collection was a questionnaire structured from literature, with scales developed and validated to measure the variables of EI, EP and SCP. The questionnaire was personally applied to the owners/managers of the companies determined from the sample.

Regarding the measurement of the variables, the EI variable was made up of three dimensions, the first, PEI used, the scale adapted from Hojnik et al. (2017) taken from previous scales of Chen et al. (2006), Chen (2008) and Chiou et al. (2011), that measures the new or significantly improved products, which must present characteristics that reduce the negative effect on the environment and includes six items; in the second, the PrEI in which an adaptation of Hojnik et al. (2017) was used based on Chen et al. (2006); Chen (2008) and Chiou et al. (2011), which measures actions to reduce the negative effects of production and consumption activities, which includes five items, and OEI which measures the incorporation of new or updated management systems that support environmental issues developed by Cheng and Shiu

(2012) in which six items are included. The EP variable is a scale developed by Li (2014), which measures the forces driving organizational change and the effects of innovative environmental practices. It is a unidimensional variable composed of four items.

Finally, for the SCP variable, the scale adapted by Ying et al. (2019), measured through a unidimensional scale composed of eight items in which managers/owners of the organizations were questioned about the profitability of investment, assets, sales, and customer satisfaction in the last three years in comparison to the competition. All variables were measured using Likert-type scale, ranging from 1–5.

Once the survey was applied, all the data collected were coded and captured in the SPSS statistical program. There were no problems of univariate normality following the criteria of George and Mallely (2010) with figures lower than 1.6 in symmetry and kurtosis; multivariate normality was obtained by verifying the Mardia coefficient with values close to 70 according to the criteria used by Ruiz and Rodriguez (2008) and Flores and Medrano (2016), eliminating cases according to the Mahalanobis distance, reported by the AMOS 26 software, leaving 192 cases as the final sample for the study. The variance inflation factors (VIF) values of all variables were checked to verify the intensity of multicollinearity finding that all values are less than five indicating that there are no collinearity problems in the data.

The general characteristics of the companies that make up the study sample in terms of the number of employees indicate that 60.4% have between 11 and 50 workers, 22.9% have between 51 and 250 and 16.7% are for those companies with more than 250 employees. As for the age of the companies surveyed, it was recorded that 7.4% have been in the market for less than 5 years, 25% between 6 and 12 years, 23.1% between 13 and 20 years and 44.4% have been in the market for more than 20 years.

Regarding the sociodemographic characteristics of the key respondents, in this case top management or owners, the companies managed by female gender represent 32.3%, while 67.7% are male gender. As for the age of the managers/owners, the maximum percentage was represented by 66.1%, whose age ranges between 25 and 34 years, 22.4%, between 18 and 24 years and finally with 11.5%, owners or managers older than 35 years. Regarding the studies of the managers or owners of the companies, 3.1% have basic education, 10.4% have high school, 14.1% have a technical or commercial career, 52.6% have a bachelor's or engineering degree, and 19.8% have postgraduate studies, of which 17.7% belong to postgraduate studies at the master's level and 2.1% have a doctorate.

Once the conceptual model was estimated from the literature review, and the descriptive characteristics of the sample of companies were examined, the data analysis was carried out, for which the structural equation modeling (SEM) methodology technique was applied, in which the relationships between the unobserved and latent theoretical variables of the model to be examined are presented (Zabaleta et al., 2020), considering two stages: the first stage consisted of a confirmatory factor analysis (CFA) to confirm the convergent and discriminant validity of the constructs, for the second stage the proposed measurement model and the structural model and the confirmation of the hypotheses were examined (Anderson and Gerbing, 1988).

Figure 2 shows the Confirmatory Factor Analysis (CFA) that was carried out to validate latent constructs involved in the study.

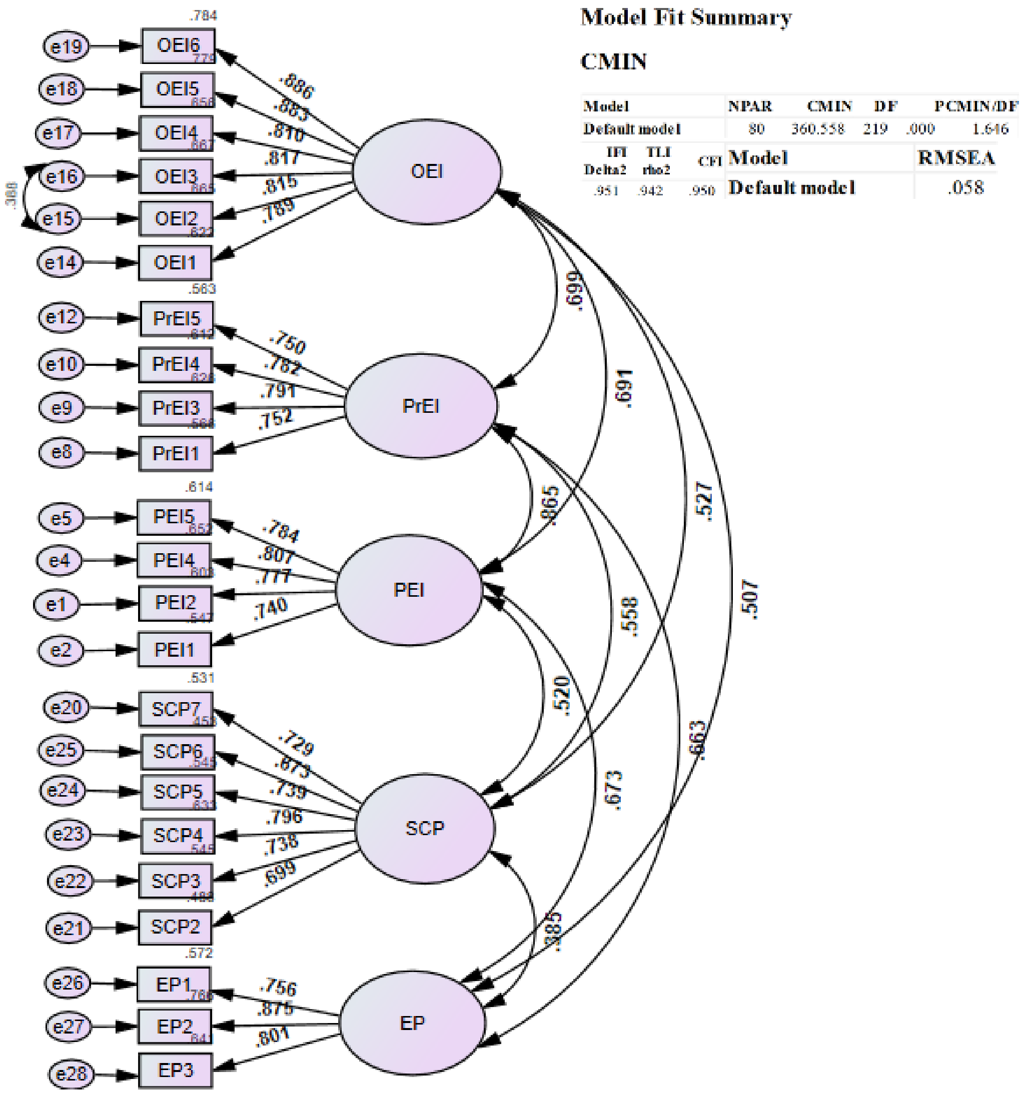

Figure 2. Graphical representation Model of Measurement (AMOS).

In the first instance, the reliability of the study constructs was verified, for which Cronbach's alpha was used to measure reliability, this coefficient indicates that, for preliminary stages, a scale will be considered reliable at a level of 0.700 (Nunnally and Bernstein, 1994), for this study it can be confirmed that Cronbach's alpha coefficients were between 0.846 and 0.934, which represents a good consistency.

For the reliability analysis, the composite reliability index proposed by Fornell and Larcker (1981) was also used. This index registered results from 0.801 to 0.926, which is considered adequate by theory, since it indicates that the values should be greater than 0.700 (Hair et al., 1995).

To verify the convergent validity, the average variance extracted (AVE) test is used, which, for each variable, suggests obtaining values greater than 0.500 (Anderson and Gerbing, 1988). In this case, the results were between 0.584 and 0.696, which explains the convergent validity of the scales.

Subsequently, the goodness-of-fit values of the measurement model were evaluated, such as the chi-square divided by the degrees of freedom Chi^2/df whose value less than three indicates a good model fit (Carmines and Mclver, 1983), in this study Chi^2/df was equal to 1.646; the root mean square error of approximation (RMSEA) with satisfactory values less than 0.08 according to the theory (Anderson and Gerbing, 1988; Hair et al., 2014), in this case a value equal to 0.057 was obtained. The incremental fit index (IFI) was 0.951; the Tucker-Lewis index (TLI) was 0.942; and the comparative fit index (CFI) was equal to 0.950, these values are also satisfactory within the theory since it is suggested to be close to 1 to obtain a good fit in the model (Bentler, 1990). In **Table 1**, in addition to finding the values of Cronbach's alpha, CFI and AVE for each variable, you can also see the average of the factor loadings with results above 0.7 and all variables report significance, the goodness of fit of the measurement model indicated in this paragraph is also shown at the end of the table.

Table 1. Reliability and convergent validation of the measurement scale.

Factor	Item	Factor loading	Average	Cronbach's Alpha	CFI	AVE
Product eco-innovation (PEI)	PEI1	0.74***	0.78	0.859	0.859	0.604
	PEI2	0.777***				
	PEI4	0.807				
	PEI5	0.784***				
Process eco-innovation (PrEI)	PrEI1	0.752	0.77	0.854	0.853	0.591
	PrEI3	0.791***				
	PrEI4	0.782***				
	PrEI5	0.750***				
Organizational eco-innovation (OEI)	OEI1	0.789***	0.833	0.934	0.932	0.696
	OEI2	0.815				
	OEI3	0.817***				
	OEI4	0.810***				
	OEI5	0.883***				
	OEI6	0.886***				
Sustainable competitive performance (SCP)	SCP2	0.699***	0.762	0.870	0.894	0.584
	SCP3	0.738***				
	SCP4	0.796***				
	SCP5	0.739***				
	SCP6	0.873***				
	SCP7	0.729				
Environmental performance (EP)	EP1	0.756***	0.811	0.846	0.853	0.660
	EP2	0.875***				
	EP3	0.801				

Note: Goodness of fit indicators: $Chi^2/df = 1.646 (p = 0.000)$; RMSEA = 0.057; IFI = 0.951; TLI = 0.942; CFI = 0.950; Significance values: * = $p < 0.05$; ** = $p < 0.01$; *** = $p < 0.001$. Source: Own elaboration.

The next step was to evaluate the discriminant validity of the model, for which the confidence interval test (Anderson and Gerbing, 1988) and the Heterotrait-Monotrait test (HTMT) were developed, which according to Henseler et al. (2015), is another technique to verify discriminant validity.

Table 2 shows the results of the confidence interval test to check the discriminant validity, on the diagonal of the table shows the AVE values and below the diagonal is the confidence interval, this procedure consists of determining whether the 1.0 is included within a lower and upper interval. The discriminant validity is confirmed once it is verified that the 1.0 is not included between the intervals of each item.

Table 2. Discriminant validity.

	(PEI)	**(PrEI)**	**(OEI)**	**(SCP)**	**(EP)**
product eco-innovation (PEI)	**0.604**				
process eco-innovation (PrEI)	0.751–0.979	**0.591**			
organizational eco-innovation (OEI)	0.579–0.803	0.579–0.819	**0.696**		
sustainable competitive performance (SCP)	0.440–0.600	0.472–0.644	0.435–0.619	**0.584**	
environmental performance (EP)	0.577–0.769	0.561–0.765	0.407–0.607	0.313–0.457	**0.660**

Source: Own elaboration.

Another technique applied to determine discriminant validity is the Heterotrait-Monotrait (HTMT), in according with this technique, the threshold for determining discriminant validity can range from 0.850 to 0.900 (Henseler et al., 2015). The HTMT analysis, it was executed with the help of the AMOS statistical software tool version 26, following Gaskin et al. (2019), as can be seen in **Table 3**, the values were from 0.406 and up to 0.857, this confirms the discriminant validity.

Table 3. HTMT analysis.

	PEI	**OEI**	**PrEI**	**SCP**	**EP**
PEI					
OEI	0.694				
PrEI	0.857	0.694			
SCP	0.533	0.527	0.566		
EP	0.693	0.507	0.683	0.406	

Source: Own elaboration based on the results of the AMOS 26 application.

4. Results and discussion

Once the measurement model was validated, the structural model was developed.

Figure 3 shows the graphical representation of the structural model, with standardized path coefficients between the eco-innovation dimensions with environmental performance, and this with sustainable competitive performance.

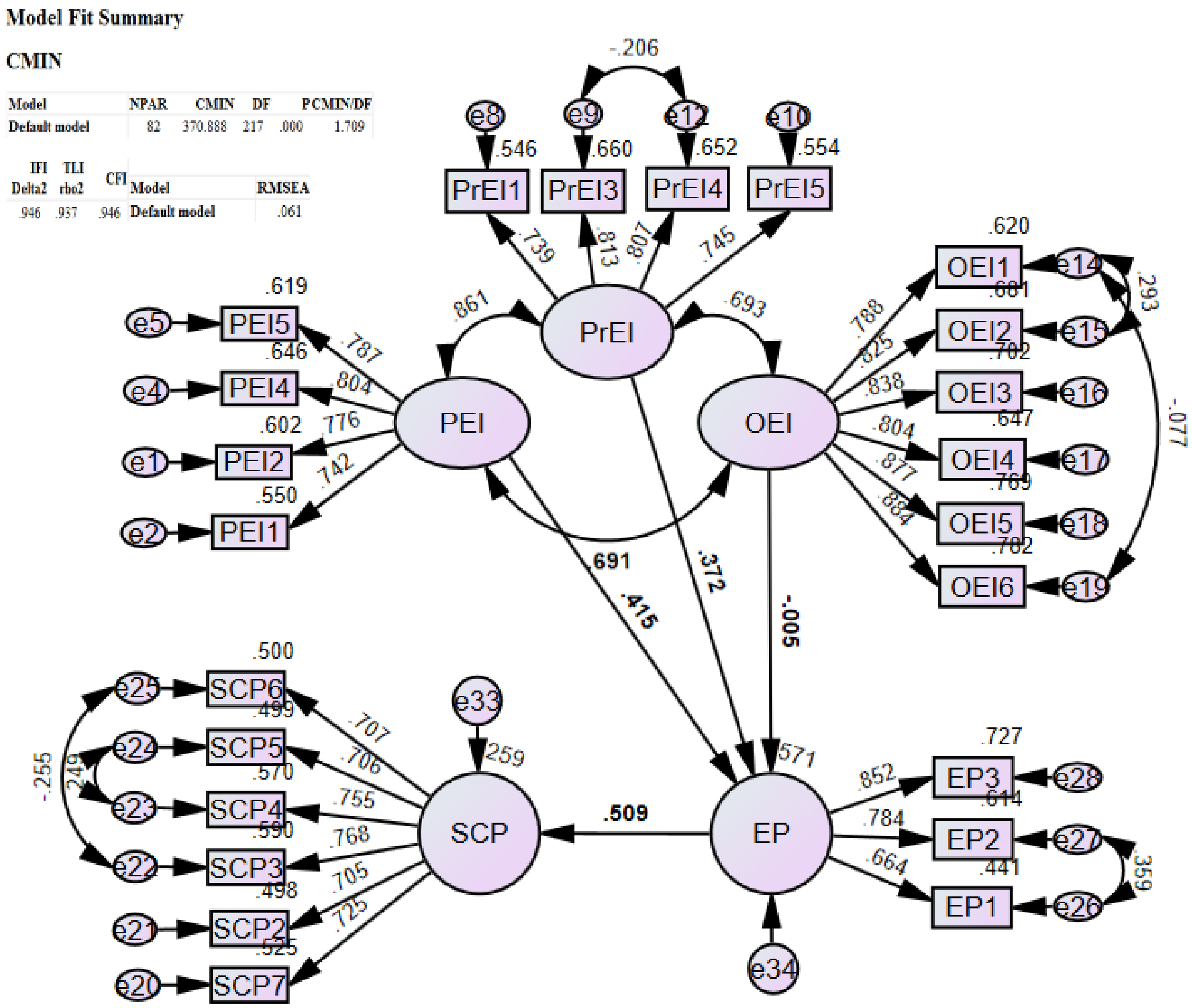

Figure 3. Graphical representation structural model (AMOS 26).

The first step was to verify the good fit of the structural model, where the value of Chi^2/df is equal to 1.709, the RMSEA is 0.061; IFI equal to 0.946; the TLI is equal to 0.937; the CFI with 0.946, this confirmed the good fit of structural model, so the next step was regarding the findings of the relationship of the hypotheses, it can be confirmed that PEI influences EP has a positive and significant since a standardized coefficient of 0.415 and a t value of 2.311 were obtained, therefore, hypothesis one is accepted. For the statement of hypothesis two, it is stated that PrEI has a positive and significant influence on EP; the findings confirm the acceptance of this hypothesis because they present a standardized coefficient of 0.372 and a *t*-value of 2.094. In the case of hypothesis three, it is stated that there is a relationship between OEI and EP; however, the value of the standardized coefficient (−0.005) and the *t*-value (0.054) show a negative influence that is not significant, which indicates that it is not possible to confirm hypothesis 3. Finally, with a standardized coefficient of 0.509 and a *t*-value of 5.359, hypothesis 4 is confirmed, which indicates that EP has a positive and significant influence on SCP. The **Table 4** shows the results of the structural model hypotheses, as well as the fit values of the empirically evaluated model.

The R^2 which show the percentage of variance of the dependent constructs that are explained by the independent variables, in the case of this study EP is explained by PEI, PrEI and OEI with an R^2 of 0.57 (57%), i.e. the variance is explained by 57%, which indicates a high level, in relation to the R^2 of SCP is 0.26 explained by EP, which indicates that 26% of its variance is explained by this variable.

Table 4. Results of the hypotheses.

Hypothesis				Standardized coefficient(*t*)	*p*-value	Result
H1	product eco-innovation	→	environmental performance	0.415 (2.311)	*	confirmed
H2	process eco-innovation	→	environmental performance	0.372 (2.094)	*	confirmed
H3	organizational eco-innovation	→	environmental performance	−0.005 (0.054)		not confirmed
H4	environmental performance	→	sustainable competitive performance	0.509 (5.359)	***	confirmed

Goodness of fit indicators: $Chi^2/df = 1.709$ (p = 0.000); RMSEA = 0.061; IFI = 0.946; TLI = 0.937; CFI = 0.946 Significance values: * = p < 0.05; ** = p < 0.01; *** = p < 0.001. Source: Own elaboration.

5. Discussion

The analysis of the effect of the three types of EI on EP and SCP provides a comprehensive vision of the contribution of each of the dimensions to EP and competitive advantage. The results respond to the influence in the first instance of PrEI, PEI and OEI with EP, it is identified in the results that PEI exerts the greatest strength in the relationship with EP compared to PrEI, in addition to the non-significant impact of OEI with EP.

For hypothesis one the results in agreement with those reported by Sahoo et al. (2023), Andersen (2021), Singh et al. (2020), Cheng et al. (2014) and Wu et al. (2022), where significant impact of PEI on EP was found. However, the results are contrary to other authors (Chiou, 2011; Zulkiffli et al., 2022), who have found that PEI does not influence EP. In the case of the manufacturing industry that was analyzed in our study, PEI is efficient enough to improve the EP of a company and confirms that the implementation and development of EI management practices already allow improve the environmental results of an organization.

For hypothesis two the results of this study in which PrEI positively and significantly influences with EP are similar those of Sahoo et al. (2023), Wu et al. (2022) and Almeida and Wasim (2023); in which it is confirmed that companies focused on learning new environmental knowledge can easily develop eco-innovative ideas in their processes improves their EP. The results also agree with those of Wang (2022), Rehman et al. (2021) and Kraus et al. (2020) as it confirms that EI practices are significantly related to EP, regardless of industry, and that it is crucial to access eco-innovative practices, which are focused on the creation and introduction of new products and processes that support through environmentally friendly measures. Likewise, the results of hypotheses H1 and H2 confirm the findings of Simmou et al. (2023) and Singh et al. (2020) in which they consider that companies more committed to environmentally related approaches invest more in technological solutions to carry out processes aimed at protecting the natural environment, and at the same time improve their EP, which depends on the quality of eco-innovative products and processes.

Regarding the results of hypothesis H3, which indicates that OEI has a positive and significant influence on EP, it is not confirmed, since its influence is not significant, which is contrary to the findings of Sahoo et al. (2023), Geng et al. (2021), Setyawati et al. (2020) and Baeshen et al. (2021), who confirm the positive and significant relationship of OEI with EP, some actually confirm that there is a strong relationship. In this study the results are similar to studies in which the findings indicate that the OEI doesn't positively and significantly influence EP, as in the case of the study by Shin and Cho (2022), who conclude that incorporating internal OEI like organizational green supply chain management actions alone is not significant in terms of positively affecting (EP), they also don´t support the organization's external green supply chain management actions such as actions with suppliers, design, waste reduction, among others, so that to improve EP both internal and external actions are required, i.e. there must be sequential actions. Regarding the results obtained in our study analyzing the manufacturing industry, the result of the non-significance and almost null relationship of OEI with EP confirms what several authors affirm in the sense that they are activities that support the EI of products and processes and these types of EI do have a direct relationship in the increase of EP. For example, the studies by Kim et al. (2021) and Shin and Cho (2022) point out that it is necessary to incorporate some moderating variables that support performance improvement. Cheng et al. (2014) point out that OEI acts as a bridge for the firm, recognizes the mediating effect of OEI to improve performance and is an impetus for product and process eco-innovation.

In the same order Wu et al. (2023), do not find a significant relationship between OEI with EP, in terms of its direct effect, but as its contribution in the indirect and total effect, they point out that if management is not aimed at green investment in companies, it can bring economic benefit but not environmental, which reflects that OE activities are low or in the results of our study even negative in relation to other activities. In this case, the results, being a study conducted in an emerging country, it is understood that companies still have to make decisions regarding the proportion of investment in EI and the maintenance of the traditional operation, on the other hand, the opening towards EI does not have results quickly, in the same sense, Almeida and Wasim (2023) point out that implementing EI in rigid organizations is costly and complex, requiring flexibility in their hierarchical structures, good communication, integration and an interdimensional flow. Regarding H4, which analyzes the positive and significant influence of EP on SCP, the results are consistent with those reported by Gąsior et al. (2022), who confirm similar results.

6. Conclusion

The results presented in this study contribute to provide empirical evidence to know which strategic capabilities drive the increase of sustainable performance in relation to the competence of companies, given the need for change demanded by the global environment to achieve sustainable objectives for the improvement of several strategic areas for the planet. A theoretical model was developed based on empirical evidence from previous studies in which it was proposed that, if companies PEI, PrEI and OEI capabilities, this will positively influence EP, which will allow them to have a greater SCP. The model was empirically evaluated with a sample of companies in the manufacturing sector of an area in a central state of an emerging country such as Mexico. The model presented an adequate fit and the four hypotheses that made up the model were contrasted. The results confirm that the three types of EI do not contribute equally to EP, PEI with strategies such as using environmentally friendly materials and packaging, recycling and using materials and resources to design and develop products with less energy, among other aspects; and PrEI with strategies such as the use of low energy consumption in materials such as water, electricity, gas and gasoline during production, use and disposal, recycling, reuse and prefabrication of products with less energy, have a major influence on EP.

As for the results on the influence of OEI such as the use of novel systems for management, information gathering and communication, participation, and investment in EI activities, on EP, it is very low and negative, and not significant. These results can be explained by the fact that for a company that produces environmentally friendly products, the benefits on EP, such as a reduction of exhaust gases, wastewater and solid waste, as well as a decrease in the consumption of hazardous materials and the reduction of environmental accidents, may not be immediate, since market consumption patterns change, product life cycles are shortened and competition increases, so the company must respond to challenges in internal management and in its response to adjustments in the environment. The development of OEI strategies requires changes in management to develop new practices, these management systems must permeate the value chain, there must be internal training and cooperation of external actors, so it will depend on a careful implementation to see positive results.

This research presents several crucial managerial implications that target the decision-makers within manufacturing units to foster their environmental performance (EP) along with sustainable competitive performance (SCP). Managers should direct their resources to PEI and PrEI, as they strongly influence environmental performance. It can be things like sustainable materials, low-emission technologies, or optimized resource efficiency in production. Firms that invest in these areas are expected to gain environmental and competitive benefits.

Since organizational eco-innovation has not significantly impacted environmental performance, managers need to think again and change their way of doing OEI. Rather than demanding immediate environmental returns from new management systems, companies might consider combining OEI with product and process innovations for higher returns or may concentrate on promoting internal and external collaboration to improve their performance. Also, improving environmental performance (EP) meets regulatory and sustainability expectations and enables sustainable competitive advantages.

Managers need to accommodate eco-innovation as an integrated part and take into partnership not just the suppliers and customers but also other stakeholders, which will motivate them to be more conscious in their contribution to greener products and processes (Ying et al., 2019). This will incorporate some environmental aspects into the marketing mix and make it stand out. The investigation naturally leads to insights that delineate the path that needs to be taken by businesses in emerging economies for adopting environmental innovation, such as strategic frameworks and lenses focused on eco-innovation due to cost constraints or awareness issues. Managers must take a holistic approach and evolve eco-innovation over time.

In summary, the results of this research imply that both a focused and an even approach to investing in eco-innovation—with a focus on products and processes—will not only benefit sustainability but also long-term competitiveness.

Some future lines of research to achieve an improvement in SCP in emerging countries would be to analyze what barriers exist in this region that inhibit the development of eco innovation capabilities, as well to investigate the role of OEI in the results produced by both PEI and PrEI in EP and SCP, since the results are not conclusive, especially in the study of different business sectors.

A more detailed investigation is necessary to face eco-innovation challenges in the manufacturing industry. For instance, technological complexity and integration imply a redesign of production and business models and integrate circular economy principles.

Also, there is uncertainty about regulations and policy, where unclear policies can hinder long-term planning. Moreover, stakeholder collaboration is necessary but complex due to the unalignment of sustainability goals and different rules and economic conditions (Nasrollahi et al., 2020). Also, there is a need to understand the eco-innovation dynamics in various sectors, for example, for the services sector, to develop competitive design tools and systems (Janahi et al., 2021).

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