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Analysis of eco-friendly business practices and their impact on environmental sustainability in a Peruvian Amazon region

Marleny Quispe-Layme[a*], Wilian Quispe-Layme[b], Sonia Cairo Daza[a], Giovana Lira Jiménez[a], Claudia Elizabet Bueno de Vega Centeno[a], Edilberto Félix Vilca Anchante[a], Flavio Edgar Córdova Amesquita[a], Gladys Quispe Mamani[a], Nelly Jacqueline Ulloa-Gallardo[c] and Luis Alberto Holgado-Apaza[c]

[a]*Departamento Académico de Contaduría y Administración, Facultad de Ecoturismo, Universidad Nacional Amazónica de Madre de Dios, Puerto Maldonado 17001, Perú*
[b]*Departamento Académico de Educación y Humanidades, Facultad de Educación, Universidad Nacional Amazónica de Madre de Dios, Puerto Maldonado 17001, Perú*
[c]*Departamento Académico de Ingeniería de Sistemas e Informática, Facultad de Ingeniería, Universidad Nacional Amazónica de Madre de Dios, Puerto Maldonado 17001, Perú*

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A B S T R A C T

Eco-friendly business practices range from energy efficiency to sustainable management; therefore, the implementation of these practices not only has the potential to mitigate environmental impacts, but also to improve the long-term competitiveness and sustainability of companies. In this study we analyze eco-friendly business practices and their impact on environmental sustainability in companies in a region of the Peruvian Amazon. A quantitative, non-experimental approach was considered, with an explanatory design; for which, a sample size of 200 companies was considered, which were randomly selected, to which two instruments were applied, the first with 7 indicators and the second with 3, valid, with an alpha of 0.720 and 0.670 respectively, assessing structural equation modeling. The results show that eco-friendly business practices are oriented towards sustainability (C.R. = 19.280), as well as preventive and eco-efficient practices (C.R. = 5.023, C.R.= 14.185); these findings can serve as a basis for the creation or improvement of public policies that promote eco-friendly business practices, encouraging companies to adopt measures that favor environmental sustainability. Therefore, eco-friendly business practices have a positive impact on environmental sustainability in companies in a region of the Peruvian Amazon; in addition, preventive practices and eco-efficient practices have a positive impact on environmental sustainability in companies in a region of the Peruvian Amazon.

1. Introduction

Concern about climate change and environmental degradation has led to a global recognition of the need for sustainable business practices. In the contemporary era, this is becoming a top priority due to growing concern about the negative effects of climate change and environmental degradation (Gómez-Bayona et al., 2023). Businesses are at the forefront of the sustainability movement because of the imperative need to preserve the environment and protect our planet. This concern has transcended from a mere ethical consideration to a business imperative in response to the increasing severity of the environmental disaster facing the world (Popescu et al., 2024). The advancement of sustainable leadership models and the regular use of environmentally friendly

* Corresponding author.
E-mail address maquispe@unamad.edu.pe (M. Quispe-Layme)

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energy sources are two changes that result from the promotion of green energy in human resources practices. These initiatives not only protect the long-term viability of organizations, but also contribute to reducing the damage that global warming is causing to the environment (Manurung, 2024). In 2015, the 2030 Agenda for Sustainable Development, established by the Member States of the United Nations, was developed. This agenda contains 17 Sustainable Development Goals (SDGs), among which SDG 12 focuses on ensuring sustainable consumption and production patterns (Ahmed Dirie et al., 2024; Zamignan et al., 2022). Bioenergy is Germany's most important renewable energy source, positioning the country as one of the world leaders in the use of renewable energy, China could reduce its emissions by 88.5% and 85.14% by 2030, with a likely decrease of 90.63% and 52.42%, respectively. India registers the highest percentage reduction in both scenarios considered, while Germany predicts the lowest percentage emission reduction relative to 2021. U.S. carbon emissions will be reduced by 83% and 79.8% by 2050 (Obiora et al., 2024). Countries around the world are implementing and promoting eco-friendly business practices, evidencing a growing global commitment to sustainability. This is reflected in significant investments, proactive public policies and the adoption of green technologies (Alam et al., 2024). Global contribution facilitates additional green initiatives, enabling competitive advantage through environmentally responsible practices (Khodair, 2024). These practices not only help reduce environmental impact, but also generate economic and social benefits, improving the competitiveness and resilience of companies (Bala, 2024). Organizations and governments are implementing policies and programs to promote eco-friendly business practices. Companies have been adopting environmentally friendly strategies, using in particular the theory of the sustainability of intentional behavior. Increasingly, companies around the world are becoming aware of these practices, seeing them as a business strategy that enables them to improve their competitiveness (Bajar et al., 2024). The adoption of green practices prioritizes environmentally friendly products, and more and more managers are incorporating environmental sustainability into their business plans. They point out that an increasing number of companies are embracing sustainability from the outset, recognizing the environmental benefits (Nikolakis et al., 2024). Eco-friendly business practices, also known as business sustainability practices, include a variety of strategies and actions designed to reduce the negative environmental impact of business operations (Candrianto et al., 2023). Eco-friendly business practices range from energy efficiency to sustainable management. Implementing these practices not only has the potential to mitigate environmental impacts, but also to improve the long-term competitiveness and sustainability of companies (Khalil et al., 2024; Tan et al., 2024). Among the urgent needs are the integration of renewable energy sources, the optimization of the use of natural resources, and the application of innovative financial instruments and investment strategies. These practices are considered strategies and actions implemented to reduce the negative environmental impact of business operations and promote sustainability (Liu & Pan, 2024).

The opportunity to positively influence a more sustainable future for well-being through environmental sustainability is significant. Therefore, the analysis of these practices has become crucial for companies. It is essential to understand how these practices, which include a variety of strategies and actions designed to lessen the environmental burden at the corporate level, can be implemented (Sunani et al., 2024). Environmental sustainability is being driven by the recognition of the negative effects of climate change and environmental degradation on ecosystems and human communities (Zhang et al., 2024). In this context, eco-friendly business practices emerge as a crucial component to mitigate the negative environmental impact of economic activities. Effectively addressing sustainability issues requires the implementation of transparent and environmentally conscious procedures (Ma et al., 2024). The goal is to ensure that the planet's natural resources and ecosystems are conserved and used responsibly, maintaining a healthy environment rich in biodiversity. Overexploitation of resources and pollution can deplete available resources, putting both human and other forms of life at risk. Biodiversity is crucial to the balance of ecosystems. Environmental sustainability promotes its conservation through the protection of natural habitats, the reduction of deforestation, and the implementation of sustainable agricultural and fishing practices (Abhisha & Melvin, 2024; Gomes et al., 2024). In the case of Peru, environmental sustainability has gained importance in both public policy and the business agenda. Environmental concerns related to sustainable business performance are addressed, and policies seek to integrate sustainability into all economic sectors. This includes the promotion of practices that protect the environment and encourage sustainable eco-economic development (Ogiemwonyi & Eneizan, 2024; Sharma et al., 2024). Energy consumption and CO_2 emissions are key drivers of economic growth. Environmental degradation indicators, analyzed using models that do not present problems of heteroscedasticity or autocorrelation, explain 24% of economic growth. In the proposed model, it is observed that an increase in CO_2 emissions translates into a 19% increase in GDP per capita, while an increase in energy consumption results in a 20% increase in GDP per capita, with an individual significance level of less than 5% in all cases (Mamani et al., 2023). Mining, for example, has been responsible for deforestation and contamination of water bodies with heavy metals, while intensive agriculture has contributed to soil degradation and biodiversity loss. The environmental effects of large-scale mining concessions are significant, given that 94% of Peru's annual copper production comes from large-scale mining (Coayla et al., 2024). The Peruvian government has implemented several initiatives to promote sustainable practices in various sectors. The Law for the Promotion of Investment in Non-Conventional Renewable Energies (Law No. 1002) and the National Agricultural Innovation Program (PNIA) are examples of efforts to encourage the use of clean technologies and sustainable agricultural practices. The Peruvian Amazon plain is a region with significant economic potential due to its wealth of natural resources and high biodiversity. However, mineral extraction and other activities have led to the leaching of heavy metals into the soil, creating serious environmental problems that have had a significant impact on the well-being of the local population and their ecosystems (Espinoza-Guillen et al., 2022). In today's world, it is necessary to find a balance between environmental preservation and economic success (Taneja et al., 2023). Despite these challenges, there are notable efforts to promote eco-friendly business practices in the Amazon region. The regional government and various non-governmental organizations (NGOs) have launched initiatives to promote responsible mining and sustainable agriculture (Adewuyi et al., 2024; Tuesta & Scurrah, 2024). These initiatives include certification programs for artisanal and small-scale mining, as well as agroforestry projects that combine agricultural production with forest conservation. The adoption of these practices not only has the potential to mitigate environmental impacts, but also to improve competitiveness and long-term sustainability.

This article aims to analyze eco-friendly business practices and their impact on environmental sustainability in the companies of Madre de Dios. In a context where sustainability has become crucial to human life as well, businesses must understand that conservation is essential and that these practices can be effectively implemented in a region with such unique and challenging characteristics.

2. Literature review

2.1 Eco-friendly Business Practices

Green business practices refer to "activities, policies and strategies that promote sustainable development by minimizing negative environmental impacts and maximizing positive contributions to the environment. These practices involve the integration of environmental considerations into various aspects of business operations, including resource management, energy efficiency, waste reduction, pollution prevention and the adoption of cleaner technologies. They also include practices aimed at promoting environmental responsibility and stewardship throughout the organization, such as eco-design, eco-labeling and eco-marketing (Schaltegger & Burritt, 2022). Companies focus on sustainability and their contribution to the environment and are motivated to rethink new approaches to the sale of environmentally friendly products and waste disposal (Véliz et al., 2020). The advance of environmental degradation, evidenced by climate change and continuing biodiversity losses, has been putting pressure on companies to increasingly adopt environmental management practices (Jabbour et al., 2012).

2.2 Types of Eco-friendly Business Practices

Companies that take proactive environmental measures report higher performance gains and significant performance gains (Balseca-Ruiz et al., 2023). Companies use these techniques in two ways:

- Preventive
- Eco-efficiency with the environment.

They are linked to particular organizational capabilities that derive from different strategic competitive attributes. In addition, a relevant but not determining factor in the adoption of environmental measures is the size of the company.

2.3 Sustainable Development

It is gravitating toward the triple idea of society, economy, fostering entrepreneurial innovation and ecology (Fig. 1).

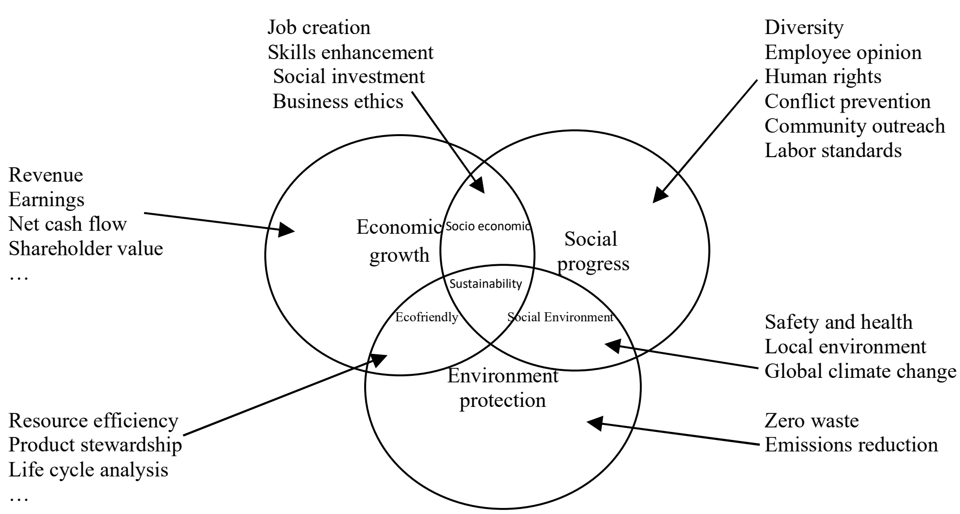

Fig. 1. Description of sustainable development (Wang et al., 2023)

Social disparity, the current eco-economic recession, environmental degradation, and rapid industrialization and urbanization (Majid et al., 2023). Sustainable development seeks to eradicate poverty and hunger, boost employment generation, manage resources efficiently, protect the environment and improve the quality of life. The goal of sustainable development is to understand how financial, human, ecological and technological systems intersect. Thus, companies and stakeholders must execute serious strategies to deal with global problems. Only when government regulations and laws prioritize environmental sustainability and adopt various ecological measures within companies and businesses can sustainable development be achieved. (Wang et al., 2023).

2.4 Environmental Identity Theory

Refers to the degree to which a person is familiar with identification through cognition, emotion, and evaluation of the meaning and importance of group members (Hu et al., 2023). People's lives are becoming increasingly urgent due to climate change, pollution, poverty and other issues, and sustainable business practices are essential to solving environmental problems.

2.5 Intrinsic Connection Between Integrated Quality Management and Corporate Environmental Performance

Considering the environmental degradation caused mainly by manufacturing industries and the inadequate studies that identify the factors that make it easier for companies to counteract this problem, corporate social responsibility (CSR) versus total quality management (TQM) plays a crucial role in improving the environmental performance of companies (CSR); these include green management strategies, green processes and green product performance (Abbas & Sağsan, 2019).

2.6. Green Theory and Green Performance

With the rise of the industrial revolution, the rate at which the manufacturing sector consumes natural resources to generate income and produce goods has increased considerably. This has led to a shortage of natural resources, especially for future generations, and a significant change in the natural environment, such as global warming. With this in mind, the General Assembly of the United Nations (UNGA) has made it mandatory for all environmental sustainability to (Abbas & Sağsan, 2019).

2.7. Green Management

It states that management should use green human resource practices to attract and retain talented employees whose environmental values and goals match those of the company. Employees should be involved in solving environmental sustainability and green management issues. They would participate in ongoing training programs and gain knowledge about green management and environmental sustainability (Aboramadan & Karatepe, 2021).

2.8. Ecological Management

Green human resource management (GHRM) is a crucial organizational strategy that supports the long-term growth of companies. Although there is a growing body of research on the impact of GHRM, little is known about the conditions and mechanisms that would facilitate understanding of the relationship between GHRM and green outcomes, The relationship between GHRM and commitment to green work is moderated by spiritual leadership. Thus, the relationship between GHRM and engagement in ecological work is moderated by spiritual leadership (Ahmed et al., 2023). The report states that green innovation is an essential and hot topic for environmental and organizational performance, and that green innovation has a significant impact on organizational and environmental performance. The moderating impact on organizational and environmental performance does not result from a bidirectional interaction (moderation) between human resource practices and green innovation (Abualigah et al., 2023).

2.9. Environmental Sustainability

It refers to the stability obtained through a balanced and harmonious interaction between humans and the environment of which they are a part. It is essential that this connection remains constant and lasting over time, ensuring that natural resources and ecosystems are managed in such a way that they can continue to exist and prosper in the future. This implies a respectful and beneficial coexistence between society and nature, promoting practices that do not compromise the ability of future generations to meet their own needs (Wiese, 2023).

This will contribute to providing solutions related to fair trade, both in similar contexts and in diverse situations. It will also facilitate the improvement of the economic situation and social welfare in the field of study. When organizations achieve fair trade, they can position themselves competitively in the market, offering fair working conditions, promoting gender equity and assuming social and economic responsibilities (Mendoza-Castañeda & Acosta-Pajares, 2023).

2.10. Determinants of Environmental Sustainability

Determinants related to environmental sustainability have been identified (Manuel et al., 2022):

2.10.1. Integrated management

The economic component focuses on the evaluation and distribution of economic benefits to employees, including aspects of social security, fiscal governance and stakeholder participation. In the environmental area, elements related to climate change protocols and regulations are highlighted, with indicators such as efficient energy use and reduction of greenhouse gas emissions. The social aspect focuses on labor policies and human talent management, covering governance and co-governance, occupational safety, gender equality, healthcare and continuous personnel training. In addition, indicators related to attention to local communities and customer satisfaction are included. Establishes that the relationship between management safety intervention and sustainable performance is indirect and mediated by human and technical safety intervention (Machingura & Muyavu, 2024) .

2.10.2. Compliance with socio-environmental regulations

The other facet of labor policy related to compliance with social, economic and environmental laws is the issue of the social component, which represents an important factor that is required by labor laws. For (Wei et al., 2024) refers that environmental regulations are market-based On green technological innovation and the different modulating effects of corporate social responsibility (CSR) on the various degrees of sustainable technological innovation. (Wesseh et al., 2024).

2.11. Corporate social responsibility (CSR)

Corporate Social Responsibility (CSR) initiatives are mainly included in linear business models, in which the overall performance of the organization is evaluated on the basis of how well the measures are applied. But the question also arises as to whether this is sufficient, which brings us to three questions that connect business models (BMs) with CSR and sustainability (Mendoza-Castañeda & Acosta-Pajares, 2023).

2.12. Ecological modernization theory (EMT)

The theory of ecological modernization (EMT) serves to maximize the advantages where the economy must always move towards environmentalism, through innovation and technical advances, EMT is a methodical philosophy of eco-innovation that aims to protect the environment while achieving the objectives of development and prosperity of the organization (Ghaffar et al., 2023). Companies have come under increasing pressure to be “eco-logical” (minimize negative effects on the environment). It is clear that some features of lean manufacturing can help preserve the environment; reducing the consumption of energy, water or raw materials, combined with waste reduction, is one way to improve a company's environmental performance. Lean manufacturing strives to reduce waste (resources that do not add value to the final product). Today, it is essential for companies to understand how lean techniques can help them become “greener” (Luján-Blanco & Fortuny-Santos, 2017), (Adeel et al., 2022).

3. Methodology

The approach is quantitative, non-experimental, with an explanatory design, where the objective was to analyze eco-friendly business practices and their impact on environmental sustainability in companies in the Peruvian Amazon (Mendoza Bellido, 2014; Sampieri & Collado, 2010). A sample of 200 companies was used. To collect data, a structured questionnaire was designed on the concepts previously reviewed, where information was collected through two instruments called “appreciation from the point of view of eco-friendly business practices” and “appreciation from the point of view of environmental sustainability” (Balseca-Ruiz et al., 2023) These are related to particular organizational skills, based on different strategic characteristics of competitiveness. In addition, the size of the company is a crucial but not determining factor in the adoption of environmental practices, establishing these 2 dimensions. In addition to this, the second instrument called “appreciation of environmental sustainability” was applied, adapted according to (Manuel et al., 2022) which establishes socio-environmental norms and integrated management as sustainability factors, these theoretical models obtained a strong theoretical denotation in the previous study through the rotation method, with 0.994 and 0.988 respectively.

3.1. Operationalization of Variables

The dimensions are preventive practices and eco-efficiency for the independent variable and the dimensions of socio-environmental standards and integrated management for the dependent variable, both instruments were validated and applied, with respect to the first instrument there are 2 dimensions such as preventive practices (with 3 indicators) and eco-efficiency practices (4 indicators) and with respect to the second variable there are dimensions such as socio-environmental standards (1 indicator) and integrated management (2 indicators). Table 1 shows the operationalization of the variables in our study.

Table 1
Operationalization of the research variables.

Variables	Dimension	Type of variable	Category
PEE: Eco-friendly business practices	Preventive practices Eco-efficiency practices	Exogenous	1: Low 2: Medium 3: High
SA: Environmental sustainability	Socio-environmental standards Integrated management	Endogenous	1: Low 2: Medium 3: High

Additionally, in Fig. 2, we present the proposed structural equation model that explains Eco Friendly Business Practices (EFP) and Environmental Sustainability (ES). For processing, the structural equation technique was used, and the following hypotheses were proposed:

Hypothesis 1: Eco-friendly business practices have a positive impact on environmental sustainability in companies in the Peruvian Amazon.
Hypothesis 2: Preventive practices have a positive impact on environmental sustainability in companies in the Peruvian Amazon.

Hypothesis 3: Eco-efficiency practices have a positive impact on environmental sustainability in companies in the Peruvian Amazon.

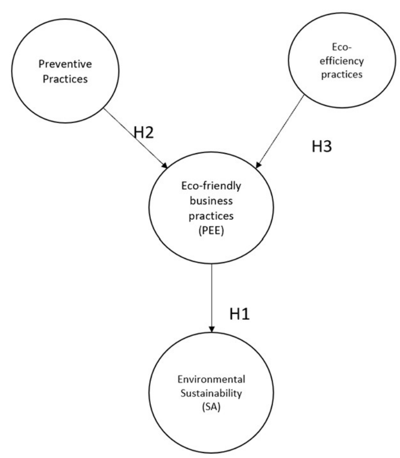

Fig. 2. Proposed structural model according to hypotheses

Fig. 2 identifies the exogenous and endogenous constructs, along with their respective relationships. The model in this study focuses on eco-friendly business practices and their relationship with environmental sustainability (a), pre-sales practices and environmental sustainability (b), and eco-efficiency practices and environmental sustainability (c). These relationships are illustrated in Fig. 2 of the model. Twenty-four questions (observed variables) were used in the questionnaires. All items were accompanied by five-point scales (1=Never, 2=Almost never, 3=Sometimes, 4=Almost always and 5=Always), which made it possible to collect information on the variables and dimensions presented in Table 2.

3.2. Structural equations (SEM)

Use of structural equation modeling (SEM) to analyze the proposed hypotheses and the interactions between variables. According to (Sánchez-Iglesias et al., 2022), Before applying SEM, it is essential to conduct confirmatory factor analysis (CFA). In this study, we conducted CFAs independently for each of the three constructs to assess the adequacy of fit for each, as recommended by (Tohari et al., 2024). Parameter estimates within SEM are obtained through three stages of the iteration process: the first stage determines the weight estimate used to assign scores to the latent variables; the second stage determines the path estimate connecting the latent variables and the loading between the latent variables and their indicators; and the third stage determines the average estimates and parameter locations (constant regression values, intercept) for the indicators and latent variables. This study investigated the hypotheses by identifying the causal relationships shown in Figure 1, with the objective of evaluating the overall fit of the structural model. In addition, further tests were carried out to verify the robustness of the model's conclusions, looking for the optimal fit. The testing and comparison of different models contribute to assess the robustness of the structural model. To do so, observed variables were included in the model, which allowed them to be measured to obtain the scores, as shown in Table 2.

Table 2
Selection of Variables for the AFC and SEM

Factors	Latent variables	Variables observed	Items
Eco-friendly business practices (PEE)	Preventive Practices (PP)	PP1: Quantity of waste generated in operations	Items 1-4
		PP2: Number of Environmental Training Programs	Items 5-7
		PP3: Proportion of sustainable or less polluting materials.	Ítem 8
	Eco-efficiency practices (EP)	PE1: Percentage of waste recycled.	Items 9-10
		PE2: Number of projects implemented to improve eco-efficiency.	Items 11-12
		PE3: Presence and quality of policies and programs aimed at promoting eco-efficiency.	Items 13-14
		PE4: Level of compliance with relevant environmental regulations and standards.	Items 15-16
Environmental Sustainability (SA)	Socio-environmental standards (CSA)	CSA1: Environmental Certifications	Items 17-19
	Integrated Management (GI	GI1: Operational efficiency by reducing costs and waste.	Items 20-22
		GI2: Level of management integration (quality, environment, safety and occupational health).	Items 23-24

To confirm the significance of the constructs, the CFA was applied, as referred to (Gorai et al., 2024) y (García-Martínez et al., 2024). This type of analysis evaluates construct validity by means of a measurement analysis within the defined structural model, confirming the presence of the variables observed in the constructs. Using AMOS version 26 software, the measurement analysis was performed, evaluating both the constructs and the reliability of the variance extracted to confirm the observed variables. In this study, a comprehensive measurement analysis was conducted to assess the validity of the proposed constructs within the defined structural model. Once the measurement model was confirmed, the full structural model was estimated using SEM, which allowed the identification of causal and non-causal relationships between the latent variables of the study. The standardized regression coefficients between the exogenous and endogenous latent variables provided information on the strength and direction of these relationships, while their associated p-values indicated the statistical significance of each effect.

4. Results

In Fig. 3 we present the structural equation modeling proposed for Confirmatory Factor Analysis (CFA), based on the literature review, considering latent variables ($\eta1$ and $\eta2$), exogenous variables ($\xi1$ and $\xi2$), observed variables ($X1$ through $X16$ and $Y1$ through $Y8$), measurement errors of exogenous variables ($\delta1$ through $\delta16$) and prediction errors of endogenous variables ($\varepsilon1$ through $\varepsilon8$), regression coefficients of endogenous variables ($\lambda1$ through $\lambda8$), regression coefficients of exogenous variables ($\lambda1$ through $\lambda16$), regression coefficients relating exogenous variables to endogenous variables ($\gamma21$ and $\gamma22$), regression coefficient relating endogenous variables to each other ($\beta21$) and structural errors ($\zeta1$ and $\zeta2$).

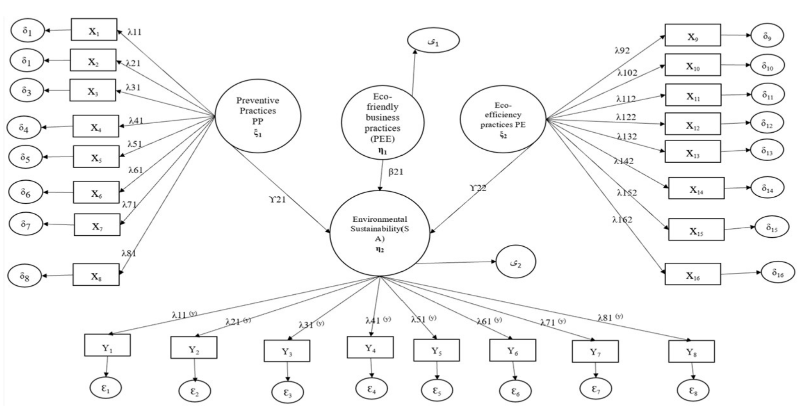

Fig. 3. Standardized estimates from the proposed model

4.1. SEM and AFC Diagram

The SEM is given by Eq. (1).

$$\eta = \beta\eta + \Gamma\xi + \zeta \quad (1)$$

The equations proposed by our model are detailed in Eq. (2).

$$\eta 1 = \beta 21\ \eta 2 + \zeta 1 \quad (2)$$
$$\eta 2 = \gamma 21 \xi 1 + \gamma 22 \xi 2 + \zeta 2$$

Eq. (3) shows the proposed equations for the endogenous variables.

$$Y_{\mathrm{i}} = \lambda \mathrm{i}1^{y}\ \eta_2 + \varepsilon_{\mathrm{i}} \quad (3)$$

with i from 1 to 8. Eq. (4) shows the proposed equations for the exogenous variables.

$$X_{\mathrm{i}} = \lambda \mathrm{i}1^{x}\ \xi_1 + \delta_{\mathrm{i}} \quad (4)$$
$$X_{\mathrm{j}} = \lambda \mathrm{j}1^{x}\ \xi_1 + \delta_{\mathrm{j}}$$

with *i* from 1 to 8
with *j* from 9 to 16

4.2 Estimation of the First Model

Fig. 4 shows the proposed model with the values obtained, where several significant relationships are observed that demonstrate the influence of PEE and SA on their observed items. The most significant p values are highlighted for Item19 (1.0), Item17(1.0), Item16(1.0), Item14(1.0) and Item 11(1.0). The significant values re-strengthen the robustness of the model, except in the cases of Item7 and Item9 (p7=-0.06 and p9=0.06), which do not show a significant relationship with PEE. These results are critical to validate the underlying theoretical structure of the model and provide a detailed understanding of how the latent variables impact the observed items in the context of the study.

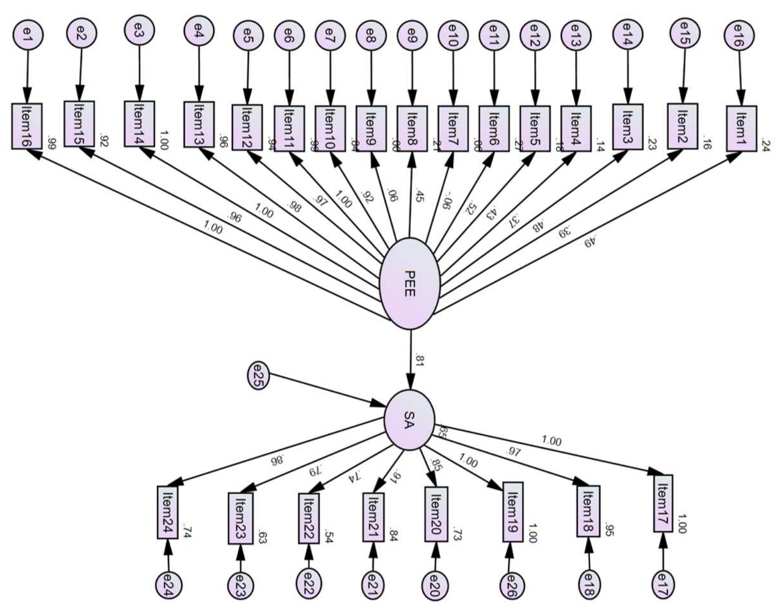

Fig. 4. Model 1 -SEM with standardized estimates

In Table 3, we present the results of the structural equation analysis, where the Estimate column represents the coefficient of the relationship between variables and items. In addition, C.R. represents the Critical Ratio value, represented by t, the table highlights the most significant values for Item19 (293.81), Item14(104.24) and Item 11(139.82). The high and significant t-values reinforce the robustness of the model, except in the cases of Item7 and Item9 (t7=0.39 and t9=0.37), which do not show a significant relationship with PEE. These results are critical to validate the underlying theoretical structure of the model and provide a detailed understanding of how the la-tent variables impact the observed items in the context of the study.

Table 3
Significant estimates from Model 1 - Relevant results

			Estimate	C.R.	P	Label
SA	←	PEE	0.609	19.165	***	par_5
Item9	←	PEE	0.032	0.899	0.369	par_1
Item4	←	PEE	0.173	5.603	***	par_2
Item20	←	SA	0.895	23.022	***	par_3
Item23	←	SA	0.555	18.471	***	par_4
Item19	←	SA	0.997	**293.807**	***	par_6
Item1	←	PEE	0.322	8.013	***	par_7
Item2	←	PEE	0.233	6.058	***	par_8
Item3	←	PEE	0.299	7.743	***	par_9
Item8	←	PEE	0.3	7.159	***	par_10
Item10	←	PEE	0.241	31.388	***	par_11
Item11	←	PEE	0.752	**104.238**	***	par_12
Item16	←	PEE	1			
Item15	←	PEE	0.973	46.123	***	par_13
Item14	←	PEE	1.009	**139.817**	***	par_14
Item13	←	PEE	0.938	64.521	***	par_15
Item7	←	PEE	-0.047	-0.855	0.393	par_16
Item6	←	PEE	0.227	8.583	***	par_17
Item5	←	PEE	0.196	6.69	***	par_18
Item12	←	PEE	0.982	52.62	***	par_19
Item18	←	SA	0.993	59.087	***	par_20
Item21	←	SA	0.941	31.904	***	par_21
Item22	←	SA	0.532	15.348	***	par_22
Item24	←	SA	0.579	23.747	***	par_23
Item17	←	SA	1			

4.3. Estimation of the Second Model

Fig. 5 shows the second proposed model with the values obtained, where several significant relationships are observed that demonstrate the influence of PE with SA and PP with SA on their observed items. The most significant p-values are highlighted for Item 6(1.0), Item 17(1.0) and Item 19(1.0). The significant values reinforce the robustness of the model, except in the cases of Item10 to Item16 (p7=0.370), which do not show a significant relationship with SA. These results are critical to validate the underlying theoretical structure of the model and provide a detailed understanding of how the latent variables impact the observed items in the context of the study.

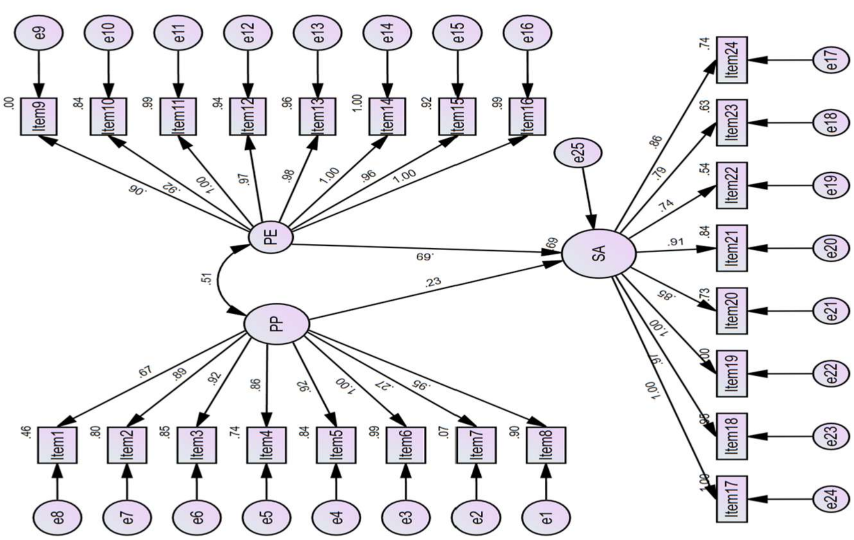

Fig. 5. Model 2 -SEM with standardized estimates

In Table 4, we present the results of the structural equation analysis, where the Estimate column represents the coefficient of the relationship between variables and items. In addition, C.R. represents the Critical Ratio value, represented by t. The table highlights the most significant values for Item 19 (293.84), Item 6 (41-43), and Item 18 (59.09). The high and significant t-values reinforce the robustness of the model, except in the cases of Item 10 to Item 16 (t=0.896), which do not show a significant relationship with SA. These results are fundamental to validate the underlying theoretical structure of the model and provide a detailed understanding of how the latent variables impact the observed items in the context of the study.

Table 4

Significant estimates from Model 2 - Relevant results

			Estimate	S.E.	C.R.	P	Label
SA	←	PP	.271	.056	4.863	***	par_22
SA	←	PE	16.308	18.229	.895	.371	par_23
Item8	←	PP	1.000				
Item7	←	PP	.329	.085	3.858	***	par_1
Item6	←	PP	.691	.017	41.426	***	par_2
Item5	←	PP	.663	.026	25.775	***	par_3
Item4	←	PP	.639	.031	20.885	***	par_4
Item3	←	PP	.905	.035	26.024	***	par_5
Item2	←	PP	.835	.036	23.281	***	par_6
Item1	←	PP	.696	.057	12.301	***	par_7
Item9	←	PE	1.000				
Item10	←	PE	7.545	8.422	.896	.370	par_8
Item11	←	PE	23.548	26.276	.896	.370	par_9
Item12	←	PE	30.733	34.296	.896	.370	par_10
Item13	←	PE	29.352	32.753	.896	.370	par_11
Item14	←	PE	31.581	35.238	.896	.370	par_12
Item15	←	PE	30.448	33.979	.896	.370	par_13
Item16	←	PE	31.304	34.929	.896	.370	par_14
Item24	←	SA	.579	.024	23.748	***	par_15
Item23	←	SA	.555	.030	18.472	***	par_16
Item22	←	SA	.532	.035	15.349	***	par_17
Item21	←	SA	.941	.030	31.903	***	par_18
Item20	←	SA	.895	.039	23.022	***	par_19
Item19	←	SA	.997	.003	293.842	***	par_20
Item18	←	SA	.993	.017	59.087	***	par_21
Item17	←	SA	1.000				

4.3.1. Evaluation of the values extracted from the first and second models

Table 5 shows the fit indices obtained and expected according to the confirmatory factor analysis. (Lepera, 2021; Soriano & Mejia-Trejo, 2022) of the first and second models. The Chi-square (χ^2) values obtained for the first and second models were significant ($p>0.05$) 2841.44, 1189.91 respectively. The root mean square error of approximation (RMSEA) for the first and second model reached values of 0.228, 0.138 respectively, for both cases this value is less than 0.05/0.08 which demonstrates the robustness of our model. The Comparative Fit Index (CFI) for the first and second model reaches values of 0.743, 0.907 respectively, for the case of model 2 this value is higher than 0.90 which shows the robustness of our model, while for model 1 the value does not exceed 0.90. The Non-Normalized Fit Index (NNFI or TLI) for the first and second model reaches values of 0.717 and 0.896 between 0.90 respectively, both cases this value is less than 0.90 which shows that it still does not reach the ideal robustness.

Table 5

Adjustment ratios obtained and expected according to the CFA

Adjustment index	Expected	Obtained model 1	Obtained model 2
Chi-square x2	>0.05	2841.438	1189.905
Discrepancies between x2 and degrees of freedom (CMIN/DF)	<5	11.320	4.779
Goodness-of-fit index (GFI)	0.90 - 1	.404	.683
Weighted adjustment index (AGFI)	0.90 - 1	.287	.618
Residual root mean square root index (RMR)	Lo más cercano a 0	.244	.156
Root Mean Square Error of Approximation (RMSEA)	< 0.05/0.08	.228	.138
Comparative Fit Index (CFI)	0.90 - 1	.743	.907
Normalized fit index (NFI)	0.90 - 1	.725	.885
Non-normalized adjustment index (NNFI o TLI)	0.90 - 1	.717	.896

4.4. Model Respecification

4.4.1. Overall fit of the proposed structural model (Model 1 and 2)

Due to the presence of scores that do not contribute to the model as well as the fit indices in models 1 and 2, alternatives to improve the model were explored. The index for modification, which represents the decrease in the Chi-Square value if a specific coefficient is estimated, provided valuable guidance. We chose to modify the model by introducing covariances, which resulted in a statistically significant improvement of the Chi-Square fit. It should be noted that these modification indices were identified from models 1 and 2. The incorporation of these covariances allowed the absolute, incremental and par-simony fit indices to conform to the established criteria. The outputs of the re-specified structural model (models 1 and 2), which include the covariances, are presented in Figures 7 and 8. These re-specified models offer a better fit to the data and provide a model that is more accurate. Respecification of the model by incorporating covariances significantly improved model fit and strengthened the validity of the relationships between variables. These covariance indices suggest what modifications can be made to improve model fit. Modification indices are an essential tool in SEM model fitting, as pointed out by (Kline, 2023) They allow the identification of additional relationships that were not originally specified in the model, thus improving its fit and validity.

4.4.2. Proposed adjusted structural models (first and second models)

Fig. 6 shows the Initial model results adjusted model with its obtained values, where it is observed that all the relationships are significant and show the influence of PEE and SA on their observed items. The most significant p-values for Item19 (1.0), Item17(1.0) and Item 11(1.0) are highlighted. The significant values reinforce the robustness of the model. These results are critical to validate the underlying theoretical structure of the model and provide a detailed understanding of how the latent variables impact the observed items in the context of the study. The standardized regression coefficients (β) indicate the strength and direction of the relationship between the exogenous and endogenous variables. A positive β coefficient indicates that an increase in PEE (exogenous variable) is associated with an increase in SA (endogenous variable).

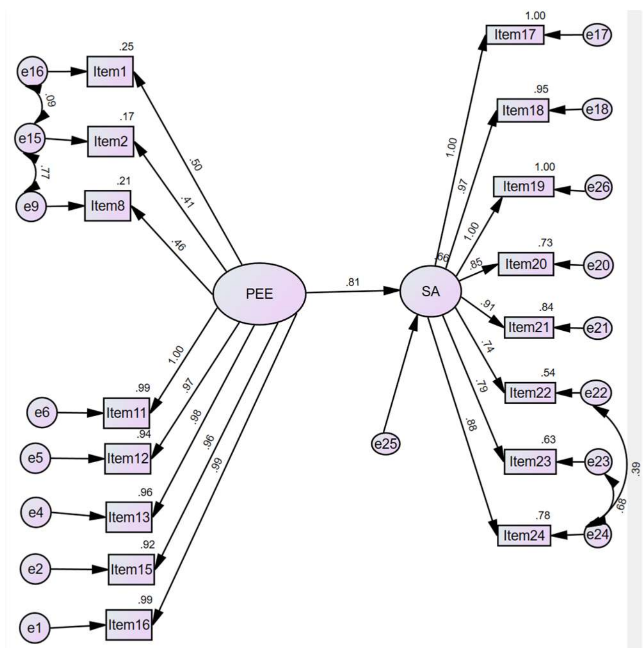

Fig. 6. Model 1 adjusted

In Table 6, we present the results of the first model adjusted according to the structural equation analysis, where the Estimate column represents the coefficient of the relationship between variables and items. In addition, C.R. represents the Critical Ratio value, re-presented by t, the table highlights that all values are significant having as the most significant values for Item 19 (293.96), and Item 11 (99.44). The high and significant t-values reinforce the robustness of the model. These results are fundamental to validate the underlying theoretical structure of the model and provide a detailed understanding of how the latent variables impact the observed items in the context of the study.

Table 6

Fitting with significant estimates of Model 1 - Relevant results

			Estimate	S.E.	C.R.	P	Label
SA	←	PEE	0.611	0.032	19.28	***	par_3
Item20	←	SA	0.895	0.039	23.026	***	par_1
Item23	←	SA	0.555	0.03	18.472	***	par_2
Item19	←	SA	0.997	0.003	**292.963**	***	par_4
Item16	←	PEE	1				
Item15	←	PEE	0.972	0.021	45.357	***	par_5
Item13	←	PEE	0.938	0.015	63.918	***	par_6
Item12	←	PEE	0.981	0.019	51.593	***	par_7
Item18	←	SA	0.993	0.017	59.048	***	par_8
Item21	←	SA	0.941	0.029	31.915	***	par_9
Item22	←	SA	0.532	0.035	15.346	***	par_10
Item24	←	SA	0.579	0.022	26.67	***	par_11
Item17	←	SA	1				
Item8	←	PEE	0.305	0.042	7.271	***	par_12
Item2	←	PEE	0.235	0.037	6.348	***	par_13
Item1	←	PEE	0.323	0.04	8.036	***	par_14
Item11	←	PEE	0.752	0.008	**99.438**	***	par_15

4.4.3. Adjusted Model 2

Fig. 7 presents the second proposed adjusted model with its obtained values, where it is observed that all the relationships are significant, showing the influence of PP with SA and PE with SA on their observed items. The most significant p-values for Item6 (1.0), Item14(1.0), Item19(1.0) and Item17(1.0) are highlighted. The significant values reinforce the robustness of the model. These results are critical to validate the underlying theoretical structure of the model and provide a detailed understanding of how the latent variables impact the observed items in the context of the study.

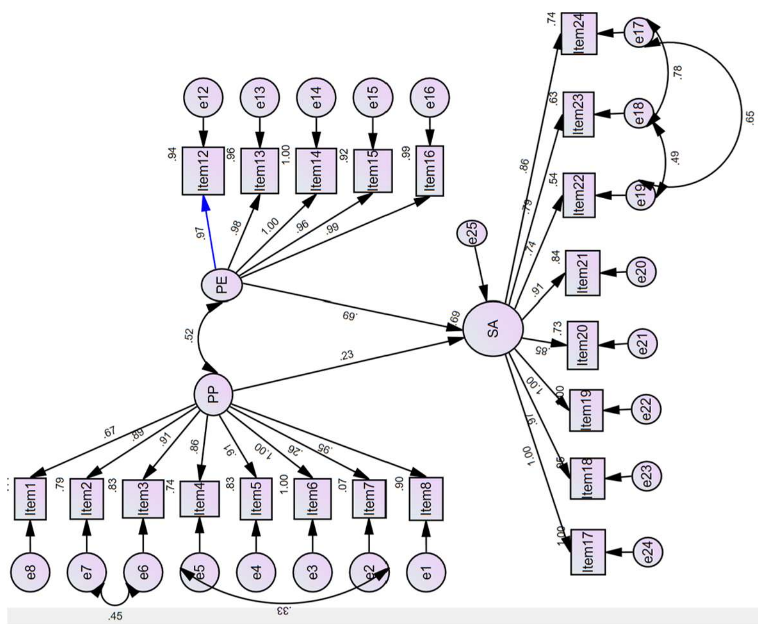

Fig. 7. Model 2 adjusted

In Table 7, we present the results of the second adjusted model of the structural equation analysis, where the Estimate column represents the coefficient of the relationship between variables and items. In addition, C.R. represents the Critical Ratio value, represented by t, the table highlights that all values are significant, having as most significant for Item19 (292.66) and Item18(59.02). The high and significant t-values reinforce the robustness of the model. These results are fundamental to validate the underlying theoretical structure of the model and provide a detailed understanding of how the latent variables impact the observed items in the context of the study.

Table 7
Fitting with significant estimates of Model 2 - Relevant results

			Estimate	S.E.	C.R.	P	Label
SA	←	PP	.282	.056	**5.023**	***	par_19
SA	←	PE	.524	.037	**14.185**	***	par_20
Item8	←	PP	1.000				
Item7	←	PP	.343	.085	4.035	***	par_1
Item6	←	PP	.703	.017	41.377	***	par_2
Item5	←	PP	.661	.027	24.264	***	par_3
Item4	←	PP	.635	.032	19.870	***	par_4
Item3	←	PP	.924	.036	25.818	***	par_5
Item2	←	PP	.837	.037	22.552	***	par_6
Item1	←	PP	.689	.058	11.968	***	par_7
Item12	←	PE	1.000				
Item13	←	PE	.955	.022	44.256	***	par_8
Item14	←	PE	1.028	.018	56.421	***	par_9
Item15	←	PE	.991	.027	36.820	***	par_10
Item16	←	PE	1.019	.020	52.227	***	par_11
Item24	←	SA	.579	.024	23.749	***	par_12
Item23	←	SA	.555	.030	18.479	***	par_13
Item22	←	SA	.532	.035	15.105	***	par_14
Item21	←	SA	.941	.029	31.913	***	par_15
Item20	←	SA	.895	.039	23.027	***	par_16
Item19	←	SA	.997	.003	**292.658**	***	par_17
Item18	←	SA	.993	.017	**59.038**	***	par_18
Item17	←	SA	1.000				

Table 8 shows the expected fit indices, obtained and adjusted according to the confirmatory factor analysis (Lepera, 2021; Soriano & Mejia-Trejo, 2022) of the first and second models. The adjusted Chi-square (χ^2) values for the first and second models were found to be significant ($p>0.05$) 394.36, 580.16 respectively. The root mean squared error of approximation (RMSEA) for the first and second adjusted models reached values of 0.122, 0.107 respectively, for both cases this value is less than 0.05/0.08 which demonstrates the robustness of our model. The Comparative Fit Index (CFI) for the first and second model reaches values of 0.955, 0.953 respectively, both cases the value is greater than 0.90 which demonstrates the ideal robustness of our model. The Non-Normalized Fit Index (NNFI or TLI) for the first and second model reaches values of 0.896, 0.945 respectively, both cases this value is greater than 0.90 which demonstrates the ideal robustness of the fitted model.

Table 8
Adjusted ratios of obtained and expected values according to the AFC

Adjustment index	Expected	Obtained model 1	Adjusted model 1	Obtained model 2	Adjusted model 2
Chi-square $\chi 2$	>0.05	2841.438	394.359	1189.905	580.164
Discrepancies between χ 2 and degrees of freedom (CMIN/DF)	<5	11.320	3.983	4.779	3.259
Goodness-of-fit index (GFI)	0.90 - 1	.404	.797	.683	.807
Weighted adjustment index (AGFI)	0.90 - 1	.287	.721	.618	.749
Residual root mean square root index (RMR)	The closest thing a 0	.244	.165	.156	.170
Root Mean Square Error of Approximation (RMSEA)	< 0.05-0.08	.228	.122	.138	.107
Comparative Fit Index (CFI)	0.90 - 1	.743	.955	.907	.953
Normalized fit index (NFI)	0.90 - 1	.725	.941	.885	.934
Non-normalized adjustment index (NNFI o TLI)	0.90 - 1	.717	.945	.896	.945

In Table 9, all the hypotheses stated in the models are accepted, indicating that the proposed theoretical relationships are empirically supported. Significance and high t-values reinforce the validity of the hypotheses. The t-value is a key indicator that evaluates the significance of the coefficients in SEM, and the common critical values provide a guide to determine it, being these values indispensable to validate the theoretical relationships proposed in the model. Thus, with respect to Hypothesis 1, it is affirmed that eco-friendly business practices have a positive impact on environmental sustainability in companies in the Peruvian Amazon, determining a t-value (R.C.) = 19.280 with $|19.280|>3.29$ (significant at 0.1%), which corresponds to a highly significant coefficient at the 0.001 level. Hypothesis 2 states that preventive practices have a positive impact on environmental sustainability in companies in the Peruvian Amazon, determining a t-value (R.C.) = 5.023 with $|5.023|>3.29$ (significant at 0.1%), which corresponds to a highly significant coefficient at the 0.001 level and Hypothesis 3 Eco-efficiency practices have a positive impact on environmental sustainability in companies in the Peruvian Amazon determining a t-value (R.C.) = 14.18 with $|14.185| > 3.29$ (significant at 0.1%) which corresponds to a highly significant coefficient at the 0.001 level, thus testing the hypotheses posed by the proposed models.

Table 9
Results of structural model 1 and 2

Hypothetical relationships	Standardized estimates	t-valor	Supported assumptions
H1:PEE → SA	.81	19.280	Aceptada
H2: PP → SA	.23	5.023	Aceptada
H3: PE → SA	.69	14.185	Aceptada

5. Discussion

Several studies have validated the use of structural equation models to assess complex relationships between latent variables. For example, authors have highlighted the importance of fit indices such as RMSEA, CFI, and TLI in model validation. The results obtained in these tables are consistent with these standards (Hair & Alamer, 2022). After carrying out the analysis regarding eco-friendly business practices and environmental sustainability, the hypothesis contrast was performed; obtaining as hypothesis 1 that eco-friendly business practices have a positive impact on environmental sustainability in companies in the Peruvian Amazon; where it was stated that there is a significant relationship between these variables in this sense, it can be stated that as eco-friendly business practices increase, the greater the impact on environmental sustainability; given that it is shown that according to the theoretical model, it reached a t-value (C. R.) = 19.280 (Table 9) which represents the significance with respect to both variables as well as the correlation coefficient of 0.81 highly related. (Rico-Straffon et al., 2023) where the authors analyzed the impact of environmental practices on the financial performance of timber companies in the Peruvian Amazon. They found that companies that adopted more sustainable environmental practices tended to have better long-term financial performance, as did those that adopted more sustainable environmental practices (Fernández-Torres et al., 2021) which concludes that positive environmental practices have a significant impact on the financial performance of tourism companies, as well as on the financial performance of tourism enterprises (Chreif & Farmanesh, 2022) which obtained as a result that ecological practices have a positive effect on the corporate reputation of the companies; this positive effect is moderated by the environmental image of the industry and the participation of the stakeholders, the companies that implement ecological practices and adequately manage the communication with their stakeholders can significantly improve their corporate reputation.

Furthermore, with respect to hypothesis 2, preventive practices have an impact on environmental sustainability in companies in the Peruvian Amazon, a t-value (R.C.) = 5.023 and a correlation index of 0.23 was determined, which allows us to determine that there is an impact on environmental sustainability in companies in the Peruvian Amazon. 23, which allows determining that there is a low positive correlation between preventive practices and environmental sustainability (Table 9). Therefore, according to the above, it can be affirmed that the higher the indexes of preventive practices, the medium impact on environmental sustainability will be, since the correlation indexes are at a low level (Min et al., 2023) which reports that the results showed that collaboration significantly and positively affected the sustainability practices of SMEs, using SEM-PLS analysis. Innovation also positively influenced sustainability practices and business performance. In addition, the positive impacts of collaboration and innovation on business performance were mediated by sustainability practices, as well as by sustainability practices (Holling & Backhaus, 2023) obtained as results of the multiple regression that refers to the general performance as a dependent variable of the green supply chain management (GSCM) practices are related to the GSCM practices, the performance of the companies and the moderators can be considered crucial to find formulation of tactics enables organizations to meet their social and environmental responsibilities without losing sight of their goal of maximizing revenues.

Similarly, the results reported by (González Ordóñez, 2022) Similarly, the results reported by [65] indicate that a crucial aspect of CSR is environmental management, which comprises a set of activities focused on anticipating and controlling the environmental impacts generated throughout the life cycle of a product or service. From the acquisition of raw materials to the final disposal of the product, SMEs can implement sustainable practices to reduce their environmental footprint and contribute to the protection of the planet. Besides, Li and Li (2024) reveals as findings that the adoption of greener practices and their impact is less pronounced for the companies for this according to their results, after several tests, have confirmed that the reliability of their findings, regarding ecological transitions, highlighting its role in guiding companies towards preventive environmental strategies and providing key information for policy makers. With respect to hypothesis 3, eco-efficiency practices have an impact on environmental sustainability in companies in the Peruvian Amazon, a t-value (R.C.) = 14.85 and a correlation index of 0.69 was determined, which allows us to determine that there is an impact on environmental sustainability in companies in the Peruvian Amazon. 69, which allows determining that there is a high positive correlation between eco-efficient practices and environmental sustainability (Table 9). Therefore, according to the above, it can be affirmed that the higher the indexes of eco-efficient practices, the greater the impact on environmental sustainability, since the correlation indexes are at a high level. From the results obtained, several authors agree with what was determined by where they found that SMEs are often unaware of the impact that eco-efficiency practices have on their financial performance and sustainable innovation. This study provided key insights into how implementing eco-efficiency actions can improve business performance, employee health and well-being. In addition, it provided SMEs with tools to make better decisions based on this information, thus facilitating better integration of sustainability into their business strategies. This not only allows them to optimize resources and reduce costs, but also to improve their reputation and competitiveness in the market, contributing to a more responsible development aligned with global trends; which is consistent with what was determined by (Nikolakis et al., 2024) proposes through its results an eco-efficiency indicator that targets the reduction of energy consumption and manufacturing waste caused by production operations, in addition to the life cycle assessment and cost analysis of a process, the proposed approach is examined in two industrial use cases, where the proposed indicator is evaluated in relation to three possible circular eco-economy strategies to improve sustainability, the use of renewable energy sources and the reuse of materials. Similarly, as found by (Grosse-Sommer et al., 2020) where he found that the environmental impact assessment follows the ISO 14040 and 14044 standards. The impacts are aggregated to obtain an overall environmental impact. Life cycle costs are determined in a similar way and can be combined with the environmental impact to obtain an overall eco-efficiency portfolio and an eco-efficiency index.

6. Conclusions

With the results of the structural equation analysis, it was possible to determine There is a positive and relevant connection between business practices that are environmentally friendly and environmental sustainability; this is because companies that implement this type of practices have a better environmental performance, it is evident that companies that adopt eco-friendly practices achieve a significant reduction in their carbon footprint and better management of natural resources, contributing to the conservation of the Amazonian ecosystem; which highlights the importance of promoting business policies that promote environmental sustainability through eco-innovation and environmental responsibility. Preventive practices, such as environmental impact assessment, continuous monitoring of emissions and the implementation of environmental risk reduction programs, have a positive and significant impact on the environmental sustainability of companies in the Puerto Maldonado region; since these practices not only help minimize the negative impacts of business activities, but also improve the resilience of companies to environmental challenges. The adoption of preventive practices allows companies to identify and mitigate potential damages before they occur, thus contributing to the preservation of the environment and compliance with environmental regulations. Eco-efficiency practices, such as optimizing resource use, reducing waste, and improving energy efficiency, have a positive and significant impact on the environmental sustainability of companies in the Puerto Maldonado region of Peru, since structural equation models show that companies that implement eco-efficiency practices achieve higher productivity and a smaller ecological footprint. These results suggest that eco-efficiency is not only beneficial for the environment, but can also improve the competitiveness and profitability of companies. Promoting eco-efficiency practices is essential to achieve sustainable development and the conservation of natural resources in the Amazon region.

Finally, sustainability-oriented business practices have a positive impact on environmental conservation in companies in a region of the Peruvian Amazon; therefore, it is important that companies adopt a proactive approach to sustainability, integrating eco-friendly, preventive and eco-efficient practices into their daily operations. In addition, government policies and community initiatives must support and encourage these practices to ensure sustainable development and the protection of the valuable Amazonian ecosystem. As part of the limitations in the research, there were difficulties in the issue of information collection and the use of the structural model, which is complex and there are few investigations that apply it. On the other hand, taking into account the importance of the research, it is necessary to continue developing similar research for national reserve areas and at the same time in urban areas of the regions of Peru and Latin America, since seeking the commitment of companies with the environment is of vital importance for the fulfilment of the SDGs today.

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