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Eco-innovation practices as a performance factor business: analysis of enterprises linked to the Guamá Science and Technology Park

Práticas de ecoinovação como fator de desempenho empresarial: análise dos empreendimentos vinculados ao Parque de Ciência e Tecnologia Guamá

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Abstract

The objective of this research was to analyze the eco-innovation practices carried out by organizations located in the Guamá Science and Technology Park, in Belém do Pará and its relationship with performance. The data were obtained through a survey, the questionnaire was applied electronically, its results were analyzed using factorial analysis and regression which showed that the practices carried out are the creation of recyclable products, reduction in energy consumption, water and training environmental. The multiple regression analysis shows that, among the factors, those most closely related to performance are environmental training and the reduction in the consumption of harmful materials in the production process. The results indicate that this research adds to the already existing theoretical body on eco-innovation, identifying that environmental training and the reduction of harmful materials in the production process are a relevant factor, which encourages eco-innovation practices and impacts on their performance, its differential lies in in its analysis being carried out in the context of an innovation management territory.

Keywords: eco-innovation, innovation park, operational performance.

Resumo

O objetivo dessa pesquisa foi analisar as práticas de ecoinovação realizadas pelas organizações localizadas no Parque de Ciência e Tecnologia Guamá, em Belém do Pará e sua relação com o desempenho. Os dados foram obtidos por meio de uma *survey*,o questionário foi aplicado de forma eletrônica, seus resultados foram analisados com análise fatorial e regressão os quais evidenciaram que as práticas realizadas são as criações de produtos recicláveis, redução no consumo de energia, água e treinamento ambiental. A análise da regressão múltipla mostra que entre os fatores, o que mais tem relação com o desempenho são treinamento ambiental e diminuição do consumo de materiais nocivos no processo de produção. Os resultados apontam que esta pesquisa se adiciona ao corpo teórico já existente sobre ecoinovação, identificando que o treinamento ambiental e diminuição de materiais nocivos no processo de produção são um fator relevante, que incentiva as práticas de ecoinovação e impacta em seu desempenho, seu diferencial reside em sua análise ser realizada no contexto de um território de gestão de inovações.

Palavras-chave: eco-innovation, operational performance, innovation park.

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1 Introduction

The need for change in practices and in the way that companies operate and interact with the natural environment is frequent among researchers and professionals in the field of management (Hazarika & Zhang, 2019; Cai & Li, 2018; Bossled et al., 2016). This change is particularly caused by the perception that natural resources are finite and that companies need to find ways to interact with the environment in search of less harmful and, therefore, more sustainable practices.

According to García (2019), over the last few years, eco-innovation has been considered an engine of economic development, as is the case, for example, of the use of biochar, intended to revitalize degraded soils, therefore improving carbon sequestration in the soil and increasing the agronomic productivity, the development of renewable energies as an alternative to fossil fuels, or the introduction of waste management, to optimize processes and their economic profitability.

On the other hand, although an increasing body of literature explores the relationship between eco-innovation practices and the performance of the company through case studies and econometric analyses, results continue to show the relationship between eco-innovation and performance, albeit in a less conclusive way such as the research by Tsai (2019), when performing a meta-regression in Japan on a database of 92 studies, concluded that eco-innovation practices and their relationship with performance increased over the years and that the positive relationships between these variables are easier to be found in companies located in developed countries. Tang (2017) conducted work with 188 manufacturing companies in China and concluded that eco-innovation of green processes and innovation of ecological products is related to better performance of companies.

The inconclusive evidence on eco-innovation and business performance may be due to regulations and institutional differences among countries, regions, or segments in different stages of development according to the research (García, 2019; Santos et al., 2017). In this sense, it is necessary to fill this gap in the field of studies that relate eco-innovation to business performance, which in the Brazilian field, and more precisely in the northern region, still has a wide field for investigation, highlighting the work by (Bacinello & Tontini, 2018) carried out in the state of Rondônia.

Thus, the objective of this work was to contribute to filling this gap from the perspective of companies based within the Technology and Science Park of Guamá (PCT Guamá), located in the city of Belém do Pará, through the following objective: to analyze to what extent the eco-innovation practices carried out by the organizations located in the Guamá Science and Technology Park (PCT Guamá) influence their business performance. The PCT Guamá aims to support sustainable regional development based on knowledge and innovation, through the creation of environments that promote interaction between the various actors involved in the process, such as companies, the government, universities, and local development. For this, the Park has two environments, an environment conducive to the viability of technological innovation and another environment that induces technological innovation. of the PCT are of environmental preservation (Pctguamá.org, 2020).

2 Theoretical-conceptual framework of reference and hypothesis development

2.1 Ecoinnovation concept and its practices in the companies

Unlike the traditional concept of innovation that is known by the academia and applied by companies, the concept of eco-innovation that according to (Fussler & James, 1996) is a process of developing new products, processes, or services that provide value to customers and businesses and significantly reduce the environmental impact.

Eco-innovation may contribute to the renewal of the entire innovation system, taking into account ecological and economic aspects and, Therefore, stimulating the creation of sustainable economic processes, such as the reduction in water and energy consumption, and the reduction in emission of polluting gases, among others. For (Carrillo & Hermosilla, 2010), compared to traditional innovation, eco-innovation has the so-called double advantage, as it can benefit society and the environment by promoting resource conservation, implementing clean energy alternatives, the reduction in waste emissions, among others.

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Over time, companies have recognized that eco-innovation does not need to be seen only as a supported cost, on the contrary, it may present a new business opportunity or exploration of a niche market, therefore, over time, eco-innovation has become a relevant concept for management because it combines economic efficiency associated with saving resources and energy (Bitencourt *et al*., 2020). In addition, it is highlighted that cost efficiency can also be used as a motivator for companies to implement eco-innovation practices (Markusson, 2011; Levidow, 2016).

This reduction in costs can be found through efficient processes that can optimize the production process, such as cleaner production, reuse and recycling of inputs, savings in water and energy, and use of inputs (Dalhammar, 2015).

According to the vision of Tseng (2013), eco-innovative practices in companies can be categorized according to the basic division of innovation (Schumpeter,1939), namely: product innovation; process innovation; organizational innovation; and marketing innovation, as will be described in the next paragraphs.

Eco-innovation practices related to the company's internal production process have energy consumption savings as their main objective (Hellstrom, 2007). It aims at improving production processes and using environmentally friendly technologies to produce goods and provide services that will eliminate or reduce the negative impact on the environment (Wong et al., 2012). The adoption of environmentally responsible processes can be a requirement or a necessary factor for the advent of eco-innovation of a product, Triguero (2013) or to improve a product with the possibility of affecting the supply chain as a whole (Klewitz & Hansen, 2014).

According to Faulkner and Badurdeen (2014), in addition to aiming at reducing energy and water consumption, eco-innovation practices in the process can introduce the 6 Rs (Reduce, Recover, Reuse, Recycle, Remanufacture, and Redesign) to generate sustainable innovations in processes of production and flow of the materials involved in the life cycle of the product. Other factors that can also be referred to as process eco-innovation are the substitution of raw materials, specific water and waste consumption profiles, and specific energy consumption.

In the production process, according to Singh, Suresh, and Sharma (2015), in their work carried out in India, companies with the highest levels of adoption of eco-innovation practices in this categorization used cleaner materials and changed their production processes, becoming the leaders in reducing their generation of chemical waste. In addition, Cai and Li (2018) point out that eco-innovation actions should focus on reducing the use of water and energy during production processes. In turn, (Van Hemel & Cramer, 2002) lists the main solutions used by companies that develop environmentally sustainable innovations: investment in material recycling; the use of recycled materials; research to extend product life; and investments in reducing energy consumption.

Moreover, Hellstrom (2007) highlights that the following can also be used: economy of materials in the production process; savings in energy consumption; agility in the production line; reuse of by-products; conversion of waste into new products; reduction of material storage; and eliminating or reducing the cost of activities related to discharge or treatment, transport, and disposal of the waste.

About eco-innovative product practices, it is the production of a new product or service that does not harm the environment or is smaller than the competitor's current product. For Wong *et al*., (2012) its main function is to encourage the efficient use of raw materials, resulting in lower costs that can lead companies to find new ways to convert waste into salable products, providing additional revenue. In addition, it should result in greater cash flow and, consequently, improved business performance through reputation, which is itself a source of market advantage (Eiadat, 2008). Krammerer's (2009) argument is that green products, in addition to their public benefits, have environmental benefits for the customer that will generate stronger consumer demand.

For Dalhammar (2015), the innovation of green products should focus both on the durability of the material and on its ability to be recycled. Finally, Aziz *et al*., (2016) claim that the useful life of the product should be extended through the functional enrichment of the product, that is, allowing it to be updated when features become obsolete.

Organizational eco-innovation may include the development of new management methods, focused on reducing the environmental impact, as well as improving working conditions and employee well-being (Roscoe, 2016). Several initiatives can result in organizational eco-innovations. For Triguero, (2013), the development of environmental training for employees is one of them. (Klewitz & Hansen, 2014) proposes the creation of a purchasing program with local suppliers to reduce emissions of pollutants related to transport, and the implementation of organizational structures focused on the environment, such as the creation of departments, teams, committees, and interdepartmental units focused on protecting the environment. Organizational eco-innovations can also involve the reorganization of routines and organizational structures, including the adoption of new forms of management (Brasil *et al*., (2016). Other practices may relate primarily to energy use, resource consumption, waste management, purchasing activities, and environmental protection programs.

As for eco-innovation-oriented marketing practices highlighted by Iriani (2015), the use of software to find ideal routes to avoid air pollution, reverse logistics and adequate packaging for products to have greater durability and ability to be recycled or reused are some key aspects in marketing innovations.

According to Sandoval et al., (2016), an eco-labeling program in the context of eco-innovation can allow companies to communicate the environmental aspects of the product. It is important to emphasize that eco-labeling comes from the growing pressure that companies face to become socio-environmentally responsible, considering that several stakeholders have pressured companies to reduce their negative impacts on society and the natural environment (Bansal, 2005; Barnet, 2007). With the rise of environmentalism, not only are consumers more willing to buy products that generate minimal impact, but society is also becoming more concerned about the environment. Communication includes practices to inform the company's stakeholders about actions taken in favor of the environment (for example, regular reports to clients on management (Tsai, 2019). The table below represents a summary of eco-innovation practices.

Chart 1: Ecoinovation practices

Fundament (Dimension/Construct)	**Summary**	**Author**
Sustainable focused innovation	1. Development of new products, processes, or services that provide customers and businesses with value, but decrease environmental impact	Fussler; James (1996)
	2- Reduction of environmental risks in comparison to the existing alternatives	Arundel; Kemp (2009)
	3-Innovations that contribute to a sustainable environment through the development of ecological improvements	Xavier et al., (2017)
Efficient practices with lower cost and environmental impact	1. Cost efficiency	Rennings (2000)
	2. Economy in water and energy use	Hellström (2007)
	3. Reutilization and Recycling	Markusson (2011)
	4. Use of the residues	Levidow *et al*., (2016)

Source: Elaborated by the authors (2021).

It can be seen in Chart 1 that eco-innovation practices have as their main dimensions focused on innovations in products, or services and efficient practices such as reducing water, energy, etc. The implication of these practices on business performance will be seen in the next topic.

2.2 Ecoinovation practices (PEI) and business performance

Business performance refers to the achievement of operational goals, usually with an emphasis on the short term (Hall, 2004). These goals can be classified into dimensions such as costs, product quality, delivery speed, and reliability.

For Wang (2017), the performance construct can be measured through the dimensions of quality, time, flexibility, and cost, and the evaluation of profitability and returns on financial investments. Table 2 summarizes the main concepts that encompass performance.

Chart 2: Business performance.

Fundament (Dimension /Construct)	**Summary**	**Authors**
Achievement of Operational Goals in the short term	1-product quality 2- Sales growth 3. Profit 4-Return on the investments 5-Flexibility of costs	Wang (2017); Hall (2004)

Source: Elaborated by the authors (2021).

There are conflicting perspectives regarding the nature of the relationship between Ecoinovation practices (EI) and company performance, traditional views claim that the adoption of EI practices weakens the competitiveness among companies, as their implementation usually requires investment in the development and adoption of new systems operational (Huang & Li, 2017). These investments are expensive and can increase production costs and harm productivity.

In addition, resources spent on reducing and preventing negative environmental impacts may exclude other innovative projects (Hottenrott & Rexhauser, 2013). According to some works, environmental investments or pollution prevention are unproductive costs for these authors, Therefore, they can increase costs and reduce revenues (Wang, 2017). Likewise, due to the exclusion effect, these investments limit a company's available technological innovation resources and may hamper the chances of pursuing competitive advantages in the market.

On the other hand, the adoption of eco-innovation practices allows companies to increase competitiveness through cost reduction and differentiation advantages (Bitencourt; Santini 2020) performed a meta-analysis with 71 works in different countries, and demonstrated that countries with a higher Human Development Index (HDI) have stronger effects between eco-innovation and company performance than countries with a lower HDI.

In Addition, Hazarika and Zhang (2019) in an experiment carried out with 140 companies that compose the Hong Kong industry segment, in China, showed that regulatory instruments, managerial consent, and organizational measures play an important role in influencing companies to be eco-innovative.

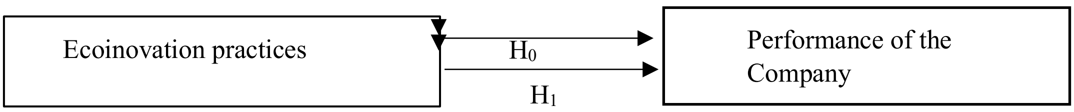
Cai and Li (2018) conduct work with 442 Chinese companies to investigate the relationship between the determinants, eco-innovation behavior, and performance. The results reveal that certain factors (i.e., technological capabilities, environmental factors, organizational capabilities, an instrument based on the market, competitive pressures, and green customer demand) contribute to the development of eco-innovation. Based on this, we have the study hypothesis:

H0: Adoption of Ecoinovation practices does not impact performance.

H_1: Adoption of Ecoinovation practices has a positive impact on performance.

Figure 1 shows the design of the research

Figure 1: Research design



Source: Elaborated by the authors (2022).

3 Methodological procedures

This research is structured in two stages: first, a systematic review of the literature in more recent national and international journals and seminal ones was carried out, to identify the concept of eco-innovation and the most common sets of eco-innovation practices applied to empirical research carried out in companies, in possession of these practices, the second stage of the research was carried out, of a quantitative nature. Thus, a survey was applied to organizations housed in the Guamá Science and Technology Park (PCT Guamá) to analyze the eco-innovation practices carried out, and their relationship with business performance.

3.1 Analysis unit and research context

The research was carried out with organizations located in the Guamá Science and Technology Park, which has 51 organizations, 17 laboratories, and even the State School of Technical Education Dr. Celso Malcher. Organizations are included in the most diverse segments such as Biotechnology, Information and Communication Technology, education, food production, energy, environmental technology, and PCT consulting Guamá.Org, (2020). PCT Guamá is the first technology park to operate in the Amazon, its objective is to stimulate applied research, innovative entrepreneurship, service provision, and technology transfer for the development of products and services with greater added value and highly competitive.

Among the 51 organizations that make up the population of PCT Guamá, two had ceased their operations and three were inoperative at the time of application of the questionnaire, thus remaining a sample of 46 organizations, among which 43 responded to the research questionnaire, with 32 resident companies, six laboratories, and five associated companies. It should be observed that it was not possible to obtain the answers to the questionnaires with the entire sample, as the data collection was carried out during the pandemic caused by COVID-19, and therefore, no contact was obtained from the three companies.

3.2 Research constructs and data collection

The research was carried out using a survey for data collection. Instrument development involved a step-by-step procedure for generating constructs and variables. The first block of the research aimed to analyze the profile of the interviewees, while the second sought to evaluate eco-innovation practices and was operationalized based on the work of Cai and Li (2018), Hojnik and Ruzzier (2016) and Liao (2017), as shown in the tables below, which indicate the existing eco-innovation practices and the abbreviation given to the variables.

Chart 3: Ecoinovation practices in the production process in the last three years

Variable	Correspondence
Eco.practice 1	We introduced practices that reduced energy consumption in the company
Eco.practice 2	We introduced practices that reduced water consumption in the company
Eco.practice 3	We invest in recycling and reuse of materials
Eco.practice 4	We make the best use of the production and storage capacity of our products
Eco.practice 5	We reduce the consumption of hazardous/harmful/toxic materials in the production process
Eco.practice 6	The company's manufacturing process reduces the use of raw materials for the efficiency of the process
Eco.practice 7	We emphasize the development of new eco-friendly products through new technologies
Eco.practice 8	We create products with high durability and the capacity to be recycled
Eco.practice 9	We create products with high durability and the capacity to easily decompose their materials
Eco.practice 10	We carry out environmental training for the employees
Eco.practice 11	We create departments, staff, committees, and interdepartmental units focused on protecting the environment

Source: Elaborated by the authors (2021).

Chart 4: Variable related to performance construct

Variable	Correspondence
Production cost	The total cost of production or services (inputs + packaging + storage + waste + depreciation + losses + transport) is lower than that of the competition, especially those that do not develop eco-innovation practices
Quality	The producer or service we offer has higher quality in comparison to the product or service of competitors, especially those that do not develop eco-innovation practices
Speed with deadlines	We can respond rapidly to changes in delivery times and/or order volumes requested by customers.
Increase in the profit	In the last three years, we have been able to observe the increase in the company's profitability concerning our competitors, particularly those that do not develop eco-innovation practices
Increase in return on the investments	In the last three years, we were able to observe an increase in the return on investments concerning our competitors, particularly those that do not develop eco-innovation practices

Source: Elaborated by the authors (2021).

The form was uploaded to the Google Forms online platform and contained objective questions on a 5-point Likert scale. Its link was sent through several channels to managers and landlords of the researched organizations, through email, direct contact through social net, and WhatsApp. Data were collected from September to December 2020.

3.3 Data analysis

Data were analyzed using multivariate statistical techniques, through Exploratory Factor Analysis and Multiple Linear Regression Analysis, using the SPSS 20.0 software, which enabled categorization of the information and identification of the relevant elements for the analysis.

Before applying the Factor Analysis, the validation of the items used in the formation of the Eco-innovation Practices (PEI) and Operational Performance (DOP) constructs was carried out, using the reliability method denominated Cronbach's Alpha. Cronbach's alpha is also understood as the squared correlation coefficient (R2). The results of applying this test show that the closer the value is to 1, the set of questions for each construct is adequate and has a strong correlation between the variables. Alpha with a degree lower than 0.7 indicates little model accuracy (Virgillito, 2010).

Fávero et al. (2009) point out that factor analysis consists of a multivariate interdependence technique that aims to synthesize the relationships observed between a set of interrelated variables, in an attempt to identify common factors through the simplification of a large number of data. Its synthetic power, with minimal loss of information, facilitates the description of the unit to be analyzed from a smaller number of concepts.

The analysis was performed using the principal components method, which means that the greatest explanation of the total variance of the sample variables is contained in factor 1, while the second greatest explanation of the total sample variance is contained in factor 2, the third largest in factor 3 and so on.

According to Fávero et al. (2009), the factor analysis method can be expressed according to equation 1:

$$Y = \Lambda F + \varepsilon$$

Where $Y = (Y1, Y2,..., Yp)^T$ is a transposed vector of observed indicators; Λ is a matrix (p x k) such that each λij element expresses the existing correlation between the Y indicator and the f factor, where Λ is called factor loading matrix, with the number k of factors smaller than the p number of indicators; F is a vector of common factors (k x 1); and ε is the vector of residual components (p x 1).

As for the adequation of the factorial analysis data, two tests were performed: the Kaiser-Meyer-Olkin Measure of Sampling Adequacy (KMO Test) and the Barllet Test of Sphericity (BTS Test). The first verifies the adequacy of the sample in terms of the degree of partial correlation between the variables, which should be small, as the factors must explain most of the association between the indicators at the same time that the residuals are poorly associated, thus, it is considered that the sample is adequate if the observed value of the test is greater than 50%, that is, KMO > 0.5 (Lobão and Silva, 2016). The second, on the other hand, tests whether the correlation matrix is an identity matrix, that is, if its values are not perfectly correlated, as in this test it is expected that the answer is negative, so that the variables present correlation (Melo; Parré, 2007).

To make the factors more easily interpretable, the data matrix was orthogonally rotated using the varimax method. This method seeks to reduce the number of indicators that are strongly related to the factors, causing the factors to be uncorrelated with each other and the variables of the factors to have a high correlation.

A multiple linear regression model was used in which the dependent variable was the operational performance and the independent variables were eco-innovation practices, a model was proposed in which the parameters were estimated using the Ordinary Least Squares Method (OLS). The assumed model was that of K parameters according to (Hayashi, 2000):

$$Y_1 = \beta_1 + \beta_2 X_2 + \beta_3 X_3 + ...\mu_T$$

Where:
Y is the dependent variable for the t observation
Xij are the dependent variables with *j*=2,3, ..., *k*
β_1 intercept equation
$\beta_{Z........}$ β_K represent the slope parameters

The estimation of β is obtained by minimizing the sum of squared residuals, such as the sample regression with k variables:

$$Y_1 = \beta_1 + \beta_2 X_{T2} + \beta_3 X_{t3} + ...\beta_k X_{tk} + \mu_T$$

Where:
Y is the dependent variable for t-observation
Xij are the dependent variables with *j*=2,3, ..., *k*
β_1 intercept equations
$\beta_{2.....}$ $\beta_{k...}$ represent the slope parallels

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$$Y_1 = \beta_1 + \beta_2 X_{T2} + \beta_3 X_{t3} + ...\beta_k X_{tk} + \mu_T$$

Which can be written in the following matrix way:

$$Y_1 = X_t \beta + \mu_{T,}\ t = 1,2,3,4 ......, n$$

Where β is a column vector of k elements with the OLS estimators of the regression coefficients and an n x 1 column vector with n Gujarati residuals, (2000). The F statistic can be defined from the explanation index of the explanatory variables, also known as the Explanation Coefficient (R^2).

After calculating the F statistic, the decision on rejection of the null hypothesis will occur based on the comparison of the tabled value of the F statistic with the calculated value at a statistical significance level of 5.0%. The SPSS Statistical Software displays Sig values. F and of Sig. t for the test of the estimated coefficients separately just by comparing this value with the statistical significance (α) of 5.0%.

The Multicollinearity assumption was evaluated using the procedure proposed by Gujarati (2000) and Fávero et al. (2009), in which the algebraic combination of the linear correlation index and the coefficient of determination or explanation (R^2) leads to two diagnostic indicators: the VIF (Variance Inflation Factor) and Tolerance. The decision measure for the presence of multicollinearity occurs when the VIF is greater than 10 (Gujarati, 2006).

The normality of the residuals was also evaluated by performing the KOLMOGOROV-SMIRNOV and SHAPIRO-WILK tests available in the SPSS software, assuming the null hypothesis that the sample comes from a normal distribution.

The assumption of autocorrelation between the residues was evaluated using the Durbin-Watson d Test, obtained from the ratio between the sum of the squared differences in the successive residues and the SQR (Sum of Square of Residues). It is based on estimated residuals. Finally, the test for the presence of heteroscedasticity was used as a way to assess the level of variability between the residues, for which the White test was used.

4. Analysis and discussion of the results

4.1 Exploratory factorial analysis: practices of eco-innovation

According to the data contained in Table 1, it can be seen that all variables have a strong relationship with the retained factors, as they have a satisfactory level of commonalities (greater than 0.500). Commonality indicates the amount of total variance that a variable shares with others.

Table 3: Factor loadings, percentage of variance explained by factors and Communalities of the indicators

	Factors			
	F1	F2	F3	Communalities
Eco. Practice 1	.409	.709		.676
Eco. Practice 2		**.839**		.774
Eco. Practice 3	**.858**			.788
Eco. Practice 4	.779			.614
Eco. Practice 5			**.857**	.816
Eco. Practice 6		.307	**.856**	.828
Eco. Practice 7		.768		.759
Eco. Practice 8		.321	.638	.530
Eco. Practice 9	.758	.372		.747
Eco. Practice 10	.698	.314	.337	.700
Eco. Practice 11	.675	.358		.661

Source: Research data (2021)

Based on the retention of factors with values greater than 1, by applying the Latent Root criterion, Hair et al. (2005), three factors resulting from the interaction of 11 variables were extracted, explaining 85.95% of the variance of the original data.

Factor 1 (F1) can be denominated in the creation of recyclable products, showing that companies have as their most preponderant eco-innovation practice the creation of products that can be recycled. In addition to products that can decompose more easily, which corroborates with the research by Dalhammar (2015) and Aziz *et al*. (2016), according to these authors, eco-innovation practices should focus both on the durability of the material and on its ability to be recycled. Moreover, it also corroborates with the research by Faulkner and Badurdeen (2014), in addition to aiming at reducing energy and water consumption, eco-innovation practices in the process can introduce the 6 Rs (Reduce, Recover, Reuse, Recycle, Remanufacture, and Redesign) to generate sustainable innovations in production processes and material flow involved in the life cycle of the product. For Dalhammar (2015), the innovation of green products should focus both on the durability of the material and on the ability to be recycled. Van Hemel and Cramer (2002) lists the main solutions used by companies that develop environmentally sustainable innovations, the investment in material recycling; the use of recycled materials.

Factor 2 (F2) can be referred to as a reduction in energy and water consumption and demonstrates that companies also have as a predominant practice the reduction in energy and water consumption, which is in agreement with the authors Hellstrom, (2007), Cai; Li, (2018), when stating that the main eco-innovation practices are those that invest in changing their production process with water and energy savings. In the production process, according to (Singh; Suresh; Sharma, 2015), in work carried out in India, companies with the highest levels of adoption of eco-innovation practices in this categorization used cleaner materials and changed their production processes, becoming leaders in reducing its generation of chemical waste. In addition, Cai and Li (2018) point out that eco-innovation actions should focus on reducing the use of water and energy during production processes.

Finally, factor 3 (F3) can be referred to as environmental training and reduced consumption of harmful materials in the production process. The factor shows that practices such as offering environmental training to employees, as well as the creation of departments, teams, committees, and interdepartmental units aimed at protecting the environment, are carried out by the company. In addition, it also shows that there is awareness for reducing the consumption of harmful materials in the production process, a practice that is very important and corroborates Wong et al. (2012), who state that this practice aims to improve processes of production and use of environmentally friendly technologies to produce goods and provide services that will eliminate or reduce the negative impact on the environment. For environmental training, which was the most important Variable in the factor, its outcome corroborates Triguero (2013), Klewitz and Hansen (2014) and Roscoe (2016), who show organizational eco-innovation practices such as the development of new management methods, focused on reducing the environmental impact.

Organizational eco-innovation may include the development of new management methods, focused on reducing the environmental impact, as well as improving working conditions and the well-being of the employees (Roscoe, 2016). Several initiatives can result in organizational eco-innovations and according to Trigueiro (2013), the development of environmental training is essential for company employees and the application of eco-innovative practices.

4.2 Exploratory factorial analysis of the operational performance

Table 2 shows the practical variables of eco-innovation with performance. So, it can be seen that all variables have a strong relationship with the retained factors, as they have a satisfactory level of commonalities (greater than 0.500).

Table 4: Factorial loads, percentage of variance explained by the factors and Communalities of the indicators

	Component		
	Variable	F1	Communalities
Correlation	Production cost	0.616	0.380
	Quality	0.805	0.648
	Speed with deadlines	0.761	0.580
	Increase Profit	0.833	0.694
	Increase Return Investments	0.848	0.719
	SQLoads	3.863	3.020
	Trace (%)	60.404	
	Sample adequation: KMO = 0.799 TB = p-value < 0.001		
	Extraction method: Principal components analysis.		
	a. 1 extracted component		

Source: Research data (2021).

Based on the retention of factors with values greater than 1, by applying the latent root criterion (Hair Jr. et al., 2005). A factor resulting from the interaction of the five variables was extracted, which explains 60.404% of the variance of the original data. It should be seen that the cost of production factor had a common value of 0.380; however, it was decided to leave it as part of this factor, as it is closely linked with efficiency in production cost, which is one of the moderators that influence companies to seek eco-innovation, according to (Watson, 2004).

Factor 1 (F1) represents the performance construct and it is strongly correlated with aspects linked to production cost, quality, speed in meeting deadlines, increases in profit, and a rise in the return on investments in the list of eco-innovation practices.

The results show the positive impact of eco-innovation practices with performance elements, corroborating the results of the aforementioned research, as will be mentioned in the next paragraph, and disagreement with the research by Huang and Li, (2017) as these authors claim that eco-innovation practices weaken the competitiveness of companies. In Addition, in the view of the research by Hottenrott and Rexhauser (2013), the resources spent on reducing and preventing negative environmental impacts can exclude innovative projects, and for Wang, (2017) environmental investments or pollution prevention are unproductive practices as they can increase costs and decrease revenues.

The results of the performance factor corroborate the research of González Benito, (2005), as it shows that eco-innovative practices can improve the financial and market performance of a company as reflected in several measures, such as sales revenue, sales growth, profitability, and return on investment. This is also corroborated by the research by Cai and Li (2018) in experimenting with 442 Chinese companies which reveal that certain factors (i.e., technological capabilities, environmental factors, organizational capabilities, a market-based instrument, competitive pressures, and client’s green demand) contribute to the development of eco-innovation.

4.3 Results Of The Multiple Regression

By obtaining the constructs related to eco-innovation practices and operational performance according to the results of the Factor Analysis, it was possible to assess the relationship between the constructs of performance practices, as well as the meaning and intensity of the relationship.

The following was the estimated model:

$$Y_1 = \beta_0 + \beta_1 F_{T2} + \beta_2 F_2 + \beta_3 F_3 ...... \varepsilon$$

Where:
D_i= Operational performance

F1= Recyclable productions production
F2= Reduction in energy consumption
F3= Environmental training
ϵ = Random error

Table 05: Linear Regression

Variable	Coefficient	Standard error	Beta	Sig	VIF
Cte	3.49	0.105		1	1
F1	0.144	0.106	1.349	0.185	1
F2	0.465	0.106	4.374	0	1
F3	0.567	0.106	5.327	0	1
R adjusted =0.525 F = 16.443 Standard error =0.558 Durbin Watson = 2.298					

Source: Research data (2020)

The estimated parameters were significant at 1.0% and show the existence of a positive relationship between each of the factors and performance. Construct F3 (Environmental training and reduction of consumption of harmful materials in the production process) is the one with the highest weight among all those that are explaining performance variations.

This shows that the environmental training factor and the reduction in the consumption of harmful materials in the production process are what most impacts the operational performance factor, which is in line with the research by Hazarika and Zhang (2019) in a study carried out with 140 companies that make up the industry segment of Hong Kong, China, in which they revealed that regulatory instruments, managerial consent, and organizational measures play an important role in influencing companies to be eco-innovative.

The second most preponderant factor was Factor 2, denominated reduction in energy consumption, which was the most preponderant with the operational performance factor, and the third and last preponderant factor was the factor denominated creation of recyclable products, which corroborates with the research of Singh, Suresh and Sharma (2015), in their study carried out in India. The companies with the highest levels of adoption of eco-innovation practices in this categorization used cleaner materials and changed their production processes, such as reducing the consumption of energy and investment in recyclable products, being leaders in reducing the generation of chemical waste.

5 Final Considerations

The results of the experiment showed that there is a positive relationship between eco-innovation and performance, which makes us reject hypothesis H0: The adoption of eco-innovation practices has no impact on performance and accepted hypothesis 1: The adoption of eco-innovation practices have an impact on business performance of organizations located in PCT Guamá.

Among the eco-innovation practices, the most prevalent ones, according to the factor analysis, are the creation of recyclable products, reduction in energy and water consumption, training and environmental awareness by the company's staff, and reduction in the consumption of harmful materials in the production process, which demonstrates the existence of adoption of eco-innovation practices by these companies, corroborating with the national and international research that was carried out.

Regarding eco-innovation practices and business performance, it was observed that it is strongly correlated with aspects linked to production cost, quality, speed in meeting deadlines, increase in profit, and a rise in the return on investments in relation to eco-innovation practices, which contradicts research that indicates that investing in eco-innovation practices can affect performance and bring more costs to companies.

Regarding the regression analysis, it shows that one factor that is the most related to performance is the training and environmental awareness by the company's staff and the decrease in the consumption of harmful materials in the production process, thus showing that this research is added to the existing theoretical body on eco-innovation, identifying that environmental training is a relevant factor that encourages eco-innovation practices on the part of employees and has an impact on their performance. Its differential lies in its analysis being carried out in the context of a management territory of innovations, such as the PCT Guamá, in which this research was developed.

The limitations of this work are mainly focused on the fact that the data were collected amid the COVID-19 pandemic, which can be considered as the main relevant factor for not being able to apply the research questionnaire to the entire population. Another obstacle was that this Research was not complemented with quantitative methods, that is, in addition to the application of questionnaires, interviews should be carried out, so it would be possible, for example, to perform an analysis of the discourse of the interviewed managers concerning eco-innovation practices and performance.

Further works can analyze other samples comparing the data to Technological Parks located in other regions in Brazil, or with organizations located outside these environments. In Addition, they can combine the research with qualitative methods, using the discourse analysis method or similar, to compare the internal or external factors that most influence eco-innovation practices and their impact on performance.

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