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The Influence of Product Innovation, Environmental Strategy and Circular Economy on Sustainable Development in Organizations in Northeastern Brazil

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Abstract

Objective: Analyze the influences of the relationships between product innovation, environmental strategy and circular economy on sustainable development in organizations in the Northeast of Brazil.

Method: The method used was quantitative and descriptive research, through a survey, using the snowball method, applied to 557 companies in the Northeast of Brazil, through the elaboration of three research hypotheses. For data analysis, statistical tests, confirmatory factor analysis, and multiple linear regression were used.

Results: Based on the analysis of the three models in the multiple linear regression, an explanation index greater than 37% (R^2) is evidenced, that is, the influence relationships present a moderate intensity, where product innovation, environmental strategy and the circular economy positively influences sustainable development in organizations in the Northeast of Brazil.

Conclusions: The model that had the greatest influence on sustainable development was model 3, with a moderate intensity of influence (46.20%), that is, the relationship between the circular economy and sustainable development. In this context, it is worth mentioning that natural resources are finite, and the world population is growing exponentially, which demands new products, food, housing, health, education, employment, and income, indicating that organizations must reduce the consumption of natural resources and the impact on the environment, where environmental strategy and circular economy can effectively contribute to sustainable development.

Keywords: Product innovation. Environmental strategy. Circular economy. Sustainable development.

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A INFLUÊNCIA DA INOVAÇÃO DE PRODUTO, ESTRATÉGIA AMBIENTAL E ECONOMIA CIRCULAR NO DESENVOLVIMENTO SUSTENTÁVEL NAS ORGANIZAÇÕES NO NORDESTE DO BRASIL

RESUMO

Objetivo: analisar as influências das relações entre a inovação de produto, estratégia ambiental e economia circular no desenvolvimento sustentável nas organizações no Nordeste do Brasil.

Método: o método utilizado foi uma pesquisa quantitativa e descritiva, por meio de uma *survey*, pelo método bola de neve, aplicado a 557 empresas no Nordeste do Brasil, por meio da elaboração de três hipóteses de pesquisa. Para análise dos dados utilizou-se testes estatísticos, análise fatorial confirmatória e regressão linear múltipla.

Resultados: Com base na análise dos três modelos na regressão linear múltipla fica evidenciado um índice de explicação superior a 37% (R^2), ou seja, as relações de influência apresentam uma intensidade moderada, onde a inovação de produto, a estratégia ambiental) e a economia circular influenciam positivamente o desenvolvimento sustentável nas organizações do Nordeste do Brasil.

Conclusões: O modelo que apresentou a maior influência no desenvolvimento sustentável foi o modelo 3, com uma intensidade de influência moderada (46,20%), ou seja, da relação entre a economia circular e o desenvolvimento sustentável. Neste contexto, vale ressaltar que os recursos naturais são finitos, e a população mundial está crescendo exponencialmente, o que demanda novos produtos, alimentação, moradia, saúde, educação, emprego e renda, indicando que as organizações devem diminuir o consumo de recursos naturais e o impacto no meio ambiente, onde a estratégia ambiental e economia circular podem efetivamente contribuir para o desenvolvimento sustentável.

Palavras-chave: Inovação de produto. Estratégia ambiental. Economia circular. Desenvolvimento sustentável.

1 INTRODUCTION

Product innovation aims to improve the quality, design, and structure of the product, which meets the needs of customers. Innovation is key to the economic development of an organization as well as a region (Schumpeter, 1934). In this context, innovation is considered the source of competitive advantage for organizations, which is triggered by new products and can be linked to environmental sustainability, to minimize the impact on the environment (Severo & Guimarães, 2022). According to Kesidou et al. (2022), for the development of product innovation, companies can seek different strategies, highlighting important contextual differences, depending on the region or organizational culture.

Regarding strategy, organizations can define deliberate or emergent strategies, depending on the economic, political, and seasonal context in which they find themselves. However, given the exacerbated environmental pollution in the environment, companies are developing environmental strategies that reduce the emission of waste, and the consumption of natural resources, through ecologically correct practices aimed at sustainable development.

Currently, the environmental impact is having repercussions worldwide, it brings a new look to the questions related to the protection and preservation of the environment, thus emerging the great international meetings (RIO+20 in Rio de Janeiro, Brazil, United Nations Climate Conference in Glasgow, Scotland – COP26, Stockholm+50, Stockholm, Sweden, among others) emerging the understanding that it is possible that economic growth can develop together with environmental sustainability (Severo et al. 2021). However, the research by Ormazabal et al. (2018) highlights that Small and Medium Enterprises (SMEs) in Spain is focused on complying with the law and, in many cases, are concerned with

the image of their company, as well as do not tend to commit to environmental issues, as they understand that this would not increase their profits and competitiveness.

In the research by Kwateng et al. (2022), the results highlight that companies that implement appropriate environmental strategies are able to sustain their competitive advantage. Dai, Chan, and Yee (2018) conducted a study of 250 Chinese manufacturing companies and highlighted that market pressures, such as customer and competitor pressures, motivate companies to develop a proactive environmental strategy. The study by Severo et al. (2021) carried out with 210 respondents in the Northeast of Brazil, shows that the environmental strategy and the environmental impact can be used to make new managerial decisions, which aim to increase the competitiveness of companies and reduce aggression to the environment.

In this context, this article brings a research question: what are the relationships between product innovation, environmental strategy, circular economy, and sustainable development? Accordingly, the study aims to analyze the relationships between product innovation, environmental strategy, and circular economy in sustainable development in organizations in Northeast Brazil.

The Northeast region of Brazil is known for its biomes, being the Caatinga (most part), Cerrado (West of Bahia, Piauí, and East of Maranhão), Atlantic Forest (Northeast Coast, up to Rio Grande do Norte), and Amazon Forest (West do Maranhão), as well as for its natural beauty, beaches, and mangroves. However, according to the Institute for Applied Economic Research (IPES, 2021), more than productivity shocks, it is necessary to combine economic growth with the reduction of inequalities for Brazil to develop and fulfill the Sustainable Development Goals (SDGs), defined by the United Nations (UN) as a goal until 2030. Specifically, the Northeast region presents an optimistic scenario of resumption of growth in the post-recession period, with an improvement in the country's productivity. It also estimates that the Northeastern economy tends to grow above the national average, however, the level of Gross Domestic Product (GDP) per capita in the region would not reach 60% of the national GDP per capita in the period, except for Pernambuco, which would approach this rate (IPES, 2021).

In addition to this introduction, the article presents the theoretical framework with the three research hypotheses, the methodology used, the results and discussions, and the final considerations.

2 THEORETICAL FRAMEWORK

2.1 Product innovation and sustainable development

According to Oh et al. (2022), the product innovation performance of companies varies between countries since certain consumer characteristics (consumer sophistication, creativity, global identity, and local identity) influence the product innovation performance of companies, which can affect the creation and the success of innovative products. In this scenario, Hair, Harrison, and Risher (2022) point out that marketing is also evolving rapidly, and these changes are emerging from transformations in management skills, technological innovations, and the evolution of consumer behavior.

Companies use a variety of practices to disseminate the knowledge generated by their Research and Development (R&D) activities, including publications and discoveries in scientific journals, patenting new technologies, and contributing to the development of standards, although the individual effects of involvement in the practices listed in company innovation are well understood, the existing literature has not considered their interrelationship (Blind, Krieger & Pellens, 2022). According to De Noronha et al. (2022), organizational agility modifies the positioning of managers and founders, to amplify the diffusion scenario of innovation and technology in organizations, reverberating in new positions in the market.

For Cancino et al. (2018), there is a need to manage innovations for sustainable growth from a systematic perspective. Considering environmentally sustainable product innovations, studies point to the development of green products as a critical element of environmentally sustainable success and business performance, where environmental certification systems and government incentives facilitate the reorganization of resources to innovate in an environmentally sustainable way (De Medeiros et al., 2022). According to Melander (2017), collaboration on green product innovations is becoming increasingly important, and research on this innovation has grown in recent years.

Green innovation has been considered one of the most significant components of economic progress, environmental sustainability, and improvement of living standards, as it has developed as a strategic objective both in theory and in practice, due to the interaction between innovation and sustainability (Moshood et al., 2022). Organizations start to innovate in a sustainable way (De Guimarães, Severo & Dorion, 2022), that is, using environmental practices, rationing the use of natural resources, optimizing the use of raw materials, and focusing on sustainable development (Hojnik, Ruzzier & Manolova, 2018; García-Sánchez et al., 2020; De Guimarães et al., 2021; Pineda-Escobar, 2022), as sustainable development meets the needs of current generations without harming the ability of future generations to have their needs met (Plan International, 2021; Abdulkadir et al., 2022). Given the above, Hypothesis 1 is presented:

H1: Product innovation is positively related to sustainable development.

2.2 Environmental strategy and sustainable development

Environmental strategies have emerged as an effective tool for companies to respond to multi-stakeholder pressures and growing environmental issues, however, despite their vital role, few studies have examined how and why companies facing the same institutional environment adopt heterogeneous strategies, rather than homogeneous, to achieve sustainable corporate development (Ali, Jiang & Ali, 2022). According to De Guimarães, Dorion, and Severo (2020), organizations systematically seek to increase operational efficiency and improve their position in the market, and one way to succeed is through the use of principles and strategies related to sustainable management.

Research conducted by Ahmed, Streimikiene, and Zhengnovidade (2021) with 798 respondents from China, India, Pakistan, Bangladesh, United Arab Emirates, and Vietnam highlights that proactive environmental strategy, the competitive advantage of differentiation, and the competitive advantage

of cost leadership have a significant and positive impact on the sustainable development of an organization in terms of its performance, for example, strategic product, production, and financial performance. Accordingly, many organizations have come to the conclusion that environmental sustainability can be a strategic part of the development of companies and are implementing integrated business models, incorporating environmental issues, and embracing competitive advantages (Severo & Guimarães, 2015).

According to Severo et al. (2019), due to the great competitiveness existing in the national and international market, organizations began to look for differentiated strategies, which guarantee their maintenance and development to maximize their organizational performance in a fickle, unpredictable, and complex business environment. In this context, the factors that lead companies to become more sustainable have been extensively investigated in the literature on environmental strategy, but some important horizontal factors are still lacking, such as the influence of peers in the same sector (Carballo-Penela & Castromán-Diz, 2015; Yang et al., 2018). For Carballo-Penela and Castromán-Diz (2015), organizations can also stimulate attitude change, providing their managers with financial assistance to receive environmental training, as well as external assistance, to develop a strategic attitude that can be an interesting policy. to encourage voluntary environmental initiatives.

Seroka-Stolka and Fijorek (2020) highlight that there is a positive effect of pressures from regulators, competitors, customers, Non-Governmental Organizations (NGOs), media, shareholders, and employees on the proactive environmental strategy, but in the case of suppliers, consumers, and high direction, the pressure relationship was more complex. In addition, large companies appear to be more resilient to pressures than smaller ones when adopting a proactive environmental strategy.

Several studies emphasize that environmental strategies (Mishra & Yadav, 2021; Lu, 2021; Kwateng et al., 2022) aim at a lower environmental impact (Severo et al., 2019), and consequently, sustainable development, through the creation of jobs, reducing poverty, improving living standards (Endris & Kassegn, 2022), as well as the opportunity to maintain natural resources for future generations (Elkington, 1998). Accordingly, Hypothesis H2 is presented:

H2: The environmental strategy is positively related to sustainable development.

2.3 Circular economy and sustainable development

The concept of circular economy is opposite to the linear form of the traditional economy, which occurs through extraction, production, consumption, and waste, that is, it meets a new way of thinking about the economy, in contrast to the linear model in force, by incorporating concern for the environment, extraction of raw materials, consumption of natural resources, reuse, and recycling, and mass consumption (Cosenza, Andrade & de Assunção, 2020; Marseletto, 2020; Uribe-Toril, Ruiz -Real & Galindo Durán, 2022).

The transition from the circular economy within Industry 4.0 requires a better understanding of government, suppliers, international organizational interests, and expectations regarding the Internet of Things (IoT) (Awan, Sroufe & Shahbaz, 2021). According to Sanches, Rocha and Duarte (2023), the

circular economy model was born with the need to transform the predominant system - which is mainly linear - where raw materials are extracted from nature, and transformed into products that are discarded at the end of their cycles. of life. The circular economy is an alternative to the traditional economy (manufacture, use, and disposal) in which resources are kept in a loop for as long as possible, to maintain their value while they are in use and redirect them to the generation of new products on-site, that is, at the end of use (Shirvanimoghaddam et al., 2020). The circular economy system can improve the product cycle and change the system and mentality, both for production and for the consumer, and has become a significant alternative to the classic economic model (Uribe-Toril, Ruiz-Real & Galindo Durán, 2022).

For Severo et al. (2019), the interest and recognized importance of environmental sustainability in the most diverse sectors is growing, especially from the point of view of the significant benefits that sustainability provides to organizations and society. For Zaccone, Santià, and Bosone (2022), organizations contribute to sustainable development thanks to their motivation to protect and care for the natural environment and human beings, as well as promote sustainability by educating and disseminating knowledge, through a model conceptual framework that shows how companies adopt circular economy models that contribute to sustainable development. In this scenario, implementing the circular economy in business operations is a practice to achieve sustainability that is extremely important to achieve the sustainable development goals established by the United Nations (Nayal et al., 2022).

In this context, Marseletto (2020) presents a framework based on 10 common strategies of the circular economy, that is, recover, recycle, reuse, remanufacture, reform, repair, reuse, reduce, rethink and refuse, which stand out for sustainable development. However, within the 17 SDGs (Plan International, 2021), the study recommended 4 items considered most relevant to meet the research objective, which list: 8) Decent work and economic growth; 9) Industry, innovation, and infrastructure; 12) Responsible consumption and production; 13) Action against global climate change. Coherently, Hypothesis H3 is presented:

H3: Circular economy is positively related to sustainable development.

Figure 1 presents the proposition of the Theoretical Model and the three research hypotheses that were empirically tested in this study.

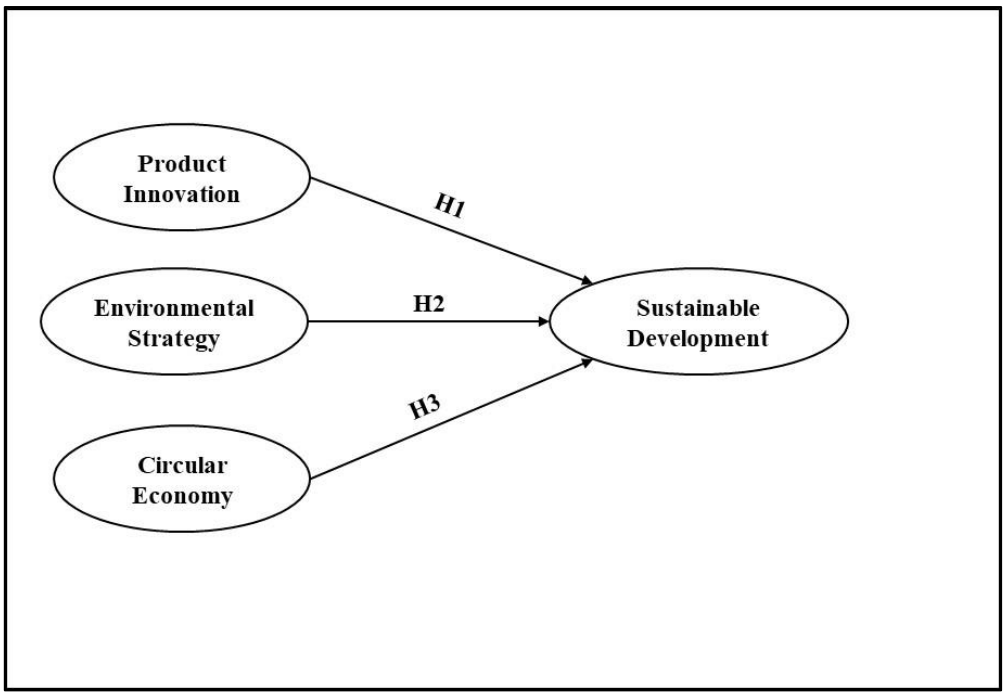

Figure 1: Theoretical Model and research hypotheses
Source: Prepared by the authors (2022).

3 METHOD

The methodology used in this study is quantitative and descriptive, through a survey applied to organizations in the Northeast of Brazil. According to Hair Jr. et al. (2013), quantitative research, like the survey, is characterized by numbers and contains hundreds of respondents.

As for the descriptive nature, Malhotra et al. (2012) inform that the purpose is to present the characteristics of the investigated sample. With regard to the investigated population, the Northeast consists of 9 states (Alagoas, Bahia, Ceará, Maranhão, Paraíba, Pernambuco, Piauí, Rio Grande do Norte and Sergipe), which is composed of 3,223,115 companies (DataSebrae, 2020). The sample is characterized as non-probabilistic, for convenience (Hair Jr. et al., 2013), and applied to 557 companies in the Northeast of Brazil.

Data collection took place through a questionnaire (Malhotra et al., 2012). The dimensions of the questionnaire were affirmative within a degree of agreement or disagreement, on a 5-point Likert scale, with (1) totally disagree and (5) totally agree. The questionnaire has six questions to identify the profile of the company and the respondent, as well as is divided into 4 Constructs of the research: i) Product Innovation (PI) – adapted from studies by Schumpeter (1934), and Severo et al. (2015); ii) Environmental Strategy (ES) – adapted from the research by Severo et al. (2021); iii) Circular Economy (CE) – prepared by the authors; and, iv) Sustainable Development (SD) – adapted from four items (Decent work and economic growth; Industry, innovation, and infrastructure; Responsible consumption and production; Action against global climate change) recommended by the SDGs (Plan International, 2021), which have 12 questions (observable variables) (Table 1).

First, the questionnaire was validated by three Doctors who are experts in the areas of study. Subsequently, to verify the understanding of the questionnaire, a pre-test was also carried out with 21 respondents.

In data collection, the snowball method was used, where the questionnaires were made available through social networks and e-mail, through a Google Forms form operated by the researchers. In this context, the Northeast Business Associations were used, as well as the telephone contact for data collection. Respondents were managers (managers, coordinators, and directors) of companies from different sectors and sizes of activity. Data collection took place between December 2021 and July 2022.

Descriptive statistics, Confirmatory Factor Analysis (CFA) were used for data analysis, which assesses whether the factors are strongly associated (Hair Jr. et al., 2013). Subsequently, Multiple Linear Regression (MRL) was used, which indicates the cumulative effects of a group of explanatory variables (X1, X2, X3, etc.) on a dependent variable (Y), and the separate effects of these explanatory variables (Y = ß1X1 + ß2X2 + ß3X3 +...+ ß0) (Hair Jr. et al., 2013).

Regarding the tests performed, for 12 observable variables, data normality, reliability, and internal consistency were verified, using Cronbach's alpha, Kaiser-Meyer-Olkin (KMO), and Bartlett's sphericity tests (Hair Jr. et al., 2013), according to Table 1.

4 RESULTS AND DISCUSSIONS

Initially, data were debugged, which sought to identify univariate and multivariate outliers, Pearson symmetry analysis with values close to Zero (Hair Jr. et al., 2013), and Kurtosis analysis, with values below 5 (Mardia, 1971). It is noteworthy that the electronic form did not allow for non-response (missing). Coherently, no outliers or missing were identified, which resulted in 557 valid cases.

4.1 Profile of companies and respondents

Concerning the sector in which the companies operate, 68.1% work in the provision of Services, 26.4% in Commerce, 3.6 are in Industries, and 1.9% work in Agriculture. As for the size, the companies were classified based on their annual revenue, being large companies (greater than R$300,000,000.00) (Brasil, 2007), Medium-sized (greater than R$3,600,000.00 and equal to or less than R$300,000,000.00), Small Business (greater than R$360,000.00 and equal to or less than R$3,600,000.00) and Microenterprise (equal to or less than R$360,000.00) (Brasil, 2011). In this context, 39.5% of the companies are classified as Large, 26.4% as Medium, 18.3 as Small, and 15.8 as Microenterprise. Regarding the 9 regions of the Northeast, in Alagoas there were 59 companies, Bahia with 53 companies, Ceará with 57 companies, Maranhão with 51 companies, Paraíba with 70 companies, Pernambuco with 85 companies, Piauí with 50 companies, Rio Grande do Norte with 65 companies and Sergipe with 67 companies.

To analyze the profile of the respondents, the gender of the respondents was verified, being 58.4% male, 40.9% female, and 0.7 declared themselves as another gender. As for education, 69.7% had

a degree, 14.5% had secondary education, 11.5% had a specialization, 2.2% had a master's degree, 1.1% had a doctorate and 1% had an elementary school. Regarding the respondents' family income, 26.6% from 2 to 4 minimum wages, 25.9% from 4 to 10 minimum wages, 23.6% up to 2 minimum wages, 14% from 10 to 20 minimum wages, and 9.9% above 20 minimum wages.

4.2 Confirmatory factor analysis (CFA)

When performing the CFA, normality and reliability tests were performed for all observable variables, through principal component analysis (intrablock analysis), following the parameters of Hair Jr. et al (2013): i) combination of observable variables in the formation of Constructs; ii) Factorial Loads of each variable (=or>0.5); iii) Commonality (=or>0.5); iii) Simple reliability: Cronbach's alpha (>0.7); iv) Total Variance Explained (=or>0.5); v) Bartlett's sphericity tests (significant p<0.001); and, vi) Kaiser, Meyer and Olkin (KMO) calculation (>0.7).

In this context, we first analyzed the normality and reliability tests for all the observable variables together, where all the statistical tests presented significant values, that is, they were within the parameters recommended by Hair Jr. et al. (2013), with Cronbach's alpha of 0.917 and KMO of 0.918.

Table 1 presents the normality and reliability tests for all observable variables, through intrablock analysis, where all Cronbach's alpha were within the recommended range, however, regarding KMO, only in PI (0.657) and ES (0.644) Constructs) were close to the recommended minimum, which does not invalidate the Construct, as the KMO result indicates that the data may be normal, as well as the Factor Loads and Total Variance Explained are above the recommended, which allows us to state that the data is consistent sufficient for AFC and MLR application.

Table 1 - Research constructs and observable variables

Construct	Questions/observable variables	Factorial Loads	Communality
Product innovation (PI)	PI1 - In the company, product innovations occurred with the contribution and participation of internal and external agents (consultancy, supplier, customer, Educational Institution or other agents).	0.820	0.673
	PI2 - At the company, product innovations used new knowledge from science and technology.	0.825	0.680
	PI3 - In the company, the product innovations allowed to reduce the impact on the environment.	0.733	0.538
	Cronbach's alpha: 0.700 Total Variance Explained: 63.04%	KMO: 0.657	
Environmental Strategy (ES)	ES1 - The environmental strategy promotes the improvement of the company's image and brand.	0.735	0.540
	ES2 - The company uses the environmental strategy to reduce atmospheric pollution that causes climate impacts.	0.902	0.814
	ES3 - The company uses the environmental strategy to improve the efficiency of the use of natural resources.	0.886	0.785
	Cronbach's alpha: 0.799 Total Variance Explained: 71.32%	KMO: 0.644	

Circular Economy (CE)	CE1 - The company promotes initiatives for the population to value remanufactured products, in terms of consumption habits.	0.856	0.733
	CE2 - The company uses the principles of the 3 Rs (reduce, reuse and recycle) materials.	0.890	0.792
	CE3 - The company aims at product lifecycle extension, sharing platforms, product as a service and resource recovery.	0.864	0.747
	Cronbach's alpha: 0.839 Total Variance Explained: 75.71%	KMO: 0.721	
Sustainable Development (SD)	SD1 - There are policies and practices in the company that aim to combat global warming..	0.903	0.816
	SD2 - In the company, the use of natural resources has premises of not harming the consumption of these resources for future generations.	0.914	0.836
	SD3 - The company's principles are to balance social, environmental and economic sustainability, aiming at sustainable development.	0.912	0.832
	Cronbach's alpha: 0.895 Total Variance Explained: 82.82%	KMO: 0.751	

Source: Prepared by the authors (2022).

Table 2 displays Bartlett's sphericity tests for each Construct surveyed (PI, ES, CE and SD), which indicates that all Constructs are significant.

Table 2 – Bartlett's sphericity tests

Construct	Qui-quadrado aprox.	Sig.
Product Innovation (PI)	315.841	0.000
Environmental Strategy (ES)	628.739	0.000
Circular Economy (CE)	672.918	0.000
Sustainable Development (SD)	1,000.878	0.000

Source: Prepared by the authors (2022).

In the PI Construct, all the observable variables presented Factorial Loads higher than recommended (=or>0.5) as well as an acceptable Commonality, with question PI2 "In the company, product innovations used new knowledge from science and technology", presented the highest Factorial Loads (0.825). This result emphasizes that in the development of product innovation, knowledge of science and technology is essential for organizations. These results corroborate the research by Oh et al. (2022) because the performance of product innovation requires knowledge of consumer needs, as well as R&D, scientific discoveries, and the development of new standards (Blind, Krieger & Pellens, 2022).

In this scenario, in the ES Construct, all the observable variables presented Factorial Loads higher than recommended, as well as the Communality, was acceptable. In the Construct of ES, the variable that presented the highest Factorial Loads (0.902) was ES2 "The company uses the environmental strategy to reduce atmospheric pollution that causes climate impacts". These findings underscore that ES can be an effective tool for companies to respond to stakeholder pressures regarding environmental issues (Seroka-Stolka & Fijorek, 2020; Ali, Jiang & Ali, 2022), as well as for climate issues that impact the environment, as it is possible that economic growth can develop together with environmental sustainability (Severo et al. 2021).

In the CE Construct analysis, all observable variables exhibited Factorial Loads higher than recommended, as well as acceptable Commonality. Accordingly, CE2 "The company uses the principles of the 3 Rs (reduce, reuse and recycle) materials", presented the highest Factorial Loads (0.890). In this context, organizations that use EC practices, by incorporating concern for the environment, that is, recycling, reuse, remanufacture, repair, reuse, reduce, strive for sustainable development (Marseletto, 2020; Uribe-Toril, Ruiz -Real & Galindo Durán, 2022), as well as being able to sustain their competitive advantage (Kwateng et al., 2022).

The SD Construct also presented all observable variables as Factorial Loads higher than recommended and acceptable Commonality. The observable variable that presented the highest Factorial Load was SD2 "In the company, the use of natural resources has premises of not harming the consumption of these resources for future generations" (0.914). This result is in line with the recommendations of Plan International (2021) since sustainable development is concerned with meeting the needs of current generations, without harming the ability of future generations to have their needs met (Abdulkadir et al. al., 2022).

4.3 Multiple linear regression (MLR)

For the MLR, the research verified the relationship between the Constructs of PI, ES, CE and SD, by the Insert method, resulting in three Models (Tables 3, 4 and 5). The first Model (Table 3) had the means of the SD Construct variables (SD1, SD2 and SD3) as a dependent variable (effect) and PI1, PI2 and PI3 as independent variables (cause).

Table 3 – Multiple Linear Regression

Model 1	R	R square	Adjusted R squared	Standard error of the estimate
	0.612[a]	0.374	0.371	0.9130

a. Predictors: (Constant), PI3, PI1,PI2
b. Dependent variable: MedSD

The second Model (Table 4) had the means of the SD Construct variables (SD1, SD2 and SD3) as a dependent variable (effect) and ES1, ES2 and ES3 as independent variables (cause).

Table 4 – Multiple Linear Regression

Model 2	R	R square	Adjusted R squared	Standard error of the estimate
	0.668[a]	0.447	0.444	0.8583

a. Predictors: (Constant), ES3, ES1, ES2
b. Dependent variable: MedSD

Finally, the third Model (Table 5) had the means of the SD Construct variables (SD1, SD2 and SD3) as a dependent variable (effect) and EC1, EC2 and EC3 as independent variables (cause).

Table 5 – Multiple Linear Regression

Model 3	R	R square	Adjusted R squared	Standard error of the estimate
	0.680[a]	0.462	0.459	08462

a. Predictors: (Constant), CE3, CE1, CE2
b. Dependent variable: MedSD

Based on the analysis of the three Models in the MLR, an explanation index higher than 37% (R2) is evidenced, that is, the influence relationships present a moderate intensity, where Product innovation (PI), Environmental strategy (ES) and the Circular Economy (CE) positively influence Sustainable development (SD) in organizations in the Northeast of Brazil (Figure 2). These findings corroborate the theoretical assumptions of Cancino et al. (2018) and Severo and Guimarães (2022), as IP can be a source of competitive advantage for companies, through the development of new products linked to environmental sustainability, to minimize the impact on the environment. Consistently, several studies have highlighted that higher education (Mishra & Yadav, 2021; Lu, 2021; Kwateng et al., 2022) aims at a lower environmental impact (Severo et al., 2019), and consequently, sustainable development (Elkington, 2019). 1998). Concerning EC, it is a new way of thinking about the economy, in contrast to the linear model in force, by incorporating concern for the environment (Cosenza, Andrade & de Assunção, 2020; Uribe-Toril, Ruiz- Real & Galindo Durán, 2022).

In this scenario, the Model that had the greatest influence on Sustainable development (SD) was Model 3 (Figure 2), with a moderate intensity of influence (46.20%), that is, the EC with the SD, as organizations can contribute to sustainable development, through the practice of EC (Zaccone, Santià & Bosone, 2022), since implementing EC in business operations is a technique to achieve sustainability that is extremely important to achieve sustainable goals development established by the United Nations (Nayal et al., 2022).

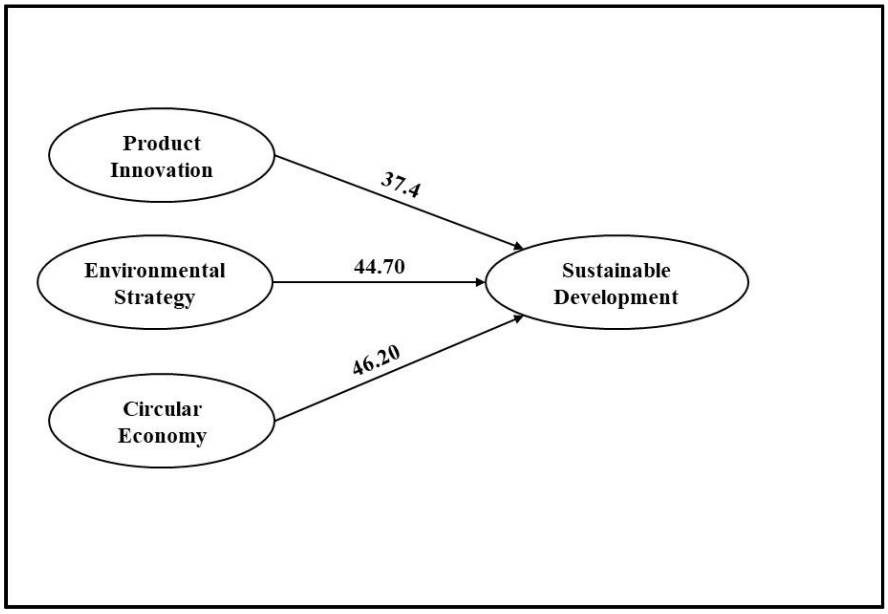

Figure 2: Final model
Source: Prepared by the authors (2022).

5 FINAL CONSIDERATIONS

The survey results highlight important relationships between PI, ES, CE, and the SD, because of the analysis of 557 companies in Northeast Brazil. Because of the above, the most relevant relationship occurred between the observable variables of EC and SD, presenting a moderate intensity in Model 3 (R2=46.20%). These results corroborate the research by Cosenza, Andrade, and Assunção (2020), Marseletto (2020), and Uribe-Toril, Ruiz-Real, and Galindo Durán (2022), as the EC is in line with a new way of thinking about the economy, in contrast to the linear model currently in force, by incorporating concern for the environment, extraction of raw materials, consumption of natural resources, reuse, and recycling, and sustainable development, which aims to maintain natural resources for future generations (Plan International, 2021).

It is worth mentioning that natural resources are finite, and the world population is growing exponentially, which demands new products, food, housing, health, education, employment, and income, indicating that organizations must reduce the consumption of natural resources and the impact on the environment. environment, where ES and EC can effectively contribute to SD.

Concerning the managerial contributions of the research, the information analyzed here allows managers and professionals in similar areas, a greater knowledge of the importance of IP, ES, and CE, helping them in the strategies for the SD. In addition to information for the adoption of environmental actions of public policies at a regional and national level, to support cities and regions, as it is necessary to combine economic growth with the reduction of social inequalities in Brazil, seeking to comply with the SDGs, recommended by the United Nations Organization (UN) as a target by 2030.

Academic contributions are linked to the development of the Analysis Framework, which was statistically validated (observable variables, scales, and Constructs), which can be replicated in different regional, national, and international contexts. The main impact of the research on the advancement of science lies in the identification of the antecedents of sustainable development, based on product innovation, environmental strategy, and circular economy, which can be the key to the success of organizations and the preservation of the environment.

As suggestions for future studies, we list the analysis of the themes researched here in other regions of Brazil, to carry out comparisons, as well as longitudinal research comparing different periods of time, and thus understanding whether organizations are contributing to sustainable development.

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