

Correlation and Representativeness Between Eco-Innovation Dimensions and Sustainability in Electric Power Companies

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Abstract The Eco-Innovation has been considered an important factor in developing of sustainable products and services around the world. The innovation when integrated to the sustainable actions certainly improves the companies’ efficiency and representativeness into their markets. This joining has been perceived in Electric Power Companies, in which the environment and sustainable objectives are the main targets to be achieved in these companies. This work proposes a methodology that uses the Transversal Cut Data Lifting (TCSL) technique, which involves self-administered questionnaires applied to managers to identify the possibilities of correlation and representativeness between eco-innovation dimensions and sustainability. An application of this proposed methodology was performed with collected data from an electric power company in Brazil and the results pointed out that there was a significant positive relationship between top management support, technological competence and environmental formalization, with the definition of proactive eco-innovation strategies. With these results, it can be considered that this study contributed to the advancement of knowledge in this area, with the definition of the interfering variables. The practical implications are recognized by an empirically applied study, which provides information on eco-innovation management. It recognizes the managing effects, allowing for more in-depth analyses, which could be considered as a relevant gap in the literature.

Keywords:Eco-innovation. Sustainable development. Innovation.

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1 Introduction

Often, companies are driven to develop innovation in their products or processes to improve competitiveness. Product development needs to be improved constantly and it is necessary to strengthen procedures in processes that incorporate the sustainable concepts along with economic aspects. In addition, industries are under constant pressure to assume environmental responsibilities [1].

In order to solve these issues, the strategies that involve eco-innovations stand out in the industrial context, since the long-term economic systems survival depends on the capacity to create and maintain sustainable economic processes [2].

Eco-innovations are defined as innovations based on sustainable development, reduction of environmental risks, pollution and other impacts generated by bad use of resources, and considering the product life cycle [3].

The authors [4] and [5] highlighted the importance of the balancing among financial, social and environmental dimensions to the sustainable development. In this way, the innovations become fundamental strategies for sustainable development in the companies.

According to [2] the definitions for eco-innovation are commonly generic; and it increases the need to better categorize eco-innovation types, in order to understand their specific characteristics, since they are tools that contribute to renew of the innovation systems.

Among the main motivational factors of a corporate innovation project are highlighted the increased market share and profitability in business. Thus, the diagnosis and analysis of sectors linked to innovation in the companies is a relevant research, since the companies only realize investments on innovation with potential of financial return [6].

Eco-innovation studies should focus on a holistic view prior to their development, recognizing that eco-innovation can occur in different ways, with different objectives and specific attributes [2], [7].

The interest to apply more sustainable technologies has led to the rise of themes related to preservation of the environment. In this context, eco-innovation provides a new approach by integrating innovation and environmental sustainability. Although, eco-innovation replies this necessity, according to [8] society still has difficulty to balance the economic dimension with the sustainable one, in the pursuit for innovation.

The authors in [9] point out the lack of strategies for eco-innovation, as well as the inherent variables of innovative process, and [10] highlights about the importance of establishing indicators to assess sustainability globally, considering the aspects of quality and economic performance. In addition, [11] points out the lack of environmental commitment of organizations.

Also, the research [8] highlights the lack of studies in the field of eco-innovation, especially face the new global scenario and the challenges posed by climate change. Therefore, the lack of methodologies for the diagnosis of the perceived level of eco-innovation in companies is still unexplored, being an important gap to be filled. Please note that the first paragraph of a section or subsection is not indented.

2 Objectives

Given the context presented, this research aims to present a theoretical view to create steps to diagnose the eco-innovation levels in medium-sized companies on energy sector, through a decision analysis with managers and experts from this sector.

This study is justified due to the recent spread of scientific works on sustainability, especially on the Eco-innovation field.

3 Methods

This paper suggests an exploratory methodology to diagnose eco-innovation in companies of the energy sector.

The instrument used for the data collection was the questionnaire proposed by [2]. The survey questionnaire was re-designed following structured interviews with managers of environmental and products development from companies, exploring issues relating to eco-innovation. The questionnaire was conceived to identify levels of the structural dimensions of eco-innovation in the power companies (eco-design, development, acceptance, product service, change of values, and governance). Figure 1 shows the methodological steps used in this proposal.

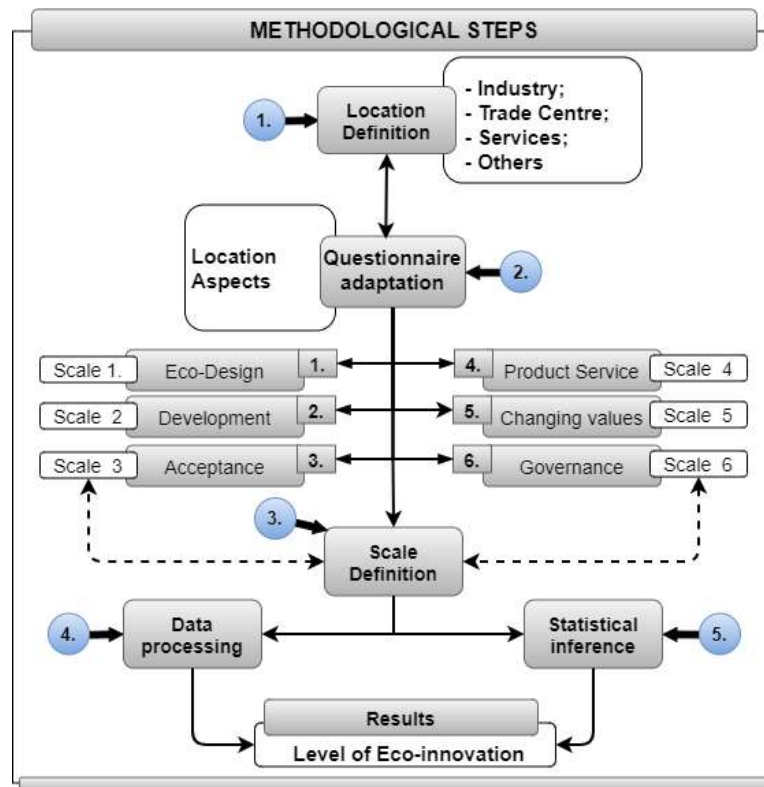


Fig. 1. Methodology flowchart.

Summarizing the figure 1, the methodological steps proposed were organized in order to identify: 1. Type of industry and commercial interests; 2. Local aspects, where the companies are operating; 3. Representative scales for eco-innovation dimensions to evaluate coherently the subjective aspects presented by experts, through structured questions; 4. Adjustments and organization of the data to find correlations and representativeness between the analyzed themes, and 5. Statistical analyzes in the collected data.

For the measurement of the respondents' perception, a balanced five-point scale was taken, with a central neutral position and equal number of favorable and unfavorable categories. Other scales may be used to characterize each dimension, according to the category analyzed, scenario evaluated, branch, or area of the group studied. However, the use of interval scales in studies related to innovation is highly indicated [9].

The proposed methodology was applied in an industry of the medium-sized electric energy sector, located in the southern region of Brazil, whose data were collected between September and October 2018. The questionnaires were answered by 5 members of the senior management.

The company studied develops products and services destined to hydroelectric plants, among them: manufacture of synchronous electric generators, electrical panels, cabinets and cubicles for the control and protection of machines; electromechanical assembly; assembly of lifting and sectioning substations; general automation for local and remote operation; solar panels; among other products and services.

The company explored in this work has contributed in approximately 19% of the total installed capacity of Small Hydroelectric Plants in Brazil (1047.8 MW) by its products and services.

4 Results

There are several kinds of eco-innovation [2]. To understand these different types and its dimensions are essential. And then, providing new business opportunities and contributing to a transformation towards a sustainable society depends on the interplay among the dimensions and the engagement of key stakeholders in the innovation process. Furthermore, all types of eco-innovation lead to environmental protection in different ways.

The eco-designing is very important to create, improve and transform a system to reduce environmental impacts of production and consumption activities [2].

Thus, the first dimension analysis seeks to identify the role impact of eco-innovation as a productive strategy as well as to diagnose the perception of the decision makers as to the dimensions of eco-innovation.

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The main findings and inferences were taken from the key dimensions of eco-innovation described by [2].

Table 1 shows the perception from the top managers about the eco-design in the company.

Table 1. Eco-Design

<i>Eco-Design (e)</i>		<i>Scala</i>				
e_1	Intensity that the organization seeks to adopt mechanisms to mitigate environmental impacts.	1	2	3	4	5
e_2	The organization is concerned with producing more with less to reduce environmental impacts.	1	2	3	4	5
e_3	The organization applies the concepts of reduction, reuse, recycling in the production process.	1	2	3	4	5
e_4	The organization seeks to design its production process taking into account the positive and negative impacts on the environment.	1	2	3	4	5
e_5	The organization looks for reducing negative impacts in order to obtain a greater competitive advantage.	1	2	3	4	5
e_6	The organization directs research and development of products and services by sustainability criteria.	1	2	3	4	5
e_7	The organization invests in training people to deal with sustainable technologies.	1	2	3	4	5
e_8	The organization invests in improve the workers knowledge and skills to design sustainable technologies.	1	2	3	4	5
e_9	The organization seeks for partnerships aiming to improve existing products and creating new ecologically products.	1	2	3	4	5
e_{10}	The product and service life cycle analysis is an integrated strategy in the organizational routine.	1	2	3	4	5

The aspects e_1 , e_2 , e_3 and e_5 demonstrate the organization's attitude regarding curative technologies. Those that repair damages to the environment, also called end-of-pipe solutions. According to [12] and [4], end-of-pipe technologies reflect a posture of pollution control at the end of the production process, being usually reactive to environmental regulation.

Add a new component at the end of a process can minimize and repair negative impacts without necessarily changing the role process that generate those impacts. It might be a good alternative to

improve the environmental, especially when costs are involved. Nevertheless, according to [2] it will only solve part of the problem.

So, cleaner solutions or preventive solutions are needed in a way to prevent deeply the pollution. The aspects e_4 , e_6 , e_7 , e_8 , e_9 and e_{10} show how the organization works with cleaner production. This implies the use of clean methods during the production process. Prioritizing the environmental goals more than the legal obligations. Preventive solutions result in increased productivity and efficiency of the organization, reduction of costs once a year, reduction of productivity and better use of resources and resources [4].

Table 2 presents the dimensions of innovation users, involving development and acceptance. Through this dimension were evaluated the involvement of customers in the process of improving products and services, as well as in the development of new products. It was observed through this lens the acceptance and adoption of eco-innovation applications by customers.

Table 2. User dimensions of eco-innovation.

<i>User development (d) and acceptance description (a)</i>		<i>Scala</i>				
d_1	The organization seeks to adapted products and services according to the needs of customers.	1	2	3	4	5
d_2	The organization tries to know what the customer's opinion about the product or service for promoting change.	1	2	3	4	5
d_3	The company identifies customers who can effectively contribute to the process of improving existing products or developing new goods.	1	2	3	4	5
d_4	The organization seeks to engage customers in the product improvement or new product development projects.	1	2	3	4	5
a_1	Customers are interested and concerned about how products are produced and consumed.	1	2	3	4	5
a_2	Customers question how the products are discarded.	1	2	3	4	5
a_3	Customers look for products with innovative and sustainable characteristics.	1	2	3	4	5
a_4	Customers want innovative products, independently the prices.	1	2	3	4	5
a_5	Customers declare themselves satisfied with innovative and sustainable products.	1	2	3	4	5
a_6	The organization realizes that there is a direction for innovative sustainable products.	1	2	3	4	5

The company studied offers products and services focused to customer needs, allowing changes to the customer's direction. It also identifies potential customers who can effectively contribute to the development of new products as well as improvements. The closest involvement with the user happens in the generation of ideas, that is, at the beginning of the project.

To know the acceptance of eco-innovation on the Market can play an important role in the business. In this sense, to involve the users in the process might be an interesting strategy. However, for this company the users are not focus on environmental benefits as much as they are on prices, and their needs.

Involving a user into the creative process and in the products and services development is not a simple task. [2] cite some barriers to this process, such as finding a correct motivation, finding out which user are able to help, a lack of technical knowledge, among others. Thus, identify the user's needs and wishes can bring real benefits to the eco-innovation process. However, [5] emphasizes the difficulty to lead with environmental gains and also keep economic and technic competitiveness.

[8] observed in their study a practical example of failure on the balance of sustainability and economic viability. In this study, the authors have also highlighted the user needs as one the most important factor to achieve eco-innovation success.

Table 3 presents the dimensions involved in service and product. By evaluating the answers regarding to these aspects it is possible to verify the sustainable business model employed by the organization.

The analysis of Table 3 points out the way that the organization creates additional value, changing the logic of delivering value to the customer, consequently the gain, to increase competitiveness and improve performance towards sustainability. It is important to highlight that the organization does not define and

does not implement innovative solutions alone, so to study its network and involvement is high recommended.

Table 3.Product and service dimension.

<i>Changes in the product service (p) and values(v)</i>		<i>Scala</i>				
p_1	The organization focuses on the sale of associated products and services.	1	2	3	4	5
p_2	The organization has ownership of the product. However, it offers expanded customer service with unlimited and individual access.	1	2	3	4	5
p_3	The organization works with a product renting and its use is not restricted to the customer and unlimited access.	1	2	3	4	5
p_4	The organization works with product/service in a way that customers can pay for the 'unit service', according to the level of use or functional result.	1	2	3	4	5
v_1	There are criteria pre-defined for the supplier's selection.	1	2	3	4	5
v_2	The contractual relationships with selected suppliers are stable.	1	2	3	4	5
v_3	The organization seeks to know the environmental performance of service providers and suppliers.	1	2	3	4	5
v_4	Suppliers are involved in the product/service planning process in order to produce innovative solutions.	1	2	3	4	5
v_5	Maintenance service providers are committed to the company's environmental policies in order to maintain the standards set in the production process.	1	2	3	4	5
v_6	Customer services have real and tangible benefits.	1	2	3	4	5
v_7	The organization communicates how to handle properly the products.	1	2	3	4	5
v_8	The organization communicates how to store properly the products.	1	2	3	4	5
v_9	The organization promotes clarification and orientation actions to potential customers.	1	2	3	4	5
v_{10}	The organization seeks to engage its network of relationships in order to achieve significant environmental solutions.	1	2	3	4	5

Governance plays an important role in eco-innovation [2]. In this sense, this dimension refers to the organization context to the eco-innovation. Table 4 shows managers' view about eco-innovation aspects.

Table 4.Governance dimension.

<i>Governance (g)</i>		<i>Scala</i>				
g_1	The organization has an explicit environmental policy.	1	2	3	4	5
g_2	The organization has a proactive environmental strategy.	1	2	3	4	5
g_3	There are clear environmental objectives.	1	2	3	4	5
g_4	There is an organizational structure with clear environmental responsibilities.	1	2	3	4	5
g_5	The organization seeks to establish a collaborative relationship with suppliers, customers, governments, non-governmental organizations, universities, and others.	1	2	3	4	5
g_6	The organization takes part in the activities promoted by sectorial entities, such as work meetings, conferences, among others.	1	2	3	4	5
g_7	Public policies stimulate the eco-innovation process.	1	2	3	4	5
g_8	Sectorial entities such as class associations and public agencies, act in a way to create networks in order to promote cooperation.	1	2	3	4	5

g_9	The organization aims to develop radical innovations rather than incremental eco-innovation improvements.	1	2	3	4	5
g_{10}	Economic criteria have the same weight as other criteria when it comes to any action toward eco-innovation.	1	2	3	4	5

According to [13] the governance can assume different positions front the environment. One of them is reactive posture, when actions are imposed by environmental legislation. Which focus on following the legislation through pollution control, by investments on corrective technologies (end-of-pipe). This does not require the company to develop competencies on new technologies production or new environmental processes. On the other hand, there is the proactive organizational posture that seeks in advance the reduction of the environmental impacts of its operation and process.

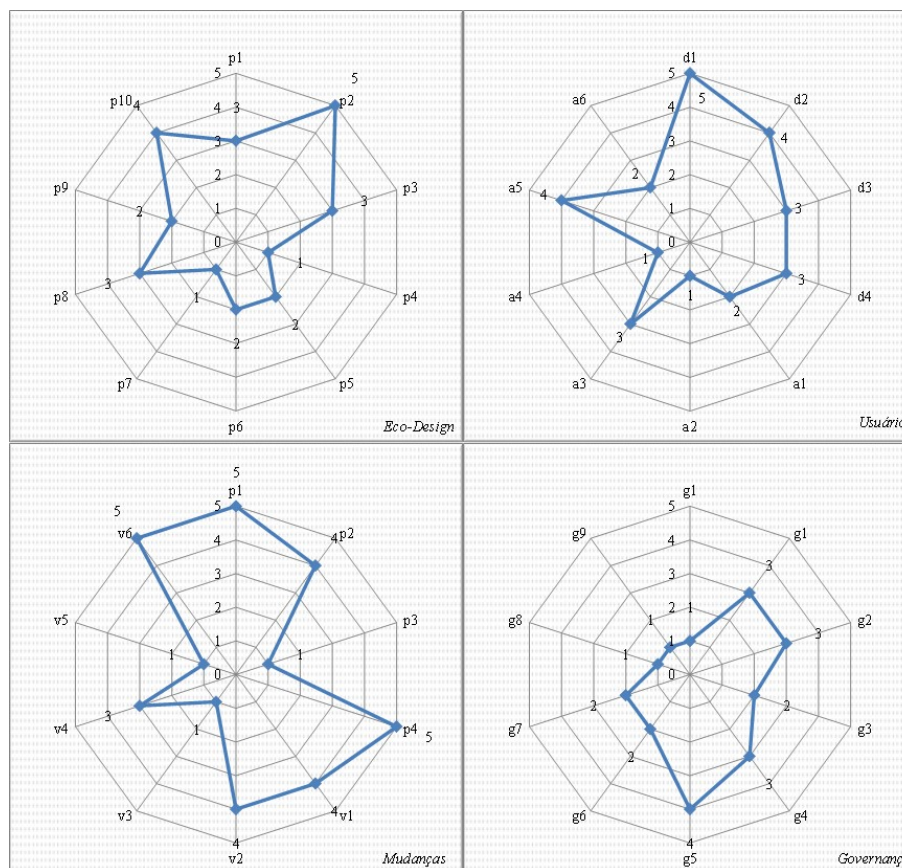


Fig. 2.Dimensions of eco-innovation.

According to [9], a proactive organization generates competitive advantage through the adoption of eco-innovative technologies, involving greater learning and developing competitive organizational capacities, thus considering environmental issues as an opportunity for competitive gains. Therefore, proactive environmental strategies tend to be accompanied by better financial performance. Once that the eco-innovation dimensions have been identified, the characteristics can be assessed as showed in Figure 2. Eco-innovation is encouraged by a number of factors outside organizations, including mainly environmental regulation. Regulations should guide the company to innovate taking account to the sustainability bases. Beside this the company may see this pressure as an opportunity for improving productivity and as well as the competitiveness company's factor. Thus, environmental issues must be seen by companies as stimulating the generation of innovations and technological, economic and competitive opportunities, being considered proactive strategies. That is, managerial knowledge and

attitudes towards technological change and environmental concerns should be encouraged by environmental regulation.

5 Conclusion

From the perspective of eco-innovation in the industrial context, this work sought to demonstrate that this analysis is pretty relevant for the companies to remain in the market. Thus, this study demonstrated a new perspective in organizations regarding to environmental regulation, which can act less as a cost and more as an opportunity, guiding them to improve productivity and competitiveness.

The study exploited an important gap, as previous observed by other authors in the literature, regarding research focused on eco-innovation strategies, their drivers and effects. Therefore, it can contribute in a significative way to the advancement of knowledge in the innovation area into the power companies.

For data collection, a questionnaire proposed by [2], redesigned through in-depth interviews with environmental managers and company product developments, exploring eco-innovation issues. The definition and analysis of the variables related to the research constructs were performed empirically from analyzes on the management of eco-innovation, allowing for in-depth study, as well as, providing discussions on this subject. Environmental regulation factors that influence the adoption of reactive and proactive eco-innovation strategies were raised.

In addition, the definition of criteria considered by managers regarding the actions of innovation and eco-innovation has an important role in the improvement of enterprise processes. As a suggestion for future work, it is planned to involve a user in the creative process and product development, which although is not an easy task, however, it can bring real benefits to the eco-innovation process, bringing greater environmental gains.

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