



# Cleaner production and environmental management as sustainable product innovation antecedents: A survey in Brazilian industries



Eliana Andrea Severo<sup>a</sup>, Julio Cesar Ferro de Guimarães<sup>a,\*</sup>, Eric Charles Henri Dorion<sup>b</sup>

<sup>a</sup> Faculdade Meridional (IMED), Department of Master in Business Administration (PPGA-IMED), Senador Pinheiro, 304, 99070-220, Passo Fundo, RS, Brazil

<sup>b</sup> University of Caxias do Sul, Department of Master in Business Administration from the University of Caxias do Sul (PPGA-UCS), Francisco Getúlio Vargas, 1130, 95070-560, Caxias do Sul, RS, Brazil

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## ABSTRACT

Cleaner production methods and environmental management practices are tools that strive for production process efficiency, the use of its input and the generation of industrial waste. These tools can significantly contribute to sustainable product innovation, due to the rational use of natural resources and the minimization of generated wastes. This study aims to measure the relations between the conditions for sustainable product innovation, considering the constructs of cleaner production and environmental management. It also examines the relationship between sustainable conditions and product innovation and financial performance as well as the size of the moderating effect of the companies on the relationship between the constructs. In this context, a Survey in 762 companies of different sizes was carried out in a leading metal-mechanic sector in Brazil. Structural Equation Modeling methods were used for results analysis. The research highlights that both Cleaner production and Environmental Management influence positively the achievement of Sustainable Product Innovation. The surveyed companies developing Sustainable Product Innovation Financial had higher performance in comparison to other companies. Another result of this study shows the strong relationship between the constructs “Cleaner production” and “Environmental Management”. It is recommended that companies combine these constructs to increase the results of sustainable innovation and financial gain. Accordingly, the way for companies to produce new environmentally sustainable products is through the presence of cleaner production and environmental management practices. The scientific value of this research is to provide for the academic community a framework for the analysis of the relations of the categories constitutes the main contribution, as well as providing management information to decide on the implementation of sustainability programs, resulting in higher financial gains through product innovations sustainable.

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## 1. Introduction

The intensification of the global industrialization, the population explosion, the development of new products and the high production and excessive consumption contributed to the economic development, but resulted in environmental degradation of the ecosystems. In this context, the development of corporate environmentalism, as a strategic part of business, is one of the most significant changes that began to occur in the markets at the beginning of the XXI century.

Those actions in the environmental area became proactive and

started to be understood as innovations inherent in a competitive strategy of organisations, requiring research and development of sustainable products (Fernández et al., 2003; Placet et al., 2005; Marchi, 2012; Gelbmann and Hammerl, 2015).

Several environmental practices can be used such as the analysis of a product life cycle and eco-design, which has been a growing global trend in the fields of engineering, architecture and design. It has the clue to develop new products, systems and services while reducing the use of non-renewable resources, and minimize their environmental impact (Casamayor and Su, 2013; Chou, 2014; Kuo et al., 2016).

Cleaner Production (CP) methods and Environmental Management (EM) practices are tools that strive for efficiency in the production process, the use of inputs and the generation of industrial waste. These tools can significantly contribute to Sustainable

\* Corresponding author.

E-mail addresses: [elianasevero2@hotmail.com](mailto:elianasevero2@hotmail.com) (E.A. Severo), [julioferro@guimaraes@yahoo.com.br](mailto:julioferro@guimaraes@yahoo.com.br) (J.C.F. Guimarães), [echdorion@gmail.com](mailto:echdorion@gmail.com) (E.C.H. Dorion).

Product Innovation (SPI), due to the rational use of natural resources and the minimization of the waste generated. Sustainable product innovation emerges as an opportunity to launch a new product on the market that meets the pressures brought about by the legislation and the global society.

In Brazil, the National Environmental Policy (PNMA), under the Law n° 10.165, of 27/12/2000, exposes that the industrial metal-mechanic sector is included in the metallurgical industry category, and is "A" rated for high potential polluting activities as natural resource users (Brazil-PNMA, 2000). Consequently, the metal-mechanic sector generates a series of solid waste, industrial effluents and air emissions.

Massote and Santi (2013) consider that the pressure of any society is not only due to progressive environmental awareness, through a consistent demand for environmentally friendly products, but it is also linked to the transformation of natural resources into products. Such change reduces the availability of natural resources and, consequently, has an impact on raw materials and water costs, as well as the launch of emitted effluents and waste. In this context, companies that adopt CP strategies will have simultaneous reductions in waste emissions and end-of-pipe pollution control expenditures, if and only if they develop new products with environmental requirements (Van Hoff and Lyon, 2013).

This research aims to measure the relationship between the sustainable product innovation antecedents considering the constructs of CP and Environmental Management. The study also examines the relationship between the Sustainable Product Innovation and Financial Performance (FP), as well as the moderating effect of Company Size in relations with the constructs. In that context, 762 companies of different sizes from the Brazilian metal-mechanic sector were analyzed.

## 2. Research hypotheses

### 2.1. Cleaner production and sustainable product innovation

From the perspective of environmental sustainability several surveys were conducted to identify the technical and organizational factors related to the development of sustainable product innovation (Elkington, 1999; Horbach, 2008; Lin et al., 2012; Marchi, 2012; Khalili and Duecker, 2013; Boons et al., 2013; Silvestre and Silva Neto, 2014).

Innovation can be in the form of changes in products and services and the way a product or a service is going to be produced or offered. Thus, innovation is defined as the development and the implementation of new ideas, which is a collective result (Van De Ven, 1986; Van De Ven et al., 1989; Garcia and Calantone, 2002). In this sense, the innovation of sustainable products can be understood as the introduction of a new or significantly improved product (good or service), with respect to its characteristics or the intended uses from products previously produced by a company (Balachandra and Friar, 1997; Tidd, 2001; Gallouj, 2007; Garcia and Calantone, 2002). It must consider the environmental requirements to reduce the use of natural resources, water, energy, materials, improvements in production processes and the environmental practices that minimize the impact on the environment and decreases the production of waste and pollutants (Placet et al., 2005; Potts, 2010).

It is noteworthy that the organisations can optimize the production process and the development of new products through the use of environmental practices, such as Cleaner Production methodologies (CP), which was created by the United Nations Industrial Development Organization and the United Nations Environment Programmes, so that companies can systematically reduce their waste and emissions (Kliopova and Staniskis, 2006; Hicks and

Dietmar, 2007; Shin et al., 2008; Lukena et al., 2016).

The concept of CP refers to actions that allow a company to qualify itself as an efficient user of raw materials and energy during a production process, aiming to increase productivity and consequently, to increase competitiveness and improve organizational performance (Severo et al., 2015). In this sense, CP technologies refer to the use and the development of new methods, techniques, materials and energy sources that minimize waste in production and throughout the product life cycle (Dunn and Bush, 2001; Tseng et al., 2009; Yonga et al., 2016).

Cleaner Production is an internal program of a company, that presents working teams that interfere with the production process, that establishes specific relationships with its suppliers and that seek environmentally sound use of natural and energy resources, considering the productive needs and minimizing the environmental impacts of business activity. However, it is a long-term strategy that can lead to a competitive advantage over competitors (Tseng et al., 2009; Guimarães et al., 2014; Bhupendraa and Sangleb, 2016; Lukena et al., 2016).

The CP method has been studied in different segments and sizes of companies, in order to embrace the efficiency in their production process, which can contribute to the development of sustainable innovation (Boons et al., 2013; Silvestre and Silva Neto, 2014). CP has to influence the process of developing new products through the practice of reducing the use of resources and emission of waste (Boons et al., 2013; Silvestre and Silva Neto, 2014; Kuo et al., 2016). Geng et al. (2010) demonstrated in their research that the increasing environmental problems in China make the regional governments of China to seek and to promote CP, including measures and coordination of the various stakeholders by providing financial support, and by providing appropriate policies and conducting training programs.

A research, realized by Van Hoff and Lyon (2013) on Mexican small and medium sized (SMEs), emphasizes that the use of CP methodologies in an emerging country can contribute to significant economic and environmental benefits within global supply chains. Furthermore Massote and Santi (2013) point out that the implementation of CP is seen as a powerful tool in the search for eco-efficiency.

In such context, the CP methods offers a viable alternative for organisations through its implementation in the production processes, which allows the minimization of waste, the generation of wastewater and atmospheric emissions, and providing efficient use of raw materials and energy, rationalization of water consumption, thus bringing economic and environmental benefits for businesses (Zeng et al., 2010; Guimarães et al., 2014; Ortolano et al., 2014; Van Hoof, 2014).

Severo (2013) confirms that the Metal-mechanic cluster companies from southern Brazil have already introduced several product innovations in the market through CP methods. From the 333 companies analyzed, 25.8% of them used the CP methods and the benefits occasioned by the CP may prevail for the sustainable development of new products. From this perspective the hypothesis H1 is:

**H1:** Cleaner Production (CP) is positively related to Sustainable Product Innovation (SPI).

### 2.2. Environmental management and sustainable product innovation

The quest for environmental sustainability is transforming the competitive landscape, demanding to business changes in the development of products, processes, technologies and business models, and making rational use of natural resources, treating and properly providing the waste generated to preserve the

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