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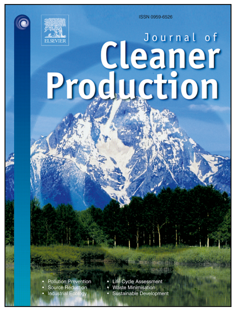


Cleaner production, project management and Strategic Drivers: An empirical study

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PII: S0959-6526(16)31507-4

DOI: 10.1016/j.jclepro.2016.09.166

Reference: JCLP 8126

To appear in: *Journal of Cleaner Production*

Received Date: 3 February 2016

Revised Date: 9 August 2016

Accepted Date: 20 September 2016

Please cite this article as: Guimarães JC, Severo EA, Vieira PS, Cleaner production, project management and Strategic Drivers: An empirical study, *Journal of Cleaner Production* (2016), doi: 10.1016/j.jclepro.2016.09.166.

# Cleaner Production, Project Management and Strategic Drivers: An Empirical Study

**Abstract**
Cleaner Production is an important means for systematically reducing waste. For its successful implementation, it is essential to ensure the effectiveness of the factors that can influence this process, such as the identification of decision criteria and an effective methodology for managing projects and implementing strategies to reach expected results. Based on the relevance of these themes, this research aims to measure relationships and correlations between constructs such as Strategic Drivers, Project Management Maturity and Cleaner Production Success, considering the moderating effect of business size. A survey of 238 manufacturing companies was used to test this hypothesis. For data analysis and interpretation, we used Structural Equation Modeling, which was implemented using a descriptive research method. Survey results show relationship strengths and correlations among the constructs, contributing to Cleaner Production research and allowing managers to make more assertive decisions. As a main result, this research points to the conclusion that there is a close relationship among Strategic Drivers, the Project Management Maturity construct, and Cleaner Production Success, as applied to the context of Brazilian industries.

**Keywords**: Cleaner production, Project management, Productivity and competitiveness, Brazil, Structural equation modeling.

## 1. Introduction

Cleaner Production (CP) has been an important mean of systematically motivating waste reduction and product reuse. CP is achieved by reducing production and use of material resources; reducing waste and pollutant emissions; and developing products that can easily go through recycling processes.

Historically because the early 1990s, one important issue that managers have needed to consider is the search for organizational performance improvements that focus on sustainability focus. The challenge consists in minimizing environmental impacts while maintaining market competitiveness. The use of environmental practices is an excellent way to achieve these goals. Among the alternatives are CP methodologies that integrate technological, economic and environmental strategies into processes or products to increase the efficiency of input and raw material usage by reducing waste, minimizing or recycling generated waste, and providing economic and environmental benefits for organizations (Porter and Van Der Linde, 1995; Guimarães et al., 2013).

Unlike conventional environmental technologies that focus on “pipe end” strategies, CP aims to integrate environmental objectives with industrial production processes to reduce waste and emissions. Considering specific environments, CP contributes to the reduction of waste and toxic gas emissions, the optimization of water and energy use, as well as improvements in the safety and health of employees. CP integrates technological, economic and environmental processes, products and services, aiming for the efficient use of raw materials to achieve economic and environmental benefits (Porter and Van Der Linde, 1995; Kjaerheim, 2005; Taylor, 2006; Glavic and Lukman, 2007). CP can act as a guide to developing and implementing sustainability plans at corporate or regional levels by highlighting good practices and responding to issues identified by governments and by many industrial sectors (Almeida et al., 2015).

For successful CP implementation, it is essential to identify and ensure the effectiveness of factors influencing this process. Studies by Tseng et al. (2009) and Guimarães et al. (2013) highlight decision criteria (Strategic Drivers) for improving the performance of CP programs. Nevertheless, CP business strategy needs control of its implementation, and companies are always looking for methods to optimize resource use. In this sense, project management methods are important aids for the implementation of corporate strategies.

Moreover, project management (PM) is becoming an increasingly important part of the entire organization management system as it is connected to strategic management and organizational tactics. Note also that various types of public and private organizational sectors seek to improve their project management processes for achieving excellence through maturity development management (Neverauskas and Railaite, 2013). In Sánchez (2015) perspective, PM should integrate sustainability in the selection and monitoring stages of projects.

However, in most Brazilian organizations, environmentally sustainable practices and PMM are still poorly exploited and difficult for managers to understand, mostly because they are concerned with legal requirements from environmental laws imposed by coercive and normative authorities (Severo and Guimarães, 2015). In this context, this study provides an academic perspective on the scenario faced by Brazilian companies, including such challenges as economic crisis, high price inflation, increasing interest rates, and a fragile political environment. Importantly, this study shows that companies can improve performance, even in a crisis environment, with the use of PM and CP methods.

For the theoretical basis of the hypotheses of this study, a survey was conducted in the database Scopus® (Elsevier BV) in June 2016, in the subject area Social Sciences & Humanities (Environmental Science), searching for "Brazil" the keyword indicated the existence of 1,618 articles, this 26 were published in the Journal of Cleaner Production. Some of these articles show that Brazil has found environmental solutions through the use of processes and materials cleaner, as well as sustainable energy sources (Milanez and Bührs, 2009; Agostinho and Ortega, 2013; Echegaray, 2014; Murakami et al., 2015; Souza et al., 2015; Vahl and Filho, 2015; Foelster et al., 2016), environmental management (De Oliveira et al., 2010; Jabbour, 2010; Campos, 2012; Jabbour et al., 2012; Jabbour et al., 2013; Delai and Takahashi, 2013; Lourenço and Branco, 2013; Da Rosa et al., 2015; Jabbour, 2015) and CP programs (Costa Jr. et al., 2013; Murakami et al., 2015).

The search in Scopus® showed that although there are many studies in Brazil on Environmental Science, there is still need for the development and publication of new research on CP programs in organizations, and the use of other management methods for implementation CP, as is the case of PM, for better economic and environmental performance of business activities.

Based on the relevance of these themes, this research aims to measure relationships and correlations among the following constructs: Strategic Drivers (SDR), Project Management Maturity (PMM) and Cleaner Production Success (CPS), considering the moderating effect of Business Size on relations between the constructs. This study analyzed 238 Brazilian companies in the manufacturing industry.

## 2. Research hypothesis

### *2.1 Strategic Drivers and cleaner production success*

Organizations seek to identify factors that can contribute to the successful implementation of process improvement programs and factors that have been the focus of relevant studies. Environmental management systems such as ISO 14001 and 14040 (De Oliveira et al., 2010; Campos, 2012; Jabbour, 2010; 2015; Foelster et al., 2016) and the Cleaner Production are ways to reduce the environmental impact of industrial activity and consumption in emerging markets (Agostinho and Ortega, 2013; Delai and Takahashi, 2013; Costa Jr. et al., 2013; Lourenço and Branco, 2013; Murakami et al., 2015; Vahl and Filho, 2015).

One of the most important continuous improvement programs is the Cleaner Production methodology, which integrates a technological, economic and environmental strategy to processes and products to increase efficiency in the use of inputs and raw materials through waste reduction, recycling, or elimination of waste generation. The methodology also provides economic and environmental benefits for organizations. In this sense, CP acts preemptively to promote a holistic view of resources and production and their influence on the economy and the environment (Kjaerheim, 2005; Nielsen, 2007; Shin et al., 2008; Bonilla et al., 2010; Guimarães et al., 2013; Jabbour et al., 2013; Souza et al., 2015). Another important issue is that environmental practices are directly related to the positive performance of the organization (Kassinis and Soteriou, 2003; Molina-Azorin et al., 2009; Jabbour et al., 2012; Severo et al., 2015).

To find elements that enhance CP results, Tseng et al. (2009) identified the most significant factors, based on worldwide criteria, that are able to increase the possibility of success when implementing CP: i) management and leadership; ii) strategic plan; iii) tools and technologies; iv) analysis and process improvement; v) customer focus. The factors identified in Tseng et al. (2009) and Guimarães et al. (2013) will be called Strategic Drivers (SDR), as these are the key elements for the support and development of cleaner production.

Environment is a strategic frontier in which organizations can act proactively and develop competitive advantages. However, changes in organizational culture may face internal and external barriers, especially the lack of public policies and availability of investment capital (Stone, 2006; Shi et al., 2008; Milanez and Bührs, 2009; Echegaray, 2014). Clearly there is no 'one-size-fits-all' approach to incorporating CP in sustainability strategies, and each individual strategy can contribute, in one way or another, to achieving the broader goal of sustainable development (Almeida et al., 2015).

To attain Cleaner Production Success (CPS), it is crucial to align management and leadership, primarily because environmental sustainability vision must come from top management, extending itself through all organizational levels and associating the program with other tools to soften the impact of problems in CP adoption (Hunt and Auster, 1990; Dobes, 1999; Amundsen, 2000; Tseng et al., 2009).

Tools and CP technologies should support processes with minimal use of resources, seeking to increase productivity, and should be used to promote the link between finished products and the recycling and reuse of waste, including an attempt to cooperate for environmental efficiency improvement (Dale and Lascelles, 1990; Getzner, 2002; Tseng et al., 2009; Da Rosa et al., 2015).

Analysis and process improvement is a key factor for reaching CPS (Guimarães et al., 2013). The success of CP is associated with organizational performance because CP is a continuous improvement concept for increasing profitability and competitiveness while protecting the environment, the consumer and the worker (Almeida et al., 2015; Severo et al., 2015; 2016).

Another key factor is that CP must necessarily be related to customer focus. Its actions are guided to improve impacts suffered by external stakeholders, which contributes to an organization’s reputation, supporting market position maintenance and long-term survival (Boks and Stevels, 2007; Severo et al., 2015).

As highlighted in the literature, Strategic Driver (SD) elements (management and leadership, strategic plan, tools and technologies, analysis and process improvement, and customer focus) have a direct cause-and-effect relationship with Cleaner Production Success (CPS). Note that studies by Dale and Lascelles (1990), Hunt and Auster (1990), Dobes (1999), Amundsen (2000), Getzner (2002), Boks and Stevels (2007), Tseng et al. (2009), Guimarães et al. (2013) and Severo et al. (2016) support the relationship between SD elements and CPS. However, these studies use only a few SD elements combined with some other factors. In this research, we chose to group SD elements to generate better analysis of their effects on CPS. Based on previous research and considering the relevance of Strategic Drivers in a company's performance, we developed the hypothesis H1.

**H1:** Strategic Drivers are positively related to Cleaner Production Success.

*2.2 Project management maturity and cleaner production success*

The Project Management Institute (PMI) establishes a set of good practices for efficient Project Management. The methodology is available in the Project Management Body of Knowledge (PMBOK, 2013). Nevertheless, Project Management (PM) is more than a set of tools; it is considered to be a results-oriented management method that can be applied to any project in any sector of the economy, used to implement strategies and achieve organizational goals (Gray and Larson, 2011; Neverauskas and Railaite, 2013). To assess the effectiveness and dissemination of the PM methodology, the PMI developed the Organizational Project Management Maturity Model (OPM3), an important tool for measuring the maturity of companies. Other researchers have also developed assessment methods with variations and differences from OPM3, which was proposed by Kerzner (2001) and is explored in this research as a basis for assessing the maturity level of surveyed organizations.

The OPM3 consists of five levels (Kerzner, 2001). In this study, we chose to use the second level of maturity, which allows a view of the PM lifecycle. Berssaneti et al.

(2012) note that, in the second level (Kerzner, 2001), the organization selects which of the common processes should be defined, operationalized and improved such that the success of a project can be repeated in another organization. The main features of this level are i) recognition of the benefits of project management, ii) organizational support for all levels, iii) recognition of the need for processes and methodologies, iv) recognition of the need for cost control, and v) development of a training curriculum in project management.

PM is becoming an increasingly important part of any organizational management system as it is linked to strategic and tactical organization (Neverauskas and Railaite, 2013). The study by Marcelino-Sádaba et al. (2015) shows that there is a lack of integration between sustainability and project management. Organizations are currently increasingly keen to include sustainability in their business. Project management can help make this process a success, but little guidance is available on how to apply sustainability to specific projects. For Tseng et al. (2009) and Guimarães et al. (2013), the success of CP is related to the implementation of efficient practices, people involvement and resource optimization.

Note that studies by Rydberg (1995), Clark et al. (2009), Schliephake et al. (2009), Zeng et al. (2010), Cabello Eras et al. (2013), Van Hoof and Lyon (2013) and Guimarães et al. (2014) found a relationship between PM and CP. Considering all different dimensions of PMM and its complexity levels, we can assume that PMM positively influences Cleaner Production success.  In this sense, we propose hypothesis H2.

**H2:** Project Management Maturity is positively related to Cleaner Production Success.

### *2.3. Project management maturity and Strategic Drivers*

Research by Killen et al. (2012) reviewed an extensive number of empirical and conceptual studies. Most of these studies associate PM with strategic theories of Resource-Based View, Dynamic Capabilities, and Absorptive Capacity. In addition, the use of these theories integrates this paper with research in other disciplines that draw upon these theories. Killen et al. (2012) show how strategic management theories provide well-studied and debated frameworks and methodologies that can be adopted or adapted for use in a PM context. The authors suggest that PM can interact with and enhance other areas of knowledge and strategic management.

Projects using OPM3 must consider factors related to sustainability at the time of portfolio composition. The main factors are the development management process for new products (Brook and Pagnanelli, 2014), the selection process for new suppliers (Lin et al., 2015) and the implementation of new processes, as well as the CP projects (Severo et al., 2015).

PM can be used for selecting portfolios and monitoring projects (Sánchez, 2015), considering the dimensions of sustainability (the Triple Bottom Line): economic, social and environmental (Elkington, 1997). Portfolio selection allows for the selection of the better mix of projects based on the simultaneous analysis of eco-impacts and contributions to organizational goals. Project monitoring aims to control project realization and determine adjustments that emerge from deviations from initial estimations (Sánchez, 2015). Increasing awareness of business and socio-ecological impacts related to society's use of materials is a driver of new management practices (Lindahl et al., 2014), which can occur by managing effective projects (Dorion et al., 2015), as is the case with Cleaner Production projects.

Economic and environmental benefits provided to companies through CP (Zeng et al., 2010; Jabbour et al., 2013; Van Hoof, 2013) can be considered results of reduced resource consumption and reduction of waste emissions, which enables sustainable development (Robèrt, 2000; Severo et al., 2015; Guimarães et al., 2015). However, for CP implementation, as well as other business strategies, it is essential to: i) identify and enhance factors leading to strategy success (Strategic Drivers), considering the CP case (Tseng et al., 2009) and ii) use a Project Management methodology for strategy implementation that considers using control gates and all-stage implementation monitoring (Gray and Larson, 2011; Dorion et al., 2015). Still, for a successful implementation of effective strategies, evaluation of PM maturity is recommended (Kerzner, 2001; Neverauskas and Railaite, 2013).

Several factors can influence the implementation of CP projects. Inadequacies can occur in changes of management processes, which include changes in leadership, strategic vision, process of processes improvement and customer orientation (Stone, 2006; Tseng et al., 2009; Zeng, 2010; Guimarães et al., 2013). However, resources should be allocated and managed to optimize their use. In this sense, Kerzner (2001), Gray and Larson (2011), Neverauskas and Railaite (2013) proposed the use of the project management methodology based on PMBOK (2013) for the implementation of complex programs that require resources that are valuable to the organization. In the literature, we note that there is no direct cause/effect relationship between CPS and PMM; however, there is evidence that these may be related because PMM is manager and project potentiator, while CP requires effective management, especially in the implementation phase. In this context of features and drivers for strategy selection, we developed hypothesis H3.

**H3:** Strategic Drivers are correlated with Project Management Maturity.

*2.4. Company Size*

Organizations have significant differences related to resource and structure availability that can influence organizational performance results. It is expected that larger companies will have a more complex administrative structure with well-defined divisions, which allows for accurate control of ongoing projects, while smaller businesses will have a much simpler structure, with more multifunctional workers, compromising project control through lack of expertise.

Studies by Trail and Meulenberg (2002), Avermaete et al. (2004), Triguero et. al. (2013), and Roder et al. (2000) show that the size of the company can interfere directly with the results of implementation of innovative projects (considering that larger companies have more resources), but these studies show that smaller companies can also have success in innovative projects. Based on the literature, this study assumes that firm size may moderate the cause-and-effect relationship between the constructs.

A variable with a moderating effect is one that affects the direction and/or strength of the relationship between two other variables (Baron and Kenny, 1986). Sharma et al. (1981) state that the use of multivariate analysis of "moderation" can be applied when the researcher is interested in identifying how the structural model is adjusted in different pre-established groups and what differences exist in regression coefficients, depending on moderator value. Sharma et al. (1981) and Byrne (2010) explain that the moderation occurs when one variable affects the strength of the relationship between two constructs, which can be measured by ANOVA or by the analysis of multi-groups models (structural equation modeling).

This research investigates the moderation effect in relations among the constructs, considering company size. Therefore, the sample was divided into two groups according to the criteria found in Brazilian legislation, which considers the company’s annual revenues in local currency (the Brazilian real). Group 1 consists of microenterprises with annual revenues up to R$360 thousand and small enterprises with annual revenues between R$360 thousand and R$3.6 million (Brazil, 2007), called Micro and Small Enterprises (MSEs). Group 2 includes medium-sized enterprises with annual revenues between R$3.6 million and R$300 million, and large enterprises with annual revenues of R$300 million and above (Brazil, 2011), called Medium and Large Enterprises (MLEs).

Considering differences between companies' sizes, we developed hypothesis H4: company size (MSEs and MLEs) has a moderating effect on Strategic Drivers, Project Management Maturity and Cleaner Production Success. Hypothesis **H4** is assessed by SEM and was divided into two parts. **H4a:** Company size has a moderating effect on the relationship between Strategic Drivers and Cleaner Production Success; **H4b:** Company size has a moderating effect on the relationship between Project Management Maturity and Cleaner Production Success. The theoretical framework as well as the hypothesis and its consequences are shown in Fig. 1.

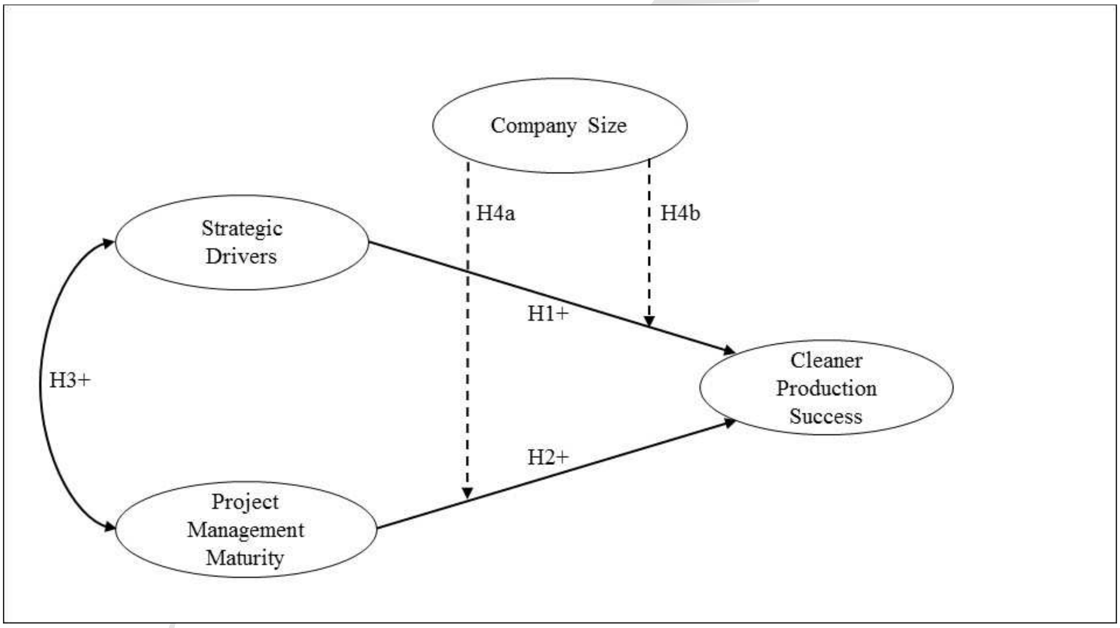


**Fig. 1.** Hypothesis model

## 3. Methodology

This research was conducted through a survey of 238 Brazilian processing companies, including micro and small organizations (with annual revenues up to R$3.6 million) as well as medium and large enterprises (with annual revenues above R$3.6 million). For data analysis and interpretation, we used structural equation modeling (SEM), conducted through a descriptive research method. Data collection took place by telephone using a questionnaire (see Table 1), which was developed based on the literature: Issues related to the Strategic Drivers construct were based on research found in Tseng et al. (2009) and Guimarães et al. (2013). For the Project Management Maturity construct (PMM), we adapted the premises of Kerzner (2001). The Cleaner Production Success construct was based on research by Severo et al. (2015). The questionnaire was administered with managers in September through November, 2014. The answers contained a degree of agreement or disagreement using a 5-point Likert scale, which offered the following choices: 1 = strongly disagree; 2 = disagree; 3 = neither disagree or agree; 4 = agree; and 5 = strongly agree.

The company selection criteria included convenience and access to the company rather than random selection. This convenience criterion for selection was used in place of random selection because we needed the participation acceptance of companies. Not all the invited companies agreed to answer the survey. The convenience criterion does not allow for obtaining a probabilistic sample, even if the number of respondents meets all criteria of significance. As a result, it is not possible to generalize the results to the total population of companies in the industrial sector.

In addition, the selection was conducted by searching industrial entries in the states of Rio Grande do Sul and Rio de Janeiro (Fiergs, 2014; Firjan, 2014) and identifying organizational websites that presented environmental management practices related to CP. Subsequent phone contact confirmed that the companies used the CP methodology and PM. Initially, we created a long list containing 647 companies (companies to which we send the questionnaire by e-mail). In the end, 252 companies answered the questionnaires regarding the use of PM and CP. To validate questionnaire understanding, a pretest was conducted, considering a sample of 36 companies among the 252. Each of the 36 companies was then included in the final sample (252) because none of them showed any difficulties in answering the questions.

**Table 1**

Factorial loads of observed variables – Varimax Rotation

| Observable variables[a] | Load[b] | Constructs |
|---|---|---|
| **SDR1)** Management and leadership: The company has an internal organization that is supported by a formal governance structure and leadership, and that defines the hierarchical relations and decision-making power. Such management and leadership are fundamental to the success of CP projects. | 0.904 | Strategic Drivers (SDR) |
| **SDR 2)** Strategic Plan: The company has a strategic long-term plan monitored by indicators, which significantly contributes to the success of CP projects. | 0.708 | |
| **SDR 3)** Customer focus: The company has, as an organizational guideline, a customer focus to determine internal actions in the production processes and | 0.784 | |

| | | |
|---|---|---|
| products that cater to customer demand with regard to environmental expectations, contributing to the success of CP projects. | | |
| **SDR 4)** Tools and Technologies: The company often uses modern production technologies and materials that cause less impact to the environment, provides resources for production operators to reduce consumption of resources (water, raw materials and energy). This last decision is considered an operational decision that is in line with the environmental strategies of the company. | 0.756 | |
| **SDR 5)** Process analysis and continuous improvement: The company has a method for the periodic assessment of earnings obtained with CP implementation as well as specific analysis of each project, using indicators to monitor resource consumption per product, emission of pollutants in the month, waste production (waste and scrap) per unit of output, financial gains from implementation of new CP projects and waste disposal by type. | 0.861 | |
| **Construct**[b]: Mean 3.5; Standard Deviation 1.222; Cronbach Alfa 0.910; KMO 0.774 | | |
| **PMM1)** Embryonic: My company and managers at all levels of the organization recognize the need for project management, given the potential benefits to be achieved through the implementation of this methodology. Our managers have recognized or identified applications of project management in various divisions of our enterprise, as well as recognized what needs to be done to reach maturity in PM. | 0.815 | Project Management Maturity (PMM) |
| **PMM2)** Acceptance - Top management: Our managers have good knowledge of the PM principles, support the project management through lectures, courses, articles and even the occasional presence at meetings and presentations by the project team. Managers understand the concept of responsibility, act as sponsors on certain projects and have shown willingness to change the traditional way of doing business to reach maturity in PM. | 0.850 | |
| **PMM3)** Acceptance - Management: Our middle level and operational managers have been trained and instructed in PM. They are committed to PM and in compliance with deadlines for goal completion; they also support the PM process and are willing to release their staff for PM training. | 0.742 | |
| **PMM4)** Growth: My company or department has an easily identifiable PM methodology that uses the concept of stages or the life cycle of a project. It also uses a PM supporting software. The company or department remains committed to early planning to reach specified quality levels and does its best to minimize scope deviations during the projects. | 0.807 | |
| **PMM5)** Maturity: My company has a system to manage both cost and project schedule regarding variation control when comparing planned objectives and follow-up reports. The company has developed a project management curriculum to improve the skills of our employees in PM and considers PM to be a professional function. | 0.801 | |
| **Construct**[b]: Mean 3.3; Standard Deviation 1.322; Cronbach Alfa 0.901; KMO 0.875 | | |
| **CPS1)** Cleaner Production Success (organizational performance): The company agrees that Cleaner Production projects are responsible for production capacity increases. | 0.857 | Cleaner Production Success (CPS) |
| **CPS 2)** Cleaner Production Success (organizational performance): The company agrees that Cleaner Production projects are responsible for production flexibility increases. | 0.868 | |
| **CPS 3)** Cleaner Production Success (organizational performance): The company agrees that Cleaner Production projects are responsible for production cost reduction. | 0.809 | |
| **CPS 4)** Cleaner Production Success (organizational performance): The company agrees that Cleaner Production projects have a major role in improving workers' safety and health. | 0.627 | |
| **Construct**[b]: Mean 3.8; Standard Deviation 1.035; Cronbach Alfa 0.839; KMO 0.791 | | |

[a] We used a 5-point Likert scale: 1 = strongly disagree; 2 = disagree; 3 = neither disagree or agree; 4 = agree; 5 = strongly agree.
[b] SPSS report.

The SEM methodology was used for both analysis and data interpretation, supported by PM and CP literature research. According to Kline (2005) and Fabrigar et al. (2010), SEM uses several combined techniques and a set of methodological procedures for statistical analysis, enabling simultaneous testing of dependency relationships and intensity measurement of those relationships. The data collection used a spreadsheet, which prevented non-response. Regarding the statistical data treatment process, we used the software SPSS version 21 for Windows®, and the SEM methodology was systematized using the software AMOS® Version 21, coupled to SPSS, as well as data recording using a spreadsheet developed in Excel® software for Windows®.

**4. Results**

The information collected from the 252 surveyed enterprises passed through a cleaning process in which 14 questionnaires were considered outliers. These questionnaires were eliminated from the research, mostly because they presented several equal answers. Following the recommendations found in Kline (2005) and Hair et al. (2007) for univariate outlier analysis, we used the z score calculations, which resulted in values smaller than 3,3 for each variable. Such findings are considered to be evidence that there are no univariate outliers. The final sample consists of 238 companies, with 175 (73.5%) Micro and Small Enterprises, and 63 (26.5%) Medium and Large Enterprises.

After data cleaning, we used Exploratory Factorial Analysis (EFA), using the Varimax rotation, to group the data on factors (constructs). The set of data from this study resulted in three constructs (Table 2) with 72.45% of the variability explanation, which shows solid construct consistency. Factorial loads from observable variables were higher than 0.5 as recommended by Hair et al. (2007). Table 2 shows results for the integrated model in which the Average Variance Extracted (AVE) of constructs showed values greater than 0.7 (which is higher than the recommended value) and Discriminant Validity (DV) presented values lower than AVE, allowing data acceptance from validity composite analysis.

Dataset confidence was assessed via each construct's Cronbach Alfa (Table 1), which is worth 0.911. Hair et al. (2007) recommended values above 0.7. The average responses (SDR = 3.5; PMM = 3.3; CPS = 3.8) demonstrate the concordance of questioned statements, which supports the existence of surveyed factors in organizations. In Bartlett's test of sphericity, the Kaiser-Meyer-Olkin Measure of Sampling Adequacy (KMO) showed values greater than 0.5 (SDR = 0.774; PMM = 0.875; CPS = 0.791), which shows EFA feasibility (Kline, 2005; Hair et al., 2007). To identify dataset normality, we carried out kurtosis index assessment using Mardia's coefficient technique. The value obtained was lower than 5, which follows the recommendations of Mardia (1971) and Bentler (1990). To further evaluate normality, we analyzed Pearson's coefficients of asymmetry, resulting in values near zero, which indicates moderate asymmetry according to Kline (2005) and Hair et al. (2007).

**Table 2**
Convergent validity and discriminant validity – Integrated model

| Constructs | Strategic Drivers (SDR) | Project Management Maturity (PMM) | Cleaner Production Success (CPS) |
|---|---|---|---|
| Strategic Drivers (SDR) | 0.770[a] | | |
| Project Management Maturity (PMM) | 0.559[b] | 0.707[a] | |
| Cleaner Production Success (SPL) | 0.392[b] | 0.425[b] | 0.770[a] |

[a] Average Variance Extracted (AVE) – Convergent Validity (CV).
[b] Construct Correlation – Discriminant Validity (DV).

Pearson's correlation analysis showed correlations above 0.8 (CPL1 <--> CPL4 0.817; CPl1 <--> CPl5 0.810), indicating the existence of multicollinearity between variables, which means that these variables statistically share the contribution to the construct and one of them can be eliminated. Nevertheless, we considered it essential to keep these variables in the survey for further analysis and understanding of the elements that make up each construct. Some variables had correlation values less than 0.5 (SPL4 <--> SPL1 0.480; SPL4 <--> SPL2 0.417; SPL4 <--> SPL3 0.458), which shows low correlation between the variables, but we decided to keep them in the analysis, considering that the criterion of factor loadings (Table 1) are above recommended values (0.5).

EFA tests, confidence and correlation allow scale and construct validation comprising the theoretical model (Fig. 1). Integrated model analysis (which measures constructs' correlations) considered the model's fitting indexes and the statistical significance of estimated coefficients. Covariance and correlation hypothesis tests (Table 3) show results that indicate significant correlations for the estimate coefficient (EC), standardized coefficient (SC), standard deviation (SD) and critical ratio (CR) indexes and do not consider the moderating effect of company size.

The AMOS software, which assesses the integrated model (Fig. 2), showed that, together, all observable variables resulted in an Average Extracted Variance (AEV) of 0.796, which is higher than the recommended value (> 0.7). The KMO value of 0.869 is higher than the recommended value (0.5); the Bartlett sphericity test showed the value 2325.614 (p <0.001); composite reliability (CR) showed a value of 0.987, which is above the recommended 0.5. Taking in consideration the premises of Hair et al. (2007) and Marôco (2010), the results of AEV and CR confirm that the observed variables are consistent. In addition, Chi-square (414.3) divided by degrees of freedom (222) is 1.9, which is less than 5.0 and thus consistent with Tanaka (1993).

Integrated model (Fig. 2) results show model adequacy because these results are within or very close to bounds recommended by Hair et al. (2007) and Kline (2005). Among those indexes is the Comparative Fit Index – CFI (0.911), Normed Fit Index – NFI (0.956), Goodness of Fit Index – GFI (0.898) and Adjusted Goodness of Fit – AGFI (0.856), with all of these values being higher than or close to the recommended 0.9. In addition, the Root Mean Squared Error of Approximation – RMSEA (0.043) is within the suggested limits of 0.05 to 0.08.

The moderating effect of company size with regard to SDR, PMM and CPS (Hypothesis H4a and H4b) was tested using the SEM multi-group technique and ANOVA, which created two groups based on annual declared revenues: i) Micro and Small Enterprises (MSEs); and ii) Medium and Large Enterprises (MLEs).

**Table 3**
Hypothesis test (Covariance and Correlation) – Integrated model.

| **Constructs** | | | ***Estimate Coefficient* (EC)** | ***Standardized Coefficient* (SC)** | ***Standard Deviation* (SD)** | ***Critical Ratio* (CR)** | **P - value** |
|---|---|---|---|---|---|---|---|
| Cleaner Production Success (CPS) | <--- | Strategic Drivers (SDR) | 0.235 | 0.118 | 0.039 | 2.997 | *** |
| Cleaner Production Success (CPS) | <--- | Project Management Maturity (PMM) | 0.293 | 0.181 | 0.054 | 3.372 | *** |
| Strategic Drivers (SDR)[a] | <--> | Project Management Maturity (PMM) | 0.563 | 0.562 | 0.008 | 7.009 | *** |

[a] Correlation constructs indexes.
***Significance level p < 0,001.

Table 4 shows the results of testing for hypothesis H4 hypothesis, which was split into H4a and H4b. The results show that company size directly interferes with the estimate coefficient (EC) and standardized coefficient (SC) with construct relations (CPS<---SDR; CPS<---PMM; SDR<-->PMM). In addition, an ANOVA calculation identified a significantly different behavior between respondent groups ($X^2$ difference) and the relationship between CPS <--- SDR and between, CPS <--- PMM has a significance level of $p < 0.001$, and correlation CPL <--> MPG shows a significance of $p > 0.05$. These results confirm the hypothesis H4.

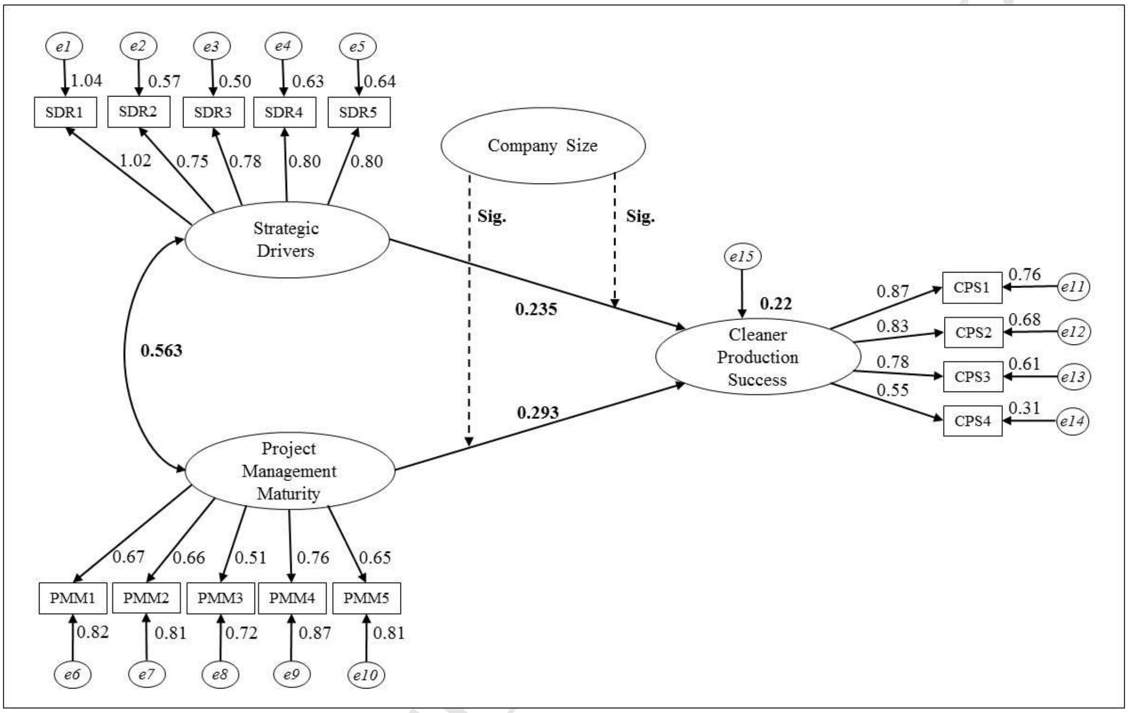


**Fig. 2.** Integrated model – Standardized Regression Weights.

**Table 4**
Hypothesis test – Company size comparison.

| Constructs | | | Integrated model | | Micro and Small Enterprises (MSEs) | | Medium and Large Enterprises (MLEs) | | *Difference $X^2$ |
|---|---|---|---|---|---|---|---|---|---|
| | | | EC | SC | EC | SC | EC | SC | Sig. |
| Cleaner Production Success (CPS) | <--- | Strategic Drivers (SDR) | 0.235 | 0.118 | 0.207 | 0.104 | 0.300 | 0.168 | 0.000 [a] |
| Cleaner Production Success (CPS) | <--- | Project Management Maturity (PMM) | 0.293 | 0.181 | 0.257 | 0.168 | 0.408 | 0.257 | 0.000 [a] |
| Strategic Drivers (SDR) | <--> | Project Management Maturity (PMM) | 0.563 | 0.562 | 0.520 | 0.519 | 0.422 | 0.236 | 0.011 [b] |

*ANOVA results between groups (MSEs and MLEs).
[a] Significance level $p<0.001$.

[b] significance level $p<0.05$.

In addition to the above analyses, we analyzed the moderating effect of business size on the correlation between the constructs of CPL and MGP. Although this assessment is not part of the hypothesis for this research, results show that the correlation between CPL <--> MPG interfered in the rates of EC and SC, showing a significant difference between the results of the two groups based on company size (MSEs and MLEs). The ANOVA calculation identified significantly different behavior between the groups ($X^2$ difference) in the correlation of SDR <--> PMM, with a significance level of $p>0.05$, which is within acceptable parameters statistically.

Note that the survey found the moderating effect of company size between the constructs; thus, smaller companies have poorer structures, which affects the results of CP implementation. Nevertheless, this research shows that such a fact can be avoided using the PM method. Other results of this research show that there is a strong and significant relationship between SDR --> CPS and PMM --> CPS, and a correlation between SDR <--> PMM, which reinforces some precepts found in the literature.

## 5. Discussion

Hypothesis test (EC and SC) based on the model theoretical (Fig. 1) expressed in Table 3 show that the results are statistically significant, so the hypotheses H1, H2, H3 and H4 (H4a, H4b) were confirmed, regarding positive relationships among the constructs.

The hypothesis H1 (Strategic Drivers are positively related to Cleaner Production Success), resulted in the EC=0.235 and SC=0.118, showing that this relationship is relevant, which are supported by research Amundsen (2000), Getzner (2002), Boks and Stevels (2007), Tseng et al. (2009) and Guimarães et al. (2013) which identified that the SDR elements (leadership and management, strategic plan, tools and technologies, analysis and process improvement, and customer focus) can cause a positive effect on innovations such as the CPS.

The results of EC=0293 and SC=0.181 of hypothesis H2 (Project Management Maturity is positively related to Cleaner Production Success) are statistically significant and increase the findings of studies of Tseng et al. (2009) and Guimarães et al. (2013) on the need to implement efficient practices in the management of CP projects, with people Involvement and resource optimization. Also studies by Rydberg (1995), Clark et al. (2009), Schliephake et al. (2009), Zeng et al. (2010), Cabello Eras et al. (2013) and Van Hoof and Lyon (2013) explain the results of this research, since the proper management of resources, through the PMM can directly influence the results of projects such as the implementation of CP.

Studies Tseng et al. (2009) identified the factors leading to success strategy (Strategic drivers), as well as Gray and Larson (2011) and Dorion et al. (2015) highlighted the need for Project Management methodology to use for strategy implementation, which reinforces the results (EC=0.563 and SC=0.562) the hypothesis H3 (Strategic Drivers are correlated with Project Management Maturity).

The hypotheses H4a (Company size has a moderating effect on the relationship between SDR and CPS) and H4b (Company size has a moderating effect on the relationship between PMM and CPS), were confirmed based on the results of the ANOVA and different values of EC and SC (Table 4), comparing the MSEs and MLEs. These results contribute to the studies of Trail and Meulenberg (2002), Avermaete et al. (2004), Triguero et. al. (2013), and Roder et al. (2000) show que the size of the company can interfere directly with the results of implementation of innovative projects, as this research has proved that the implementation of CP has different relationships in MSEs and MLEs.

Note that the relationship between CPS<---SDR is higher in MLEs (EC=0.300 and SC=0.168)) compared to MSEs (EC=0.207 and SC=0.104) as well as the results of the measurement of relation CPS<---SDR which is higher in MLEs (EC=0.408 and SC=0.257) compared to MSEs (EC=0.257 and SC=0.168), which reinforces the concept that larger companies have more resources and are managed better because They have a specialized structure in departments.

The results of the correlation between SDR<->PMM, which shows that the MSEs is greater (EC=0.520 and SC=0.519) compared with MLEs (EC=0.422 and SC=0.236) show that the use of methods project management can significantly improve the results of the use of strategic resources, even in small companies that have a more simplified formal structure. This is to improve the efficiency and productivity of the company, the rational use of strategic resources.

In addition, the study of the moderating effect of company size between the constructs (SDR, PMM, CPS), applied in this provides advances research in statistical validation metrics, which can be used in further research and provide managers with important tools needed for CP projects.

## 6. Conclusion

The paper measured relationships between SDR, CPS and PMM, considering the moderating effect of company size. Studied companies showed a significant relationship between SDR and CPS, supporting hypothesis H1, as well as a relationship between PMM and CPS, which supports hypothesis H2.

Assumptions made by Tseng et al. (2009) and Guimarães et al. (2013) with regard to the Strategic Drivers that can determine the success of Cleaner Production were investigated in this study and showed them selves to be relevant. Although the studies by Tseng et al. (2009) and Guimarães et al. (2013) have different goals and analysis techniques that differ from this research, we note that the results of this paper reinforce the need for companies to establish strategic factors for the optimum success of the CP. In addition, using the project management methodology proposed by Kerzner (2001), Gray and Larson (2011) and Neverauskas and Railaite (2013) contributed significantly to helping surveyed companies to achieve greater effectiveness in CP program implementation.

The main contribution of this research is the confirmation of hypothesis H3, which leads to the conclusion that there is a close relationship between the SDR and PMM constructs. This finding raises a new research area for CP because identifying which project management systems interact positively with the CP decision factors can contribute to the assertiveness of CP management actions.

Hypothesis H4 (H4a, H4b) was considered confirmed through measurement of the moderating effect of company size. In this research, we found that the largest companies (MLEs), with complex and specialized structures, leverage results of CP implementation using SDR and PMM. Table 5 summarizes the research hypotheses confirmed in this study.

**Table 5**
Research Hypotheses

| Hypothesis | Description | Confirmation |
|---|---|---|
| **H1** | Strategic Drivers are positively related to Cleaner Production Success | Confirmed |
| **H2** | Project Management Maturity is positively related to Cleaner Production Success | Confirmed |
| **H3** | Strategic Drivers are correlated with Project Management Maturity | Confirmed |
| **H4a** | H4a Company size has a moderating effect on the relationship between Strategic Drivers and Cleaner Production Success | Confirmed |
| **H4b** | H4b Company size has a moderating effect on the relationship between Project Management Maturity and Cleaner Production Success | Confirmed |

This study has limitations related to the ability to generalize the results, even with the methodological strictness that SEM advocates. The results contribute to scientific research, however, statistically significant research would require a larger sample, so we suggest that more quantitative studies be conducted concerning other segments of the economy and comparisons with other countries.

Regarding academic implications, this study presents a framework for the analysis of SDR, CPS and PMM, constructs that could be used by other researchers and applied to different sectors and countries; thus, comparisons could be made with the Brazilian case, supporting discussions in the literature as companies demand means to analyze these constructs. In this context, the academic community and professionals from related fields will have metrics that are not related only to financial indicators, as many companies in Brazil, especially small and medium-sized companies, do not allow disclosure of financial and property information.

We also highlight that this study refers to the moderating effect of company size on the correlation between SDR and PMM, which showed significant differences, and that MSEs had lower rates than MLEs, which may be explained by the administrative expertise of MLEs. Still, MSEs show a significant correlation, which reinforces the academic importance of this study.

## Acknowledgment

This research had financial support of Fundação Meridional (IMED), Passo Fundo-RS, Brazil.

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**Highlights**

Survey on cleaner production in Brazilian manufacturing industry.

Strategic Drivers and cleaner production success.

Project management maturity and cleaner production success.

Project management maturity and Strategic Drivers.

The structural equation modeling process applied the cleaner production practices.