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GREEN DYNAMIC CAPABILITIES AND THE GREEN INNOVATION PERFORMANCE IN THE BRAZILIAN CEMENT INDUSTRY

Capacidades verdes dinámicas y el desempeño de la innovación verde en la industria cementera brasileña

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ABSTRACT

The purpose of this paper is to analyze the connection between green dynamic capabilities and its influence on the green innovation performance (GIP) in the Brazilian cement industries. To this study, it was used 303 survey questionaries sent to the Brazilian cement industries' managers, it was obtained 90 valid answers back. The research includes the green dynamic capability constructors and dimensions, and green innovation performance. The results unveiled that, among the relations studied, the companies prominently direct their efforts towards two green dynamic capability dimensions which are linked with the green innovation performance, they are: integration of internal and external resources. Regarding the resource construction and reconstruction, although it has been noticed effort, these have been in a lesser extent. The research revealed possibilities to improve this sector's studies in the country, and to the management practice targeting sustainability requirements.
Keywords: Green dynamic capability, Green product innovation performance, Green process innovation, Cement industry.

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CAPACIDADES VERDES DINÁMICAS Y EL DESEMPEÑO DE LA INNOVACIÓN VERDE EN LA INDUSTRIA CEMENTERA BRASILEÑA

Green dynamic capabilities and the green innovation performance in the brazilian cement industry

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RESUMEN

El objetivo de este trabajo es analizar la conexión entre las capacidades dinámicas verdes y su influencia en el desempeño de la innovación verde (GIP) en las industrias cementeras brasileñas. Para este estudio, se utilizaron 303 cuestionarios de encuesta enviados a los gerentes de las industrias cementeras brasileñas, se obtuvieron 90 respuestas válidas. La investigación incluye los constructores de capacidades dinámicas verdes y las dimensiones, y el rendimiento de la innovación verde. Los resultados revelaron que, entre las relaciones estudiadas, las empresas dirigen sus esfuerzos de manera destacada hacia dos dimensiones de capacidad dinámica verde que están vinculadas con el desempeño de la innovación verde, que son: integración de recursos internos y externos. En cuanto a la construcción y reconstrucción de recursos, si bien se ha notado esfuerzo, estos han sido en menor medida. La investigación reveló posibilidades para mejorar los estudios de este sector en el país, y para la práctica de gestión orientada a los requisitos de sostenibilidad.
Palabras clave: Capacidad dinámica verde, Rendimiento de la innovación de productos ecológicos, Innovación de procesos verdes, Industria del cemento.

INTRODUCTION

The increasing society demand for sustainability inserts in the organization agendas higher demand for them to change their operation, products and/or services into environmentally acceptable. Pressures can even come from suppliers and/or customers (Sarmiento and Vargas-Berrones, 2018). To answer these new, more and more urgent, demands, the organizations must mobilize their capabilities to integrate internal and external resources and reconfigure the existent resources, reorienting, restructuring, and redefining organizational management and strategies, especially in changing environments, which, for Teece *et al*. (2016), consist in places of uncertainty and full of unknows.

The dynamic capabilities (DC) are recognized as key-factors to a company adaptation to its changing environment (Castiaux, 2012), and in the context of sustainable development, they are relevant as they are the center to all company's initiative to reach sustainability (Rashid *et al*., 2014). The search for the adaptation to the sustainability criteria passes through the insertion of green innovation as an effort that positively influence the competitivity and sustainable development. Therefore, the DC view works as a theoretical reference to the organization dynamic comprehension seeking green innovative activities that meet the new and urgent demands from society. From this context, it emerges the green dynamic capabilities (GDC) perspective, which is the DC focused on the environment requirements and serves as theoretical reference to the organizational dynamic comprehension searching for green innovative activities, which is a dynamic adapted to a scenario more and more competitive, focusing on sustainable matters.

Seeking to meet the sustainable development requirements, it is inserted the cement industry, responsible for 3% of the greenhouse gases global emissions, and for 5% of the world CO2 emission (World Business Council for Sustainable Development, 2002). Furthermore, Klee and Coles (2004) understand that the cement industry faces increasingly strong legal pressure and from interested parties, especially when it refers to its business social responsibility requirements.

Previous studies have already related the dynamic capabilities focused on environmental requirements to the green innovation, such as: Chen (2008); Chen *et al*. (2006) and Dangelico *et al*. (2017). Although there are efforts to elucidate changing environments, especially in the strategy area, it is necessary to identify the dimensions that influence the green innovation results for companies to continue competitive in the market and to collaborate with the environmental context, however, the studies have not been conclusive yet. It is intended to fill the gaps regarding the role the GDC have on the green innovation performance (GIP), guiding the companies to cope with the changes on the environmental requirements, as well as for them to contribute to minimize the impact their operations have in the environment.

Based on what has been seen, this research aims to evaluate the extent that the GDC contribute to the GIP, collaborating so the company continue to be competitive in the market. The results provide insights regarding the relation between GDC and GIP, and carry theoretical and practical contributions to the studies in the field and to management strategies in the cement industry companies. Therefore, the general objective of the present paper is to analyze the relation between GDC and GIP applied to the Brazilian cement industry.

1 THEORETICAL FOUNDATION

The DC concept was proposed, at first, by Hamel and Prahalad (1989). In 1994, based on the Resource Based View (RBV), Teece and Pisano (1994) broaden the understanding of the link between capabilities and competitive advantage. To the authors, the RBV, although an important resource theory, it has not been capable of clarify how companies successful in the global market demonstrate "timely response, fast and flexible product innovation, in addition to management capability to coordinate and redeploy efficiently internal and external competencies" (Teece and Pisano, 1994, p. 537).

The term DCs, therefore, refers to the ability the company have to integrate, build, and reconfigure internal and external competencies toward business environment changes (Teece *et al*., 1997, 2016). Eisenhardt and Martin (2000) corroborates stating that the DCs are a company's abilities to use resources in the process of integration, reconfiguration, gaining and releasing resources. DCs enable companies to conjecture, shape, and adapt themselves to the transformations on competitive and complex environments (Felin and Powell, 2016).

Looking at the environment where the highly polluting companies operate, such as the chemical industry, or the cement industry – the present study object -, may be featured, today, as uncertain and troubled, since society and the game rules impose new demands regarding sustainable requirements, the companies need to adequate themselves to assure their survival. In such contexts, in which the usual competencies and routines no longer meet the imposed requirements, the DCs are necessary, which may need to adapt with time.

The continuous growing literature demonstrates the interest for better understanding of the company's adaptation abilities in fast-moving environments, and that adjust themselves to the sustainable development requirements. From this view and aiming to understand the DCs under the new needs perspective, the scene starts to aim the environmental changes concerning the sustainability requirements, and as the DCs operate in these environments, these capabilities are named 'Green Dynamic Capabilities'.

DCs oriented by the sustainability requirements, in this paper understood as GDC, are featured by the capacity a company has to 'integrate, built, and reconfigure internal and external competencies and resources in order to incorporate environmental sustainability to the development of new processes and products related to environmental protection, aiming to respond to market changes' (Dangelico *et al*., 2017; Yousaf *et al*., 2022). It may also be understood as capacities a company has to explore their resources and existing knowledge, to renovate and develop their green organizational capabilities, reacting to a more and more dynamic market (Amaranti *et al*., 2019; Chen and Chang, 2013; Teece *et al*., 1997), and they are positively connected to green creativity, and green process and product performance (Chen and Chang, 2013).

Thus, in this paper, the GDC are a company's capacities to integrate, built, and reconfigure internal and external, its capabilities and competencies (Dangelico *et al*., 2017; Teece, 2007; Teece *et al*., 1997; Zahra *et al*., 2006), to incorporate environmental sustainability in the development of new products (Dangelico *et al*., 2017) and/or processes, to answer to the changes in the market (Lin and Chen, 2017) and assure sustainability. This paper position is based on Dangelico *et al*. (2017)'s three types of DCs, sustainably oriented. The three types have been adapted to this research reality, and they are: external resources integration (Sensing), internal resources integration (Seizing), resource construction and reconfiguration (Transforming).

To Chen *et al*. (2015), the environmental sustainability is featured as one of the main green innovation boosters, and the existing literature is deficient of a sturdy, and empirically testable structure, indicating specific insights on the connections between GDC and GIP, subdivided in Green Process Innovation Performance (GPROCIP) and Green Product Innovation Performance (GPRODIP). On the other hand, the GIP is related to the products innovation or improved new processes (Organisation for Economic Cooperation and Development - OECD, 2018), including technology innovations involving in saving energy, prevent pollution, waste recycling, green product projects, and corporate environmental management (Chen *et al*., 2006). It is related to performance, taking into consideration the company's position and the green image it generates (Pinsky *et al*., 2015).

Based on the discussion above, it is raised the general hypothesis that the higher a company's GDC, higher it is the company's GIP, and it is suggested the following hypotheses:

a) The Sensing positive effect on the GPRODIP: the Sensing is the GDC, called knowledge and sustainable competencies exchange and integration among the external and internal actors of a company. It includes knowledge integration on the products environmental impact during the client's use, the suppliers' knowledge and competencies integration in the components' environmental impact, materials or production processes, and the collaboration to channel members to reduce the products' environmental impacts (Dangelico *et al*., 2017). The Sensing is, therefore, related to the capability a company has to convert and use new knowledge to the organization learning regarding sustainability requirements.

Green innovation, however, is usually classified as green product innovations and green process innovations, representing the activity related to product development and innovative processes that may reduce environmental impacts (Chen, 2008; Chen *et al*., 2006). Therefore, GPRODIP is related to environmental innovation, including innovating products already involved, energy saving, pollution prevention, waste recycling, without toxicity, or green product projects (Chen *et al*., 2006). To the discussion above, it is stated that the Sensing would positively affect the GPRODIP, and would imply the following hypothesis: Hypothesis 1 (H1) the Sensing is positively associated to the GPRODIP.

b) The Sensing positive effect on the GPROCIP: the Sensing is related, as previously mentioned, to the capability of a company to convert and use new knowledge to the organization learning regarding sustainability requirements. The GPROCIP is related to environmental innovation, including innovating products already involved, energy saving, pollution prevention, waste recycling, without toxicity, or green product projects (Chen *et al*., 2006). To the discussion above, it is stated that the Sensing would positively affect the GPROCIP, and would imply the following hypothesis: Hypothesis 2 (H2) the Sensing is positively associated to the GPROCIP.

c) The Seizing positive effect on the GPRODIP: the Seizing is the GDC referred as the exchange and integration of environmental knowledge and company's competencies. It includes the multifunctional collaboration between environmental unities and other specialized ones (as manufacturing, marketing, and design) and the knowledge and sustainability competencies integration in roles and/ or departments inside the company (Dangelico *et al*., 2017). This integration between environmental units and specialized ones becomes important to the GPRODIP to happen in the company. To the discussion above, it is stated that the Seizing would positively affect the GPRODIP, and would imply the following hypothesis: Hypothesis 3 (H3) the Seizing is positively associated to the GPRODIP.

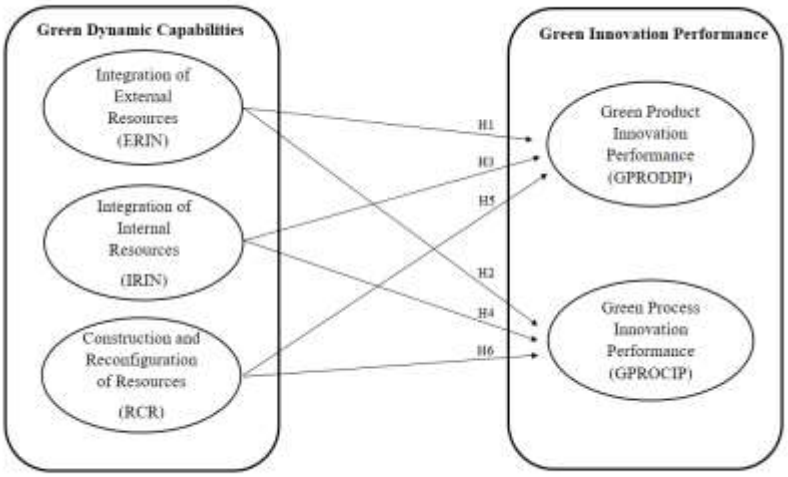
d) The Seizing positive effect on the GPROCIP: the multifunctional collaboration between the company's internal and environmental unities and the knowledge and competencies integration may collaborate with reducing the environmental impact from the manufacturing process, as the use of input and raw material, and the emission of gases harmful to the environment and to life on our planet. To the discussion above, it is stated that the Seizing would positively affect the GPROCIP, and would imply the following hypothesis: Hypothesis 4 (H4) the Seizing is positively associated to the GPROCIP.

e) The Transforming positive effect on the GPRODIP: the Transforming is related to the creation of environmental knowledge and competencies inside a company, and the reconfiguration of company's resources aiming to face environmental Sustainability challenges (Dangelico *et al*., 2017). Hiring environmental specialists, training and R&D actions, in addition to the organizational structure reconfiguration directing them to sustainability, collaborate to the development of new green products, consequently, to the GIP. To this discussion, it is stated that the Transforming would positively affect the GPRODIP, and would imply the following hypothesis: Hypothesis 5 (H5) the Transforming is positively associated to the GPRODIP.

f) The Transforming positive effect on the GPROCIP: the Transforming collaborates to the Green Process Innovations since it enables the ones involved in the process to have a greater direction and, consequently, a greater performance. To the discussion above, it is stated that the Transforming would positively affect the GPROCIP, and would imply the following hypothesis: Hypothesis 6 (H6) the Transforming is positively associated to the GPROCIP.

As such, this study states that the GDC and the GIP influence positively in the company's competitive advantage. The research framework is shown in Picture 1.

Picture 1 – Model of Proposed Research



Source: Elaborated by the authors

2 MATERIALS AND METHODS

This paper's approach is quantitative, and it has been done through survey research. The model was created based on Chen (2008); Chen *et al*. (2006) and Dangelico *et al*. (2017) it was used this type of research to define and adapt each GDC and GIP, having alterations in its composition based on the studies by Chen *et al*. (2006); Lin and Chen (2017); Teece (2007); Teece *et al*. (1997) and Zahra *et al*. (2006). Differently from the works that support a model creation, which analyze companies in groups of different levels of environmental changes focused on the sustainable requirements, it was used as an exogenous variable to the model, the environmental changes directed toward the sustainability requirements.

This study has been applied in national context, and the selected sector is the Brazilian cement industry. It was chosen this sector since it has been suffering meaningful influences regarding environmental changes on sustainability requirements for the past years. It is important to highlight that no research on GDC and GIP has been identified in this sector, nor in the national and international literature.

The reason why the Brazilian cement industry is this research object is: the cement manufacturing process has a significative impact on the environment. It is responsible for about 5% of the global CO_2 emission (World Business Council for Sustainable Development, 2002) among other harmful gases; the cement industry operates in a dominant position over the building materials supply chain. Its decision and actions affect all the stages of the delivery chain, starting at the mining companies and ending at the 'buyers' (that is, the residents) from the finished buildings (Isaksson and Steimle, 2009; Romaniuk, 2011); in 1999, according to World Business Council for Sustainable Development (2002), 10 CEOs from the most important global cement industries (including ones based in Brazil) met to start a volunteering program aiming to guarantee the segment to remain in the market and keep its competitivity by the implementation of a program that would reduce negative externality on the environment and communities in its operations. Together, they sought sustainability and sector continuity, since its high impact on the environment and communities where they operate. This group of Brazilian cement industry features are important to the theory improvement.

2.1 Sample and data collection

The Brazilian cement industry sample n = 93 questionaries answered, from 303 possible ones (31% return) was based on a cross-sectoral focus to assure a sufficient sample for the data generalization, among the 100 factories unit spread all over the national territory. It was used primary data to all categories from the research to test the hypotheses, since there are no public reports from these companies that enable the GDC and GIP evaluation from secondary data.

The questionary has been developed from works that have already developed and applied research scales to GDC and GIP (Chen, 2008; Chen *et al*., 2006; Dangelico *et al*., 2017), as well as literature authors research (Chen *et al*., 2006; Lin and Chen, 2017; Teece, 2007; Teece *et al*., 1997; Zahra *et al*., 2006). It has been included questions on GDC and GIP and their components. The questionary comprises questions regarding the responders' and companies' profiles. The structed data collection instrument to this research has been measured based on the seven-point- Likert scale, due to it has been as well accepted practice in this type of research, and adequate to the applying context. The scale was organized in: (0) Do not apply; (1) Totally disagree; (2) Strongly disagree; (3) Somewhat disagree; (4) Neither agree nor disagree; (5) Somewhat agree; (6) Strongly agree; and (7) Totally agree. The questionary was applied using Google Forms.

2.2 The constructs measurement

The constructs (GDC and GIP) used in the study are described below, considering its dimensions and respective variables, according to the proposed model.

2.2.1 Green Dynamic Capabilities

The GDC are constituted in three dimensions, each one of them with specific variables: External Resources Integration (Sensing), Internal Resources Integration (Seizing), Resource Construction and Reconfiguration (Transforming).

2.2.1.1 External Resources Integration

Based on Dangelico *et al*. (2017)'s study, this dimension measures the Sensing and it includes five variables: (Sensing 01) the company integrates the customers' requirements into the product performance; (Sensing 02) the company integrates the knowledge in environmental impact into its products during customers use; (Sensing 03) the company integrates the suppliers' knowledge and competencies regarding environmental components and material impact; (Sensing 04) the company integrates the suppliers' knowledge and competencies regarding production process environmental impact; (Sensing 05) the company collaborates with the distribution channels' members (such as wholesalers, retailers, among others) to reduce products environmental impact.

2.2.1.2 Internal Resources Integration

Based on Dangelico *et al*. (2017)'s study, this dimension measures the Seizing and it includes five variables: (Seizing 01) the company has the collaboration between specialized environmental unit (such as environmental sustainability managers, environmental sustainability unit) and project office/department from the business strategy unit; (Seizing 02) the company has the collaboration between specialized environmental unit (such as environmental sustainability managers, environmental sustainability unit) and production office/department from the business strategy unit; (Seizing 03) the company has the collaboration between specialized environmental unit (such as environmental sustainability managers, environmental sustainability unit) and marketing office/department from the business strategy unit; (Seizing 04) the company integrates environmental knowledge and competencies in (design, manufacturing, marketing, among others) office/departments from the business strategy unit; (Seizing 05) the company facilitates the exchange of cross-functional environmental knowledge with the business strategy unit.

2.2.1.3 Resource Construction and Reconfiguration

Based on Dangelico *et al*. (2017)'s study, this dimension measures the Transforming and it includes eight variables: (Transforming 01) the company hires environmental specialists (such as life cycle evaluation and environmental project specialists); (Transforming 02) the company trains (such as attendance in conferences, workshops, and courses) product development team members to update their knowledge and competencies regarding the environment; (Transforming 03) the company trains (such as attendance in conferences, workshops,

and courses) R&D personnel aiming to update their environmental knowledge and competencies; (Transforming 04) the company acts aiming to reinforce environmental R&D (such as wide the range and the investments); (Transforming 05) the company reconfigures the organizational structure to focus on environmental sustainability (by creating a new division, reconfiguring product lines); (Transforming 06) the company reconfigures the product development teams to include environmental specialist; (Transforming 07) the company rebuilds the relations with suppliers (environment auditioning the supplier, changing suppliers) to reduce the products' environmental impact; (Transforming 08) the company rebuilds the relationship with customers (such as rentals instead of sells) to reduce the products' environmental impact.

2.2.2 Green Innovation Performance

The GIP consists in two dimensions and each one of them have their specific variables: Green Product Innovation Performance (GPRODIP), and Green Process Innovation Performance (GPROCIP).

2.2.2.1 Green Product Innovation Performance

Based on the studies by Chen (2008), and Chen *et a*l. (2006), this dimension measures the GPRODIP and it includes seven variables: (GPRODIP 01) in the products' development or project, the company defines the raw materials that generate less pollution; (GPRODIP 02) in the products' development or project, the company defines the input that generate less pollution; (GPRODIP 03) in the products' development or project, the company defines the raw materials that uses less quantity of energy and resources; (GPRODIP 04) in the products' development or project, the company defines the input that uses less quantity of energy and resources; (GPRODIP 05) the company uses less raw material to create the product aiming to conduct the product's development or project; (GPRODIP 06) the company uses less input aiming to conduct the product's development or project; (GPRODIP 07) the company starts a product's development project in case that is easy to recycle, reuse and decompose.

2.2.2.2 Green Process Innovation Performance

Based on the studies by Chen (2008), and Chen *et al*. (2006), this dimension measures the GPROCIP and it includes nine variables: (GPROCIP 01) the company, in its manufacturing process, effectively reduces the residues emission; (GPROCIP 02) the company, in its manufacturing process, effectively reduces the hazardous substances emission; (GPROCIP 03) the company, in its manufacturing process, recycles residues that may be treated and reused; (GPROCIP 04) the company, in its manufacturing process, recycles its emissions that may be treated and reused; (GPROCIP 05) the company, in its manufacturing process, reduces water use; (GPROCIP 06) the company, in its manufacturing process, reduces electricity use; (GPROCIP 07) the company, in its manufacturing process, reduces fuel use; (GPROCIP 08) the company, in its manufacturing process, reduces raw materials use; (GPROCIP 09) the company, in its manufacturing process, reduces input use.

2.3 Questionary and pre-test language adaptation

After creating the questionary, it was done the language adaptation to the cement industry. In order to do so, it was used this paper authors' experience in the cement sector. In addition, it was done three in-depth face-to-face interviews with three cement industry managers holding over 10 years of experience in the sector, each interview with an average duration of one hour and a half. The interviewees had suggestions regarding the comprehensibility of the questions and the questionary structure, which were considered and inserted in the new version of it.

Following, it was done the scale validation by construct through the average and standard deviation generated in Google Forms. Later, intending to increase the content validity, it was done a pre-test with 10 respondents different from the interviewees from the previous stage, featured as respondents with knowledge and experience in the cement sector. It was collected feedback of what could be considered questionable, ambiguous, or incomprehensible, and they were incorporate to the questionary, resulting in a third version of the data collection

tool done in 2018. Thus, it was considered that the language used in this paper tool's questions were adjusted to the Brazilian cement industry.

All of the 100 cement producing factors were initially contacted by phone, besides the Brazilian Portland Cement Association, to request the managers' email and phone number. Afterwards, the data collection tool was sent to the managers of Brazilian-based industries via electronic form, by the institutional email, phone call, and, in some cases, by Linkedin® (strictly professional social network). The emphasis on the managers as responders was an alternative to assure that the answer could represent the company's reality regarding the studied categories. The questionaries were collected in the period between November 7th, 2018 and November 30th, 2018. The responders' position in the companies are: CEO, director, superintendent, manager, and coordinator. Regarding the sample profile, it was verified that 33% of the cement industries have been in the market from 1 to 20 years, 23% have been in the market from 40 to 50 years, and 44% have been in the market for over 50 years.

2.4 Measure validation

The content validation was obtained through the scales developed and applied by Chen (2008), Chen *et al*. (2006), Dangelico *et al*. (2017) and the literature on dynamic capabilities from the works of Lin and Chen (2017), Teece (2007), Teece *et al*. (1997) and Zahra *et al*. (2006). The language adaptation was certified through the in-depth interviews previously referred to, and the scales adjustments were oriented by the pre-test done with knowledgeable and experienced responders from the cement industry. These interventions intended to minimize the measurement errors.

The data normality analysis was done by Kolmogorov-Smirnov (K-S) test. In addition, it was used Fisher's asymmetry coefficient (g1), and the Fisher's kurtosis coefficient (g2). From the tests, it was noticed that all values obtained to the K-S test have shown $p < 0,05$, indicating that the data do not present normal distribution. This evidence is corroborated by the asymmetry and kurtosis values. The finding is justified by the concentrated distribution, in high values, larger than the average.

Yet, analyzing the assumptions to the statistic tests, the next step done to analyze the data homogeneity was the use of Levene's F test. After analyzing the data, it was observed that the GPROCIP dimension presented $p<0.05$, 0.027. In these cases, the null hypothesis is rejected and, in a 95% level of trust, the population variances are not homogenic. The other dimensions, Sensing, Seizing, Transforming, and GPRODIP presented $p>0.05$, 0.776, 0.167, 0.724, 0.935, respectively, enabling to conclude that, in a 95% level of trust, the population variances are homogenic.

Intending to evaluate how much these constructs are reliable, it was used the internal consistency analysis by the Cronbach's Alpha test, which is necessary to evaluate the proposed scale. The Cronbach's Alpha test was applied in each dimension and its respective variables. The construct values obtained for GDC (0.94) and GIP (0,94) have presented values above 0.70, which, according to Hair Júnior *et al*. (2009), are values that demonstrate the research tool reliability. When the dimensions were analyzed, the coefficient valued were between 0.78 and 0.95, which demonstrates each dimension reliability. Lastly, when analyzing the general coefficient, the value also exceeds 0.70, represented by 0.97. These results enable us to suggest that the research tool has presented satisfying internal consistency.

The multicollinearity analysis, in the structural model, was done by the Variance Inflation Factor (VIF). Variables presenting values over 5 indicate possible multicollinearity problem (Hair Júnior *et al*., 2009). Analyzed data detected indications of multicollinearity, which has been adjusted.

After the first statistical analysis, it was done the structural equations modeling via PLS-SEM, preceded by the exploratory factor analysis, and CFA.

3 RESULTS AND DISCUSSION

The first statistic test done to investigate the positive relation the GDC with the GIP was the correlation coefficient. It is relevant to emphasize that, due to sample data do not follow a normal distribution, it was applied the Spearman's correlation coefficient, nonparametric test alternative to the Pearson coefficient. In addition to Spearman's correlation coefficient, it was applied Friedman and Wilcoxon tests to evaluate the relation's difference

and size. Apart from those, it was applied the PLS-SEM structural equations method to verify the relation. Aiming to present the data and to prove the internal dimensions connections with the two analyzed constructs, it will be evaluated, initially, the relations between each construct dimension to verify their behavior, and, lastly, the connection between GDC and GIP.

Table 1 - Correlation Coefficient between GDC and GIP dimensions

	Spearman 's Rho	ERIN	IRIN	RCR	GPRODIP	GPROCIP
ERIN	Correlation Coefficient	1,000				
	p- value (2 extremes)					
	N	90				
IRIN	Correlation Coefficient	.717**	1.000			
	p- value (2 extremes)	0,000				
	N	90	90			
RCR	Correlation Coefficient	.679**	.750**	1.000		
	p- value (2 extremes)	0.000	0.000			
	N	90	90	90		
GPRODIP	Correlation Coefficient	.648**	.648**	.733**	1.000	
	p- value (2 extremes)	0.000	0.000	0.000		
	N	90	90	90	90	
GPROCIP	Correlation Coefficient	.534**	.598**	.560**	.724**	1.000
	p- value (2 extremes)	0.000	0.000	0.000	0.000	
	N	90	90	90	90	90

Source: Elaborated by the authors

* The correlation is significative in the 0,01 level (2 extremes).

Regarding the correlation between the GDC and DIV dimensions treatment, the first relation to be analyzed is between Sensing and GPRODIP and GPROCIP, according to Table 1. Based on the data above, it is possible to notice that the correlation coefficient between Sensing and GPRODIP was rho 0.648 and p-value 0.000. When the Sensing and the GPROCIP correlation is analyzed, it is noticed that rho's coefficient correlation was 0.534 and the p-value 0.000. Therefore, both correlations are significative in 0.01 significance level, and considered to be moderate. Thus, it is suggested that when increasing Sensing, GPRODIP and GPROCIP also increase.

The second correlation analyzed is between Seizing, GPRODIP, and GPROCIP. It is noticed that the correlation coefficient between Seizing and GPRODIP was rho 0.648 and p-value 0.000; and between Sensing and GPROCIP was rho 0.598 and p-value 0.000. Thereby, the correlations are significative, in 0.01 significance level, and considered to be moderate. It is suggested that when increasing Seizing, GPRODIP and GPROCIP also increase; however, when increasing Sensing, GPROCIP increases less than GPRODIP.

Continuing the GDC and GIP relation evaluation, the correlation between Transforming and GPRODIP obtained a rho correlation coefficient 0.733 and p-value 0.000. This was the higher correlation among the dimensions. The Transforming and GPROCIP correlation showed a 0.560 rho coefficient and 0.000 p-value. It is concluded that the correlations are significative, and the significance level is 0.001, and considered high and moderate, respectively. Thus, it is suggested that when the Transforming increases, GPRODIP and GPROCIP increase as well, although in different levels.

Aiming to perform which would be the highest relations between the variables, it was applied the Friedman, the Wilcoxon, and the Bonferroni tests. Applied together, these tests enable the identification of higher relations.

The first Friedman test was applied aiming to verify whether the GDC and GIP constructs are extracted from the same population.

Table 2 - Friedman Test to GDC and GIP

Friedman Test	
N	90
qui-squared	39.961
gl	4
p-value	0.000

Source: Elaborated by the authors

According to Table 2, it is possible to notice that the Friedman test demonstrates that there is a difference between constructs, in other words, the actions done in each construct have distinct levels, 39.961 qui-squared and p-value < 0.05. Although the test does not inform which is higher or lower, this way, to identify the difference, it was used the Wilcoxon test.

Besides, aiming to avoid type II error, it was applied the Dunn-Bonferroni test to each relation between GDC and GIP dimensions. It is observed in Table 3 that the results converge on the Wilcoxon test results, dismissing the type II error possibility.

Table 3 - Wilcoxon and Bonferroni test to GDC and GIP

	ERIN IRIN	RCR ERIN	GPRODIP ERIN	GPROCIP ERIN	RCR IRIN	GPRODIP IRIN	GPROCIP IRIN	GPRODIP RCR	GPROCIP RCR	GPROCIP GPRODIP
Wilcoxon-Z test	-1.207[b]	-3.847[c]	-.990[b]	-1.990[b]	-5.613[c]	-.587[c]	-.814b	-4.677b	-4.656b	-1.565b
P-value (double tailed)	0.228	0.000	0.322	0.047	0.000	0.557	0.416	0.000	0.000	0.118
Adjusted p-value (Bonferroni)	0.942	0.005	1.000	0.593	0.000	1.000	1.000	0.000	0.000	1.000

Source: Elaborated by the authors
a. Classification Test Signed by Wilcoxon.
b. Based on negative rank.
c. Based on positive rank.
Adjusted p-value were combined by the Bonferroni correlation to the multiple tests.

The Wilcoxon and Bonferroni tests results suggest that, between Seizing and Sensing, with 0.228 p-value and adjusted p-value 0.942, both > 0.05; GPRODIP and Sensing with p-value 0.322 and adjusted p-value 1.000, both > 0.05; GPROCIP and Sensing with p-value 0.047 and adjusted p-value 0.593, it was rounded off the first one and considered the second, both > 0.05; GPRODIP and Seizing with p-value 0.557 and adjusted p-value 1.000, both >0.05; GPROCIP and Seizing with p-value 0.416 and adjusted p-value 1.000, both > 0.05; and GPRODIP and GPROCIP with p-value 0.118 and adjusted p-value 1.000, both >0.05, therefore, it is suggested that there is no difference between ranks, thus they are considered equals.

Regarding the Transforming and Sensing relation, the p-value is 0.000 and the adjusted p-value 0.005, both > 0.05; Transforming and Seizing with p-value 0.000 and adjusted p-value 0.00, both > 0.05; GPRODIP and Transforming with p-value 0.000 and adjusted p-value 0.000, both > 0.05; GPROCIP and Transforming with p-value 0.000 and adjusted p-value 0.000, both > 0.05, the tests results indicate a divergence between ranks, therefore, they are considered different. To identify which were the highest, Table 4 was created, based on Friedman, Wilcoxon, and Bonferroni, through average ranks and significancy. Thereby, it was possible to identify that, in the relation between Transforming and Sensing, the Sensing level is higher; between Transforming and Seizing, the Seizing level higher; between GPRODIP and Transforming, GPRODIP is higher; DIPROCIP and transforming, GPROCIP is higher, therefore, it is understood that the focus is lower in the Transforming dimension.

Table 4 - Joint evaluation of Friedman and Wilcoxon tests with Bonferoni adjustments

	ERIN	**IRIN**	**RCR**	**GPRODIP**	**GPROCIP**
ERIN		= 0.942	> 0.005	= 1.000	= 0.593
IRIN	= 0.942		> 0.000	= 1.000	= 1.000
RCR	< 0.005	< 0.000		< 0.000	< 0.000
GPRODIP	= 1.000	= 1.000	> 0.000		= 1.000
GPROCIP	= 0.593	= 1.000	0.000	= 1.000	

Source: Elaborated by the authors

Continuing this research hypotheses analyses, it is highlighted the correlations and the structural analysis between constructs. Based on what may be observed, all the constructs show positive correlations, from moderate to high ones, and the established hypotheses between constructs have been accepted. Thus, it is expected that the correlation between GDC and GIP to be positive as well.

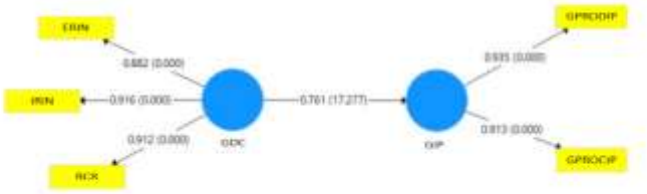
Table 5 - GDC and GIP correlation coefficient.

Spearman's rho		**GDC**	**GIP**
GDC	Correlation Coefficient	1000	0.723**
	P-value (2 extremes)		0.000
	N	90	90
GIP	Correlation Coefficient	**0.723****	1.000
	P-value (2 extremes)	**0.000**	
	N	90	90

Source: Elaborated by the authors
** The correlation is significative at 0.01 level (2 extremes).

It is noticed in Table 5 that the correlation between GDC and GIP obtained a 0.723 rho correlation coefficient and p-value 0.000. Therefore, it is suggested that the correlation is significative in 0.01 significancy level, and considered high. Lastly, and to conclude the analysis, it was used the PLS-SEM analysis.

Picture 2 - Structural relation between GDC and GIP.



Source: Elaborated by the authors

It is seen in Picture 2 that the relation, in industrial level, is high and converges on the found Spearman coefficients, as well as with the dynamic capabilities' theory, suggesting the dynamic capabilities influence on the Innovation, in here analyzed by the environment perspective.

Table 6 - Structural analyses between GDC and GIP.

Structural Relations	f2	Structural Coefficient	Default error	T-value	P-value	Adjusted R2
GDC -> GIP	1.373	0.761	0.045	17.136	0.000	0.574

Source: Elaborated by the authors

In the structural analyses, the critical value used was 2.57, which is equivalent to the significancy level 0.01, and the t-value result was 17.136. Lastly, in the structural coefficient analyses, p-value is significative in 0.01 level of trust.

The adjusted determination coefficient, adjusted R^2, aims to identify whether the relations, theoretically predicted, are supported by empirical data. It was analyzed by bootstrapping and it was obtained 0.01 statistical significancy level. Therefore, GDC explain in 57,4% the GIP. In other words, it is possible to suggest that the GDC variation have high power of explanation over the GIP variation.

Regarding the exogen construction, GDC to explain the latent endogenic variable GIP presented 1.373 effect size f2. The effects are considered large, according to the values presented by Hair Júnior *et al*. (2009). It is noted that all relations, in the structural model, are significative in 0.01 significancy level; the structural coefficient and the R^2 are considered moderate. In other words, the relation GDC and GIPs hypotheses is accepted: the GPCs are positively related to GIP.

CONCLUSION

The fundamental aim of this research was to analyze the hypotheses that the higher the cement industry GDC, higher will be the its GIP. The model has been adapted by the works of Chen (2008); Chen *et al*. (2006) and Dangelico *et al*. (2017). It was considered, specifically, the cement industry, since it is a context that has not been analyzed on the GDC' perspective, and the pressure, higher and higher, from the environmental changes regarding the sustainability requirements.

The established relations were confirmed, when Sensing increases, GPRODIP and GPROCIP increase as well. When Seizing increases, GPRODIP and GPROCIP increase as well; however, when Seizing increases,

GPROCIP increases less than GPRODIP. When Transforming increases, GPRODIP and GPROCIP increase as well; however, in different levels. Analyzing the differences, it is possible to suggest that there are no differences between Seizing and Sensing. Although, when analyzed Transforming and Sensing, it is suggested there is a difference between the dimensions, making it possible to state that the focus in Transforming is lower. In addition, it was confirmed, from analyses by PLS-SEM structural equations, that the relation, in industry level, is high and converge on found Spearman coefficients, as well as with the dynamic capabilities theory, that suggest the dynamic capabilities influence on Innovation, in here analyzed on the three environment pillars. In other words, it is possible to suggest that the GDC variation have higher power to explain GIP variation. Thus, it is suggested that the GDC are positively related to GIP.

However, what, in fact, do these relations express to the cement industry? The analysis evidenced that: a) the cement industry may convert and use new knowledge for organizational learning regarding sustainability requirements influenced by innovation in products and processes that are involved with energy saving, pollution prevention, residue recycling, no toxicity; b) the cement industry is capable of changing and integrate environmental knowledge and competencies inside the company, influencing innovation of products and processes that are involved with energy saving, pollution prevention, residue recycling, no toxicity; c) the cement industry, in lesser degree, is capable of creating environmental knowledge and competencies inside the company and reconfiguring its resources, aiming face the environment sustainability challenges, influencing innovation of products and processes that are involved with energy saving, pollution prevention, residue recycling, no toxicity. These evidences reflect on the efforts the cement industry in obtaining GIP both in its processes, and in the offer of environment responsible products.

In essence, this paper brings some considerable contributions, such as: a more complete the validation relation between GDC and GIP and for a sector that is more and more influenced by environment changes regarding Sustainability; and (b) the evidence of how the relations between GDC and GIP is done in Brazilian cement industry, even identifying which are the more representative. As to the Brazilian cement industry pragmatic aspects, some results require notoriety, since they may collaborate to organizational management: the GDC configurations that reveal the green innovation base from the sector, and the bases clarification which has been given emphasis in the search of GIP, making possible to improve.

It is acknowledged that future research may be capable of comprise other sectors highly pollutant, in addition to the ones related to services, to analyze the congruence of this paper's found results. The fundamental limitation identified in this survey regards the difficulty in obtain more return from the sent questionaries, limiting the analyses, besides from being based on one sector.

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