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The Effect of Global and National Value Chains on Environmental Innovation and Research and Development: An Analysis of Ibovespa Companies

Lucas Benedito Gomes Rocha Ferreira[1]
Denise Isabel Rizzi[2]
Crisiane Teixeira da Silva[2]
Valmir Emil Hoffmann[2,3]

Abstract

Purpose – To analyze the effect of national and global value chains on environmental innovation and research and development in the context of Brazilian companies listed on the Ibovespa.

Theoretical framework – Value chain and open innovation.

Design/methodology/approach – This is descriptive, documentary research that uses a quantitative approach, through the analysis of secondary data extracted from Refinitiv Eikon. The research population consisted of 70 non-financial companies listed on the Ibovespa between the years 2016 and 2020.

Findings – The global value chain affects environmental innovation and research and development (R&D) in a positive and significant way, revealing that companies with more evidence in their reports on formalizations with suppliers and customers show improvements in their environmental products with ecological designs and carry out more R&D spending. Those companies that have, in addition to national connections, connections with companies from other countries are more likely to have greater capacity for innovation.

Practical & social implications of research – The research helps in understanding how organizations can improve their value chain, considering geographic aspects and interorganizational relationships, providing more assertively innovative resources.

Originality/value – Although a national value chain does not influence any increase in environmental innovation, it does impact higher R&D spending. As eco-innovation involves voluntary disclosure, it is inferred that companies that are limited to maintaining relationships in Brazil do not receive the same institutional pressure, when compared to companies with a global value chain, since the latter are connected with firms in countries with greater enforcement mechanisms regarding sustainable practices.

Keywords: global and national value chain, environmental innovation, research and development, Ibovespa.

1. Regional University of Blumenau, Department of Accounting, Blumenau, Brazil
2. Federal University of Santa Catarina, Department of Accounting, Florianopolis, Brazil
3. University of Zaragoza, Zaragoza, Spain

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1 Introduction

Research on value chain and innovation topics is developed from different perspectives and may include supplier selection processes and control mechanisms (Lou et al., 2022). It is also noteworthy that some innovation efforts allow for the achievement of environmental sustainability and minimization of negative societal impacts (Munten et al., 2021). These themes consider seminal studies from the 1990s, which dealt with these issues by discussing how innovation occurred (De Toni et al.,1998) and how more integrated management of the value chain could promote more innovations (De Meyer, 1998).

Value chain and innovation are constructs linked to performance. De Meyer (1998) recommended that European industries form partnerships with customers and suppliers to become more competitive in the industrial environment. We note that, more than twenty years later, this idea of linking the value chain and innovation to performance persists (Chen et al., 2020). But for a company to remain competitive in the market, it needs to be aware of the opportunities available for innovation (Theyel, 2013). Thus, managing innovations is relevant for an organization's survival, whether for a significant improvement or creating a new product or process (Baskaran & Mehta, 2016).

On the one hand, the value chain is related to innovation (Chen et al., 2020). On the other hand, it is connected to inter-organizational relations (IORs) (Sedita et al., 2021). IORs are fundamental for companies' financial performance since they provide resources in a complementary way, effectively increasing their business competitiveness (Palmatier et al., 2007). IORs also expand the firm's technological capabilities and offer the possibility of efficient knowledge transfer (Belussi et al., 2010). Sedita et al. (2021) presented an example of this transfer in the wine industry in northeastern Italy.

When researching value chain and innovation through the theoretical lens of open innovation, Ambos et al. (2021) mentioned that these two variables propose an idea of creating and applying some novelty at any stage of the value chain, such as changes in the offer or design of new products or services. In the same understanding, according to Buciuni and Pisano (2021), the innovation capabilities of leading companies and the product innovation cycle are directly linked by the specific structure of the value chain in which they operate.

However, when analyzing the exchange of resources between companies, this can be expanded or restricted, even if the chain is within the same territory (Sedita et al., 2021). Discussing how companies can benefit from participating in IORs according to regional configurations has yielded the literature on the global value chain (GVC) (Humphrey et al., 2020). In this sense, the knowledge dissemination that can lead to innovation does not occur uniformly since it depends on the exchanged knowledge (Sedita et al., 2021) and on the process of regional configuration of the value chain (Humphrey et al., 2020).

Although IORs are recognized as positive for organizations, research on the subject cannot determine the difference in the impact on innovation of a company that is limited to maintaining national supplier-customer relationships (national value chain – NVC), from one that, in addition to this local connection, also holds IORs with companies from other countries (GVC). Thus, by considering the regional dimensions in the value chain classification, this study seeks to answer the following research question: what is the effect of global and national value chains on environmental innovation and research and development (R&D)?

This study selects Brazilian companies listed on the Ibovespa to answer this question. We chose the Ibovespa index because it reflects the portfolio of assets listed on the *Brasil, Bolsa, Balcão* stock exchange, which is the most representative of the Brazilian stock market. To achieve the objective, we operationalized a multiple linear regression. As the originality of this study consists in considering the regional dimensions in classifying the value chain, we illustrated the existing relationships between the Ibovespa companies in the NVC.

This research contributes by systematically pointing out the difference in the impact on innovation of a company that is limited to maintaining supplier-customer relationships in the same country (NVC) compared to one that, in addition to these local connections, maintains relationships with companies from other countries (GVC). The second contribution is to highlight the positive relationship between global and national value chains and innovation capacity. Lastly, the study advances the IOR literature by highlighting evidence on the range and effects of open innovation practices and opportunities in different value chain scenarios.

The structure of this study consists of five sections. The first comprises this introduction, while the second

presents the literature review where we discuss the value chain and innovation topics. The third section shows the methodological structure used for constructing this research. The data analysis and discussion of the findings feature in the fourth section. In the last section, we present the study conclusions along with limitations and proposals for future research.

2 Literature review and hypothesis development

We can understand innovation as the implementation of a new or improved product or process (Organisation for Economic Cooperation and Development, 2018), which is a reduction of the concept presented by Schumpeter (1934), who defined it as the creation of new services or raw materials, markets, and organizations. The definition provided by Knox (2002) sees innovation as the generation of value since the author defines it as a unique way of delivering better value or quality.

The literature also discusses open innovation in line with the traditional innovation concept. Chesbrough (2003) conceptualizes open innovation as a process that crosses the company's boundaries. Therefore, this concept reveals that companies rely on their internal innovation capabilities and use several external actors and resources to advance their innovation process or access new markets (Chabbouh & Boujelbene, 2020). Open innovation contributes to reconfiguring business models and establishing IORs to generate innovation among the partners distributed along the supply chain (Caetano & Amaral, 2011).

Thus, open innovation has become an increasingly relevant instrument for managing innovation (Torchia & Calabrò, 2019). This relevance is related to its metric with three dimensions: (i) the inbound dimension that aims to internalize external resources to innovate; (ii) the outbound dimension, which is related to practices that aim to externalize the company's internal resources to open up new markets; and (iii) the coupling dimension that combines inbound and outbound practices (Chabbouh & Boujelbene, 2020). Hence, open innovation leads to a change in the management paradigm (Bogers et al., 2018) and, consequently, to improvements in companies' innovative efforts.

Moreover, other studies have shown a positive link between open innovation and the R&D process (Belussi et al., 2010; Paula & Silva, 2018; Chabbouh & Boujelbene, 2020). These studies show that, by allowing the use of an external knowledge network, organizations absorb new knowledge from this environment, attracting partners and exploring opportunities for collaboration.

Open innovation practices allow benefits that stimulate connectivity, reputation, and awareness of innovation opportunities in companies (Theyel, 2013). This greater stimulus for innovation and higher R&D investments are also associated with the ability of organizations to promote environmental innovation (Scarpellini et al., 2018; Varyash et al., 2020). Some studies are analyzing managers' concerns with eco-innovation, as it reflects on an organization's ability to reduce costs and environmental charges and thereby create market opportunities (Carrión-Flores & Innes, 2010; Sahin et al., 2021).

The relationship between the value chain and innovation proposes creating and applying some novelty at any stage of this chain (Ambos et al., 2021), which can thus connect to changes in the supply or design of new products or services. In this context, the innovation capacity of companies directly links to the structure of the value chain in which they operate (Buciuni & Pisano, 2021).

According to the findings of Shang et al. (2022), many companies, mainly in the coal-fired power generation sector, are finding solutions for their processes through environmental innovation, where, in addition to reducing emissions, they can reduce production costs. In this context, the scale of environmental and social challenges faced by the world requires large and small companies to develop sustainable innovative solutions that are economically, environmentally, and socially viable (Dasgupta, 2021).

Environmental innovation or eco-innovation has collaborated in advancing competitiveness in the market, promoting the sustainability of the company and the environment in which it operates, and promoting a positive effect on the environment (Journeault, 2016). Thus, eco-innovations differ from other technological innovations mainly due to their relevant impact on clean production, regional development, and infrastructure (Aldieri et al., 2019).

In the context of organizations, it is necessary to resort to studies that deal with cooperation between companies that work with similar objectives to achieve a greater volume of innovation, as well as better organizational performance (Groot & Merchant, 2000). One way to raise these indicators is for organizations to carry out IORs, thus enabling cost reductions, higher support in

human resources, and access to new markets in search of opportunities and technological resources (Chenhall, 2003).

When analyzing management practices through the advantages acquired by IORs, the most evident results have been the collective potential in the search for solutions, market power, technological innovations, and the value chain (Barringer & Harrison, 2000). However, among these practices, the value chain was the one that stood out among the studies by Barringer and Harrison (2000).

The value chain involves the activities developed internally in the company, which follow a flowchart with inputs, processes, and outputs of a product or service, as well as creating value for its customers (Porter, 1985; Koc & Bozdag, 2017). For these reasons, organizations have begun to analyze the structure of the value chain to differentiate themselves from competitors, requiring the expansion of production to extend their activities, even primary activities such as support, technology, and innovation (Hansen & Birkinshaw, 2007).

Although the value chain terminology seems clear, the literature presents other characteristics. The GVC typology is defined as connections between local companies, for instance, in Brazil, with international organizations, such as companies in China or the United States (Gereffi, 2001). So this GVC will facilitate governance between the parties, influencing what and how production should occur until reaching the final consumer (Kano et al., 2020).

The GVC promotes the automation of productivity standards, business strategies, and regulatory changes (Gereffi et al., 2005). But this construct is not new since the expansion of the GVC occurred in the 1980s, with the commercial opening up of production, which boosted competition and facilitated international competition, accelerated production, and cost reductions (Gereffi, 2001).

According to Kano et al. (2020), the GVC would be a geographically distinct type of governance with interrelated functions and operations that produce goods and services consumed globally. Thus, with the advancement of the value chain, scholars have realized how it influences the impact of the digital transformation of retail companies (Reinartz et al., 2019). In addition, the performance of organizations that are part of the value chain tends to be considered since, when operating in networks, access to new investments in business networks becomes likely, as well as opportunities for sustainable competitive advantage (Ricciotti, 2020).

Due to the participation of larger companies in the value chain, Hansen and Birkinshaw (2007) analyzed the innovation value chain with more than 130 interviews carried out in multinationals. The authors identified the strengths and weaknesses of the chain, making it possible to compare the innovation capabilities between the strong and weak links in the chain. Moreover, according to global changes in innovation power, Lema et al. (2015) showed that multinational subsidiaries and local suppliers achieve innovation capabilities based on R&D in the Brazilian automobile industry.

In the value chain, knowledge can be shared in several ways, and the degree of this knowledge obtained between organizations depends on the position of the actors in the respective network (Hoffmann et al., 2014) or even on the stage of value creation in the chain (Sedita et al., 2021). That facilitates knowledge transfer, cost reductions (Sedita et al., 2021), and the possibility of growth. For Gereffi et al. (2005), the primary actors within the value chain are the leaders who pass on new knowledge, which can occur vertically and horizontally. Thus, considering that the innovation capacity measured in this study consists of eco-innovation and R&D spending, the first hypothesis of the work is established:

H_1: The global value chain positively influences innovation capacity

Concerning the effects of relationships with different geographically close organizations, Dyer (1996) showed that these interactions can yield more innovations due to the capacity for informal exchanges and the greater frequency of professional visits between the entities in the value chain. However, establishing a value chain is not a guarantee of success since there may be problems in knowledge transfer (Wareham et al., 2005) or even in selecting knowledge to be exchanged (Sedita et al., 2021).

Hoffmann et al. (2014) highlighted that geographical proximity facilitates the rapid exchange of information between companies, sociocultural structures, and institutions. Therefore, this process helps collective learning and permanent innovation, which are advantages not available to companies located outside the national context of the company in question. Thus, we devise the following hypothesis:

H_2: The national value chain positively influences innovation capacity

In addition to the independent variables, Figure 1 recognizes the impact of control variables on

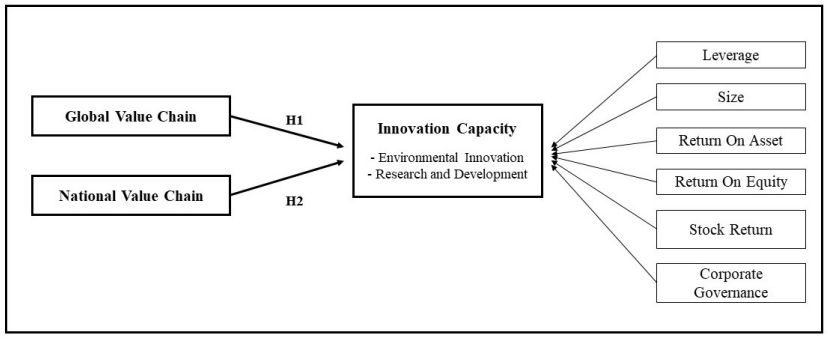

Figure 1. Research construct.

innovation capacity. Póvoa and Monsueto (2011) showed that the company's size influences its propensity to innovate in products and processes. According to Porter (1985), there are associations between high company leverage and an innovation-based strategy. Moreover, Audretsch (1995) highlighted that profitability is responsible for promoting subsequent innovative activities for companies in industries with many technological opportunities. Regarding market performance, Zaniboni and Montini (2017) showed that the normal return on shares of innovative companies is greater than the expected market return. Lastly, Scherer and Voegtlin (2020) discussed the potential effect of different corporate governance models on responsible innovation.

3 Method

This research is documental, using data collected from the Refinitiv Eikon database. Moreover, it is descriptive and uses a quantitative data approach. The companies listed on the Ibovespa between 2016 and 2020 comprise the population. It is noteworthy that the choice of this period is due to the greater voluntary disclosure in the Environmental, Social, and Governance (ESG) reports from 2016 on. The index contains companies with greater disclosure of voluntary information, such as the Environmental Innovation Score and R&D spending.

The sample, in turn, was designed based on the non-financial companies with information for calculating the variables. It is noteworthy that disclosure of information on R&D and innovation indicators is not mandatory. Thus, the study sample contains 70 non-financial companies, totaling 350 observations during the analyzed period. Table 1 details the number of companies by sector and their respective percentage according to the Global Industry Classification Standard.

Table 1
Sector of companies in descending order of quantity

Sector	Code	Quantity	Percentage
Cyclical consumption	2	13	18.57%
Public utility	10	11	15.71%
Non-cyclical consumption	3	10	14.29%
Industry	6	9	12.86%
Materials	8	9	12.86%
Health	5	5	7.14%
Energy	4	4	5.71%
Real estate	9	4	5.71%
Information technology	7	3	4.29%
Telecommunication	1	2	2.86%

Source: Research data.

This research population is primarily represented by sectors such as cyclical consumption (18.57%), public utilities (15.71%), and non-cyclical consumption (14.29%). The telecommunication and information technology sectors have the lowest representation in this study sample, accounting for, respectively, 2.86% and 4.29%.

Table 2 shows the variables used in this study, collected from the Refinitiv Eikon database. The dependent variables measuring companies' innovation capacity consist of the Environmental Innovation Score (EIC) and R&D spending. The EIC indicator is comprised of the dimensions of innovation focused on the use of green resources and the reduction of pollutant emissions.

As independent variables, the regional configurations of the value chain were acknowledged, such as national and global. For its measurements, the excerpt count providing proof of supplier-customer relationships was divided by the number of existing relationships between the companies evidenced in the value chain reports extracted from Refinitiv Eikon.

Table 2
Specification of variables

Variable	Measurement		Source
Dependent Variable - Innovation Capacity			
Environmental Innovation Score (EIC)	Score that reflects the company's ability to reduce costs and environmental burdens for its customers and thus create market opportunities through environmental products with sustainable processes or ecological designs. This score, derived from ESG reports, ranges from 0 to 100.		Aldieri et al. (2019) and Varyash et al. (2020)
Research and Development (R&D)	Measures research and development expenses incurred in a given period.		Chabbouh and Boujelbene (2020)
Independent Variables – Value Chain Regional Settings			
Global Value Chain (GVC)	$\frac{\text{Fragment Count}}{\text{Value Chain Relationships}}$	Measures the supplier-customer relationship score at a global level.	Sedita et al. (2021)
National Value Chain (NVC)	$\frac{\text{Fragment Count}}{\text{Value Chain Relationships}}$	Measures the score of the supplier-customer relationship in Brazil.	Lema et al. (2015)
Independent Control Variables			
Leverage (LEV)	$\frac{\text{Current Liabilities + Non-Current Liabilities}}{\text{Total Assets}}$		Scarpellini et al. (2018)
Size (SIZ)	Logarithm of Total Assets		Póvoa and Monsueto (2011)
Return on Assets (ROA)	$\frac{\text{Net Profit}}{\text{Total Assets}}$		Chabbouh and Boujelbene (2020)
Return on Equity (ROE)	$\frac{\text{Net Profit}}{\text{Total Equity}}$		Chabbouh and Boujelbene (2020)
Stock Return (SR)	Refers to the difference in the share price of company *i* at time *t* in relation to time *t - 1* divided by the share price of company *i* at time *t - 1*.	$\frac{P_{i.t} - P_{i.t-1}}{P_{i.t-1}}$	Zaniboni and Montini (2017)
Corporate Governance (CG)	Score that measures the company's ability, through the use of best management practices, to generate greater value for shareholders. This score, derived from ESG data, ranges from 0 to 100.		Scherer and Voegtlin (2020)
Sector and Year Fixed Effects			
Year	2016, 2017, 2018, 2019, and 2020.		
Sector	(1) Telecommunication; (2) Cyclical Consumption; (3) Non-cyclical Consumption; (4) Energy; (5) Health; (6) Industry; (7) Information Technology; (8) Materials; (9) Real Estate; (10) Public Utility.		

Note: $P_{i.t}$ - Share price of company *i* at time *t*. **Source:** Elaborated by the authors.

The adopted independent variables representing the value chain allow a broad view of innovation management, not restricted to the traditional approach, focused on the product development process or intensive R&D activities developed in global contexts and Brazil. The value chain score is calculated by dividing the textual evidence count that indicates the supplier-customer relationships by the number of existing relationships.

We operationalized data using multiple linear regression (OLS) with sector and year fixed effects. The econometric model tested is based on stakeholder engagement to highlight the relationship between the value chain and innovation, as shown in Equations 1 and 2:

$$EIC = \beta_0 + \beta_1 GVC_{tj} + \beta_2 NVC_{tj} + \beta_3 LEV_{tj} + \beta_4 SIZ_{tj} + \beta_5 ROA_{tj} + \beta_6 ROE_{tj} + \beta_7 SR_{tj} + \beta_8 CG_{tj} + FixedEffectsSector + FixedEffectsYear + \varepsilon \quad (1)$$

$$R\&D = \beta_0 + \beta_1 GVC_{tj} + \beta_2 NVC_{tj} + \beta_3 LEV_{tj} + \beta_4 SIZ_{tj} + \beta_5 ROA_{tj} + \beta_6 ROE_{tj} + \beta_7 SR_{tj} + \beta_8 CG_{tj} + FixedEffectsSector + FixedEffectsYear + \varepsilon \quad (2)$$

We operationalized equations 1 and 2 separately with and without the control variables, carried out in the STATA® software. Equation 2 involves a sensitivity test since it works with another innovation variable: R&D spending. The assumptions of the multiple linear regression models were tested and are presented in the analysis of results. It is noteworthy that we solved the possible heteroscedasticity problems by using robust standard errors.

Moreover, we used the UCINET software to illustrate the existing relationships between the companies on the Ibovespa in the NVC.

4 Analysis of results

This section intends to present and analyze the results. At first, we show the descriptive statistics of the research variables and the t-test of means to verify differences between companies with evidence of relationships in the value chain. Subsequently, we present the results of the regressions that investigate the influence of the GVC and NVC on environmental innovation and R&D spending. Lastly, we identify the existing relationships of the NVC according to the companies listed on the Ibovespa.

4.1 Descriptive statistics and t-test of means

Panels A and B in Table 3 present, respectively, the descriptive statistics of the variables and the t-test to compare the companies with and without evidence of a value chain. The descriptive statistics include the mean, standard deviation, 25th percentile, median, 75th percentile, and the number of observations of the analyzed variables.

Panel A shows that the companies present, on average, 23 points in environmental innovation, 53 in corporate governance, and 59.3 in R&D spending. Moreover, their assets and equity return, respectively, around 3.7% and 1.1% in profits. For each BRL 1.00 of total assets, the companies present capital of BRL 0.71 from third parties.

Panel B demonstrates that the companies with evidence of a value chain present, on average, higher levels of eco-innovation, R&D spending, leverage, return on equity, and corporate governance. This result offers a detailed profile of the extent of open innovation adoption throughout the value chain, demonstrating that companies with supplier-customer relationships seek additional opportunities to implement open innovation practices in all their connections (Póvoa & Monsueto, 2011; Theyel, 2013).

The study by Theyel (2013) pointed out that companies that develop products with their customers

Table 3
Descriptive statistics and t-test of means

Panel A - Descriptive statistics						
Variable	**Mean**	**Standard deviation**	**25th percentile**	**Median**	**75th percentile**	**Observation**
EIC	22.65	30.97	0	0	41.23	309
R&D	59.3	1.62	2.78	8.97	19.6	57
GVC	1.01	1.39	0	0	2	350
NVC	0.71	1.4	0	0	0	350
LEV	0.633	0.24	0.49	0.65	0.76	349
SIZ	23.68	1.27	22.95	23.74	24.46	349
ROA	0.037	0.72	0.010	0.041	0.068	349
ROE	0.011	1.54	0.046	0.121	0.187	349
SR	0.39	0.69	-0.005	0.24	0.605	326
CG	52.82	21.09	36.89	55.4	69.8	309

Panel B – T-test of means between groups of firms with and without evidence of value chain relationships								
Variables	**With a value chain**			**No evidence of a value chain**			**Student's t test**	
	Mean	**SD**	**Obs.**	**Mean**	**SD**	**Obs.**	***T***	**Significance**
EIC	27.96	32.41	131	18.48	29.34	178	2.632	0.008***
R&D	104.6	215.4	30	12.33	13.85	27	2.267	0.031**
LEV	0.71	0.27	135	0.586	0.207	214	4.421	0.000***
SIZ	24.36	1.24	135	23.25	1.087	214	8.497	0.000***
ROA	0.021	0.091	135	0.048	0.055	214	-3.083	0.002***
ROE	0.075	0.53	135	-0.028	1.925	214	0.75	0.46
SR	0.25	0.49	133	0.49	0.782	193	-3.39	0.000***
CG	59.68	16.96	131	47.88	22.37	178	5.25	0.000***

Note: SD: Standard deviation; Obs.: Observation.
Source: Elaborated by the authors.

are statistically larger. In line with this finding, Panel B shows that organizations with evidence of a value chain are also larger. However, those companies with supplier-customer relationships present a lower return on assets and normal return on equity.

4.2 Regression

Table 4 presents the results regarding the influence of value chains (global and national) on environmental innovation (Environmental Innovation Score). We tested multiple linear regression assumptions which did not present problems as demonstrated by the Jacques Bera (normality of residuals), Durbin Watson (autocorrelation of residuals), and variance inflation factor (multicollinearity between the variables) tests.

According to Table 4, the OLS regression models were significant and positive for the global value chain but irrelevant for the national value chain. However, when we add the control variables, the results are significant concerning leverage, size, and return on assets. Return on equity, stock return, and corporate governance were not relevant in this sample.

In economic terms, an increase of one standard deviation in the global value chain (Table 3, Panel A) is associated with a 23.48% increase in eco-innovation in relation to the mean [(1.39*3.826)/22.65]. Moreover, the model that adopts eco-innovation as a dependent variable has an explanatory power of approximately 21%, increasing by 5.11% when the control variables are added. Thus, this explanatory power reached a value equivalent to that evidenced by Moreira et al. (2020), who analyzed the innovative performance models of companies in the Brazilian industry.

We performed a sensitivity test to provide robustness to the findings of the primary analysis. Thus, we used another innovation variable: research & development spending. This test was applied to correct a possible bias caused by selecting a single environmental innovation variable derived from the ESG reports. Table 5 presents the sensitivity test results.

The models presented were significant and had an explanatory power that varied between 72.49% and 90.91%, making it possible to suggest that the sensitivity test models are more useful for the effect of the value chain on innovation when using R&D spending as a dependent variable, despite the low number of observations (57). Moreover, the global and national value chains present positive and significant relationships with R&D expenses. We can infer from this result that companies more engaged in customer-supplier relationships have higher innovation capacity.

Table 4
Regression Result (Equation 1)

Variables	Dependent Variable: Environmental Innovation Score			
	Coefficient	t statistic	Coefficient	t statistic
Constant	37.446***	3.93	-118.034**	-2.48
Global Value Chain	**5.178*** **	2.95	**3.826** **	2.14
National Value Chain	-1.405	-0.79	-1.949	-1.05
Leverage	-	-	**24.826** **	2.53
Size	-	-	**5.898*** **	3.15
Return on Assets	-	-	**86.453*** **	2.87
Return on Equity	-	-	0.171	0.17
Stock Return	-	-	0.126	0.04
Corporate Governance	-	-	-0.055	-0.66
Sector and Year Fixed Effects	Yes		Yes	
Significance of the Model	0.000***		0.000***	
R^2	21.49		26.60	
Adjusted R^2	17.47		21.16	
Jacques Bera	0.0003		0.0009	
Variance Inflation Factor	3.08		2.92	
Durbin-Watson	2.11		2.17	
Number of Observations	309		305	

Note: Significance levels: ** p<0.05, *** p<0.01.

Source: Elaborated by the authors.

Table 5
Sensitivity Test Results (Equation 2)

Variables	Dependent Variable: Research and Development			
	Coefficient	t statistic	Coefficient	t statistic
Constant	-7.27	-1.09	-2.17***	-5.40
Global Value Chain	**6.08*** **	2.93	**4.21** **	2.11
National Value Chain	**4.45** **	2.05	-3.23	-1.10
Leverage	-	-	-9.99	-1.14
Size	-	-	**1.01*** **	5.57
Return on Assets	-	-	1.54	0.90
Return on Equity	-	-	2.31	1.23
Stock Return	-	-	1.84	1.16
Corporate Governance	-	-	-2.21	-0.17
Sector and Year Fixed Effects	Yes		Yes	
Significance of the Model	0.000***		0.000***	
R^2	72.49		90.91	
Adjusted R^2	64.17		86.24	
Jacques Bera	0.0001		0.0015	
Variance Inflation Factor	3.15		5.02	
Durbin-Watson	0.071		0.072	
Number of Observations	57		57	

Note: Significance levels: ** p<0.05, *** p<0.01.

Source: Elaborated by the authors.

4.3 Discussion of results

Given the results presented in Tables 4 and 5, the GVC exerts a high explanatory power regarding the innovation of the sampled companies. Thus, the more active supplier-customer relationships a company has, the greater the market possibilities are through the technology of environmental products with ecological designs and higher R&D spending. This result corroborates Caetano and Amaral (2011) by associating the innovation of companies that work together and value chain enhancement, advancing the open innovation process through new learning opportunities. Moreover, according to Scarpellini et al. (2018), this finding is relevant to deepen the measurement and allocation of financial resources specific to eco-innovation.

Furthermore, this study shows that the NVC did not present significant results when the dependent variable was eco-innovation. That may be explained by the fact that these connections in Brazil do not receive the same institutional pressure compared to companies with a GVC since the latter connect to companies that operate in countries with higher institutional enforcement mechanisms regarding environmental practices. However, when analyzing R&D spending as a dependent variable, the findings are consistent with the results of Lema et al. (2015), as a NVC increases innovation capacity.

These results are consistent with the studies by Belussi et al. (2010), Paula and Silva (2018), Chabbouh and Boujelbene (2020), and Sahin et al. (2021), who showed a positive link between open innovation and the R&D process. These studies identified that using an external knowledge network allows companies to capture new knowledge, attracting connections and stimuli for higher investments in R&D and managers' concerns with eco-innovation.

The results also corroborate the findings by Theyel (2013) since innovation in organizations is a prominent factor and is influenced by the relationships between business partners. Moreover, for Shang et al. (2022), when companies invest in innovation, they find solutions to many problems, as these organizations recognize the benefits of the value chain, especially when the connections are global.

Regarding the control variables, Tables 4 and 5 highlight that leverage, size, and return on assets significantly impact innovation capacity. Concerning leverage, the higher the liability level, the greater the innovation level, a result corroborated by Belussi et al. (2010) and Scarpellini et al. (2018).

As for size and return on assets, the results are compatible with evidence from Chabbouh and Boujelbene (2020) since the company's performance characteristics are relevant to seeking higher innovation through R&D processes. Large companies are more likely to generate complex interactions and lead to more open innovation processes. These findings also corroborate Reinartz et al. (2019) by associating companies' innovation and performance, especially when they operate in business networks, which can bring more leverage.

Table 5 confirms the primary analysis (Table 4) regarding the relationship between a GVC and innovation capacity. Thus, we cannot reject H1, which assumes that "a GVC positively and significantly influences innovation capacity." However, unlike the primary analysis, NVC relationships showed only a positive and significant relationship for R&D, which partially supports H2, even though this result does not persist when we add the control variables.

The findings have implications for academics and professionals. For researchers, there is evidence on the scope and effects of open innovation practices and opportunities in different regional configurations of the value chain and its association with knowledge management and a greater innovation capacity in companies. Moreover, professionals can acquire insights into their business strategies by recognizing that adopting open innovation and value chain practices can encourage improvements in eco-innovation and the expansion of R&D spending.

On the other hand, this study raises the need to rethink public policies that influence the decisions of companies in Brazil regarding the disclosure of voluntary information, improving institutional enforcement mechanisms regarding environmental sustainability practices. Thus, national and global value chain strategies must consider the assumptions of open innovation to promote higher innovation capacity.

4.4 Ibovespa index and the national value chain

In addition to investigating the effect of global and national value chains on innovation capacity, this study identified the existing relationships between companies belonging to the Ibovespa index and the amount of textual evidence that indicates supplier-customer relationships. The amount of evidence extracted from news and files showing supplier-customer relationships was obtained from the Refinitiv Eikon database through the companies' value chain reports. We list the amount of textual evidence between each link in the respective arrows in Figure 2.

Out of the 70 investigated companies distributed in 10 sectors (Table 1), only 15 maintain relationships with companies of the same index distributed in six sectors. Furthermore, although the companies CPFL Energia, Eneva, Fleury, Klabin, Rumo, and Telefônica Brasil are on the Ibovespa, they have no connections with companies in this index. However, these firms are recognized in the NVC because they have relationships with other publicly traded national companies.

According to Figure 2, the cyclical consumption sector has companies in the NVC as customers and suppliers since Petrobras Distribuidora provides resources for Azul, Gol, and Centrais Elétricas Brasileiras and receives inputs from Petróleo Brasileiro Petrobras. Among these relationships, the strongest, in terms of supply, is the

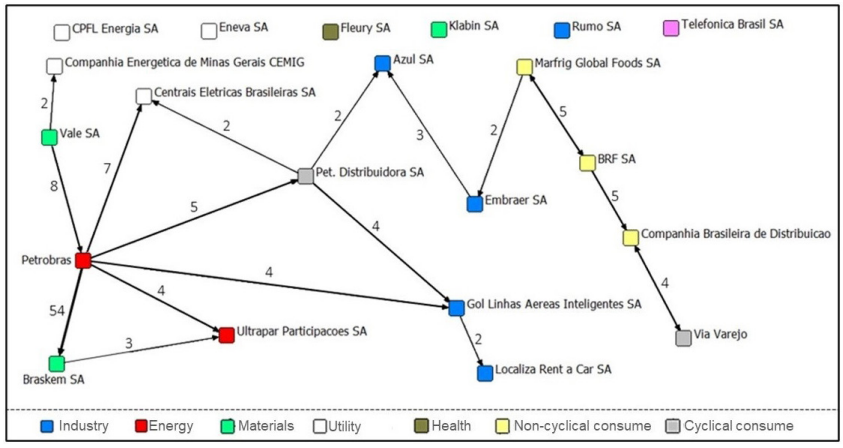

Figure 2. National Value Chain in the Ibovespa.

relationship with Gol, as four texts evidence this NVC, and regarding receipt, five texts show this association for Petrobras.

Companies in the utility sector have relationships exclusively as customers, as CEMIG was a consumer of Vale (two pieces of evidence), and Centrais Elétricas Brasileiras received supplies from Pet Distribuidora and Petrobras. In the energy sector, Petrobras supplying Braskem SA provided 54 textual pieces of evidence, consisting of the association with the highest number identified. It is noteworthy that Petrobras acted as a customer of Vale (eight pieces of evidence). Another company belonging to the energy sector was Ultrapar, a client of Petrobras (four pieces of evidence) and Braskem (three pieces of evidence).

As for the industry sector, only Azul and Localiza were represented in the NVC as customers since we found no evidence of supply relationships for these companies. On the other hand, Gol and Embraer had connections as customers and suppliers. Another relevant point to be highlighted was the supplier and customer relationship for the same company, as in Marfrig and BRF (five pieces of evidence) and Companhia Brasileira de Distribuição and Via Varejo (four pieces of evidence).

5 Conclusions

The objective of this study was to analyze the effect of global and national value chains on eco-innovation and R&D in the context of Brazilian companies in the Ibovespa. Through secondary data, we collected information that portrays the global and national value chains and economic-financial, market, and innovation variables.

The results show a positive and significant influence of the global value chain on eco-innovation and R&D spending, revealing that companies with higher scores in their supplier-customer relationships have improvements in environmental products with ecological designs and carry out more R&D spending. Thus, those companies with connections with firms from other countries besides national partnerships are more likely to have a greater innovation capacity.

When analyzing the national value chain, although it does not show a significant relationship with eco-innovation, a positive and significant effect on R&D expenses stands out. Considering that eco-innovation consists of voluntary disclosure, we infer that companies limited to maintaining relationships in Brazil do not receive the same institutional pressure as companies within a global value chain since the latter connect to firms in countries with higher institutional enforcement mechanisms concerning ESG practices.

This study provides practical contributions by showing, through empirical evidence, the range and effects of open innovation practices and opportunities in different regional dimensions of the value chain. Moreover, the research provides insights into possible business strategies by recognizing that adopting open innovation and value chain practices can increase eco-innovation and R&D expenses. Besides these implications, it suggests the need for public policies that influence the decisions of companies in Brazil regarding the disclosure of voluntary information and improving institutional enforcement mechanisms regarding sustainable practices.

This study covers only the value chain activities evidenced in the corporate reports published by the companies, which limits the understanding of activities and synergy effects between open innovation practices among different organizations. In addition, further investigation is needed through longitudinal, qualitative, and experimental research on the causal factors that affect the adoption of open innovation and value chain practices.

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Authors:
1. Lucas Benedito Gomes Rocha Ferreira, PhD in Accounting and Administration, Regional University of Blumenau, Blumenau, Brazil.
E-mail: lucasbenegrf@gmail.com
2. Denise Isabel Rizzi, PhD in Accounting, Federal University of Santa Catarina, Florianopolis, Brazil.
E-mail: rizzi.denise@gmail.com

3. Crisiane Teixeira da Silva, PhD Student in Accounting, Federal University of Santa Catarina, Blumenau, Brazil.
E-mail: crisiane.silva26@gmail.com
4. Valmir Emil Hoffmann, PhD in Business Administration, Federal University of Santa Catarina, Florianopolis, Brazil.
University of Zaragoza, Zaragoza, Spain.
E-mail: emil.hoffmann67@gmail.com

Authors' contributions:
1st author: Definition of research problem; development of hypotheses or research questions (empirical studies); development of theoretical propositions (theoretical work); definition of methodological procedures; data collection; statistical analysis; analysis and interpretation of data; manuscript writing.
2nd author: Definition of research problem; development of hypotheses or research questions (empirical studies); development of theoretical propositions (theoretical work); statistical analysis; analysis and interpretation of data; manuscript writing.
3rd author: Definition of research problem; development of theoretical propositions (theoretical work); statistical analysis; analysis and interpretation of data; manuscript writing.
4th author: Development of hypotheses or research questions (empirical studies); development of theoretical propositions (theoretical work); literature review; critical revision of the manuscript; manuscript writing.