ISSN: 2359-1048
Novembro 2023

PAYING TO BE GREEN: UNDERSTANDING THE ENVIRONMENTALPROACTIVITY AND ITS BENEFITS FROM BAYESIAN NETWORK

LEANDRO RODRIGUES
UNIVERSIDADE DE SÃO PAULO - USP

SIMONE VASCONCELOS RIBEIRO GALINA
ESCOLA POLITÉCNICA DA UNIVERSIDADE DE SÃO PAULO USP - ENGENHARIA DE PRODUÇÃO

Introdução
Firms need to be aware of environmental issues when developing their strategy. Many of them have changed their strategy from reactive to proactive. Thus, a theory highlighting a proactive environmental strategy has been developed. Considered a type of Dynamic Capability, this theory is relatively new, and the results related to Proactive Environmental Strategy (PES) and its outcomes are still inconsistent. Regarding that R&D plays a crucial role in eco-innovations, studies on PES as DC have yet to consider the complementarity between PES and R&D in their construct.
Problema de Pesquisa e Objetivo
To fill in the gaps pointed out by the literature, related to the Proactivie Environmental Strategy (PES) and the possible complementarity of internal R&D, this study aims to deepen the knowledge about the benefits of PES from a DC theory. To better comprehend the phenomenon, we investigate the PES outcomes adding the R&D as a condition for better results of PES; moreover, beyond environmental results, we deepened our analysis introducing business performance in the model.
Fundamentação Teórica
Proactive Environmental Strategy (PES) is based on the principle that firms develop environmental strategies not only to comply with regulations or to respond to external pressures (Garcés-Ayerbe & Cañón-de-Francia, 2017) but they act anticipating regulations and detecting environmental issues as opportunities (Aragón-Correa & Sharma, 2003). Defined as a Dynamic Capability (Aragón-Correa & Sharma, 2003) it is a relevant strategy for those firms that operate in contexts permeated by constant changes, it is positively related to innovation capability.
Metodologia
Quantitative Research. Database: Community Innovatio Survey (cis) Only innovative firms were considered. The sample consisted of 4,346 observations from 9 European countries. Method of analysis: bayesian network Variables of this study are related to proactive environmental strategy, business performance, internal R&D, product, process, market and organizational innovation, benefits from eco-innovation, and firm size.
Análise dos Resultados
The main benefits for environmentally proactive firms are material, energy, and pollution reduction, as well as recycling. We found evidence that when firms are environmentally proactive and invest in internal R&D, they provide benefits for end users. Another result is related to competitive advantage in costs by reducing materials, and energy consumption. Our findings did not evidence the relationship between PES and business performance. The benefits of PES are more evinced for firms, independent of the size. Considering end user, the benefit is basically for large firms with internal R&D.
Conclusão
We indicate further qualitative studies aiming to deepen the knowledge about the effect of proactive environmental strategies in periods of turbulence, for example: if firms environmentally proactive have a better performance during this periods. We also suggest research that investigates the micro-foundations of PES as DC, mainly in times of high levels of uncertainty, and to understand how these capabilities could be complemented by other organizational capabilities.
Referências Bibliográficas
Aragón-Correa, J. A., & Sharma, S. (2003). A contingent resource-based view of proactive corporate environmental strategy. Academy of management review, 28(1), 71-88. Garcés-Ayerbe, C., & Cañón-de-Francia, J. (2017). The relevance of complementarities in the study of the economic consequences of environmental proactivity: analysis of the moderating effect of innovation efforts. Ecological Economics, 142, 21-30.

Palavras Chave
Dynamic Capabilities, Eco-innovation, Research and Development

PAYING TO BE GREEN: UNDERSTANDING THE ENVIRONMENTALPROACTIVITY AND ITS BENEFITS FROM BAYESIAN NETWORK

1 INTRODUCTION

The organization clearly represents the negative impact on the environment mainly because of the quantity of waste generated or the large number of natural resources consumed by them. In this sense, firms play a crucial role when referring to environmental protection. To respond to regulatory and social pressure, firms have considered changing their strategies related to sustainability issues. In this context, firms have changed their behavior from reactive to proactive to solve environmental inefficiencies (Fraj et al., 2015).

Many studies have been carried out regarding environmental proactivity, that is, environmental strategies beyond compliance with regulations. However, the results are still heterogenous when considering the relationship between proactive environmental strategies and financial performance or competitive advantage (Delmas, Hoffmann, & Kuss, 2011).

For Delmas et al. (2011), these different results can be explained because, in general, research is rooted in economics that external evidence aspects and do not aim to understand the organizational capabilities that support environmental proactivity and, this way, achieve competitive advantage and,/or better financial performance.

Indeed, this heterogeneity found in the studies might also be due to the complexity of the Proactivity Environmental Strategy – PES (Sharma, Aragón-Correa, and Rueda-Manzanares, 2007) because this theory is relatively new (Fraj et al., 2015) and studies considering firm levels are still scarce (Lee & Min, 2015), therefore, there is a need of investigations that aim to deepen the knowledge about PES, mainly from Dynamic Capabilities lens.

Defined as a type of Dynamic Capability (Aragón-Correa & Sharma, 2002), firms environmentally proactive develop strategies not only to comply with regulations or external pressures but they go beyond (Aragón-Correa & Rubio-Lopez, 2007), they anticipate themselves to the regulations and in a proactive way detecting environmental issues as opportunities (Aragón-Correa & Sharma, 2002). As DC, it is a relevant approach for firms operating in dynamic contexts (Chan, Lai, & Kim, 2022), it is related to eco-innovation (Reyes-Santiago, Sánchez-Medina, & Díaz-Pichardo, 2019), firm performance (Benitez-Amado & Walczuch, 2012; Reyes-Santiago et al., 2019) and competitive advantage in costs (Garcés-Ayerbe & Cañón-de-Francia, 2017).

Studies in Corporate Social Responsibility have evidenced that R&D enhances knowledge and develops products and processes (McWilliams & Siegel, 2000); more precisely, R&D plays a crucial role in eco-innovations. However, the results are divergent (Tsai & Liao, 2017).

Indeed, studies on PES as DC have yet to regard the complementarity between PES and R&D in their construct. Sharma, Aragón-Correa, and Rueda-Manzanares (2007), conducting a study in the ski resort sector, comment that PES involves integrating internal knowledge supported by organizational capabilities. Internal R&D is the foundation of technological knowledge (Tsai & Liao, 2017); in this way, it might be necessary for PES.

To fill in the gaps pointed out by the literature, this study aims to deepen the knowledge about the benefits of PES from a DC theory. To better comprehend the phenomenon, we investigate

the PES outcomes adding the R&D as a condition for better results of PES; moreover, beyond environmental results, we deepened our analysis regarding business performance.

Another novelty of this research is related to the method; generally, the studies have been conducted from the econometric analysis method. As an alternative to econometric methods (Kim & Park, 2008), we carried out this research to analyze the probabilities of achieving environmental benefits and introduce eco-innovation.

The results suggest that firms can achieve results from PES related to costs by reducing materials, energy, as well as benefits for the end user. Therefore, this benefit is provided by PES jointly R&D for large firms. Another finding is associated with the type of innovation; PES is strongly related to process innovation; however, to achieve better PES outcomes, the firm size matters, but with the presence of internal R&D.

We did not find a relationship between business performance and PES; however, the sensitivity analysis shows that business performance is sensitive to product innovation and R&D; in this sense, firms environmentally proactive can have superior benefits from PES if they can complement this type of DC with other firm resources, such as R&D, which is highly associated to eco-innovation (Tsai & Liao, 2017).

This research is structured as follows: firstly, we developed a theory conceptualizing PES from DC theory and combining PES with R&D, from which we developed questions; in the next section, we present the methodological aspects followed by results and discussions; after these sections, we show theoretical, methodological, and managerial contributions; lastly, final considerations are presented.

2 THEORY BACKGROUND

2.1 PROACTIVE ENVIRONMENTAL STRATEGY FROM DYNAMIC CAPABILITY LENS

The conceptualization of PES is based on the principle that firms develop environmental strategies not only to comply with regulations or to respond to external pressures (Garcés-Ayerbe & Cañón-de-Francia, 2017) but they act anticipating regulations and detecting environmental issues as opportunities conditioned by the business environment (Aragón-Correa & Sharma, 2003), voluntarily firms go “beyond to regulatory requirements” (Aragón-Correa & Rubio-Lopez, 2007, p.358)

PES is developed by firms that voluntarily invest in resources or new products or processes, aiming to avoid negative environmental effects and remain competitive (Tsai & Liao, 2017). Defined as a Dynamic Capability (Aragón-Correa & Sharma, 2003; Moreno & Reyes, 2013; Garcés-Ayerbe & Cañón-de-Francia, 2017), it is a relevant strategy for those firms that operate in dynamic contexts permeated by constant changes (Chan, Lai, & Kim, 2022), it is positively related to innovation capability (Yang et al., 2019), eco-innovation (Reyes-Santiago, Sánchez-Medina, & Díaz-Pichardo, 2019), firm performance (Benitez-Amado & Walczuch, 2012; Reyes-Santiago et al., 2019), and competitive advantage (Mishra & Yadav, 2021) more precisely, the advantage in costs (Garcés-Ayerbe & Cañón-de-Francia, 2017).

From the DC lens, it is a high-order construct (Menguc, Auh, & Ozanne, 2010) that enables firms to integrate, build and reconfigure processes to achieve competitive advantage (Teece et al., 1997). Based on the Einsenhardt and Martin (2000) concepts of DC, Aragón-Correa, and Sharma (2003, p.74) state that PES is "dependent on the specific and identifiable process," "consists of the

best practices" with "commonality across the firms," "social complexity and organizational specificity," and "path dependent."

Finally, it is interesting to comment that PES is complex (Sharma, Aragón-Correa, and Rueda-Manzanares, 2007) and a relatively new theory (Fraj et al., 2015), and many researchers have made efforts to find positive results related to PES. However, there is a need for studies that aim to understand how firms can achieve these outcomes (Menguc, Auh, & Ozanne, 2010), such as financial performance or competitive advantage (Delmas et al., 2011)

2.2 PROACTIVE ENVIRONMENTAL STRATEGY AND R&D

McWilliams and Siegel (2000) argue that R&D investment is a type of technology investment that contributes to knowledge improvement and develops product and process innovation with a positive effect on productivity. Their findings suggest that R&D is associated with corporate social responsibility (CSR).

Regarding that CSR implies environmental strategies, we quote Lee and Min's (2015) findings, which suggest the positive impact of green R&D and general R&D on environmental proactivity, and Tsai and Liao's (2017) research, which points out a strong relationship between eco-innovation and R&D and development of technology. However, empirical studies have demonstrated that the results regarding this relationship are still inconsistent.

Because PES is a new theory (Fraj et al., 2015), it is clear the need for studies to advance the knowledge about this strategy. Following this reasoning and gaps pointed out by the literature, we propose a study based on the Bayesian network, aiming to deepen the understanding regarding PES as Dynamic Capability, eco-innovation, and its benefits, considering the complementarity with internal R&D. From these assumptions, we developed the questions:

Q1: What is the probability of firms having benefited from eco-innovations derived from PES, given the presence of internal R&D?

Q1: What is the probability of firms investing in eco-innovations driven by proactive environmental strategy, given the presence of internal R&D?

Q3: What is the probability of firms having high business performance driven by proactive environmental strategy, given the presence of internal R&D?

3 METHODOLOGICAL ASPECTS

Considering this research's objective, we conducted a quantitative study. Regarding that, we aim to deepen the understanding of variables related to the innovation field; the data were obtained from Community Innovation Survey (CIS2014) database once this database is generally used in innovation studies (Kim, Hoi, Tuam, & Trung, 2019). The data were collected from 2012 to 2014 inclusive, and comprised innovative European firms.

For this study, we considered only those firms which answered “yes” to the questions related to product/service and process innovation. After deleting missing values for interest variables, the sample consisted of 4,346 observations. Sample details are shown in Table 1.

Table 1: Sample description

Countries	**Firms' Size**		
	Small and medium	large	Total
Bulgaria	395	77	472
Estonia	95	22	117
Greece	412	84	496
Hungary	377	141	518
Lithuania	551	131	682
Latvia	118	32	150
Portugal	1,462	220	1,682
Romania	90	59	149
Slovakia	37	43	80
Total	**3,537**	**809**	**4,346**
Internal R&D			
No	1,735	271	2,006
yes	1,802	538	2,340
	3,537	**809**	**4,346**

Source: CIS2014

3.1 VARIABLES

Similar to Tsai and Liao (2017), we measured proactive environmental strategy (ENV_PROACT) from the question in which firms answered the question about the degree of importance regarding the driving factor of innovation with environmental benefits, the answer ranges from 0=not important to 3=high importance. Based on Chaminade et al. (2012), this variable was recoded, where 0 and 1 are low, and 2 and 3 are high.

TURNOVER is considered "one of the key measures of business's performance" (Madaleno, Robaina, & Meireles, 2020); based on this argument, we measured the question related to the total turnover in 2014. To fit this variable to the method of analysis, we discretized the continuous variable into three-categories variable, using method K-means (clustering) from RStudio, where values >= 5.47e+09 are high; values < 5.47e+09 and >= 1.61e+09 are medium, and values <1.61e+09 are low.

Internal R&D refers to the categorical question of whether firms have (1) or not (0) intramural R&D. Variables related to the benefits of eco-innovation were obtained from the question of whether the firm introduced product, process, organizational, or marketing innovation with any of these benefits (no=0; yes=1), benefits within the firms (ECOMAT; ECOENO; ECOPOL; ECOSUB; ECOREP; ECOREC) and benefits for end users (ECOENU; ECOPOS; ECOREA; ECOEXT).

Still considering the benefits of eco-innovation, we included in our model variables related to the type of innovation from which firms obtained these benefits (ECOPRD; ECOPROC; ECORG; ECOMKT), where no=0 and yes=1.

Variable FIRM_SIZE was operationalized from the average number of employees in 2014. We recorded these variables, 0=small and medium-sized firms and 1=large firm.

3.2 METHOD OF ANALYSIS

The Bayesian network was used to analyze the data and provide the probabilities according to questions. It is an appropriate method for innovation studies and an alternative method for those commonly applied in this kind of research, such as econometric methods (Kim & Park, 2008).

The Bayesian network comprises qualitative and quantitative characteristics. The qualitative aspect is evidenced by an acyclic graphic formed by nodes related to the variables and arcs that describe conditional independence; the parameters learning are the quantitative aspects regarding conditional probability distributions. From the Bayesian network, we can deepen the knowledge about causal relationships between variables, about a problem, and predict the effect of an intervention (Kim & Park, 2008).

This method is an exciting approach for learning causal relationships and deepening the knowledge about a problem or predicting the effect of an intervention (Kim & Park, 2008). We opted for PC algorithm because it is applicable to different data distributions and causal relations (Zhang, Schölkopf, Spirtes, & Glymour, 2018), "computationally efficient and asymptotically reliable" (Spirts, Glymour, & Scheines, 2000, p.122), and "one of the earliest and the most popular algorithm" (Bayesfusion, 2022, p. 488).

The software GeNIe Modeler was used, and it has been available freely for academic users (https://www.bayesfusion.com); this software applies a significance level of 0,05 for independence tests by default. To create the network, we provided background knowledge (Frame 1), and all missing values were deleted. Otherwise, the software does not work.

We provided the background knowledge following this reasoning: 1) characteristics of the firms which might influence the strategy and RRDIN investments; 2) variables that impact eco-innovation; 3) results of investments in RRDIN and environmental proactivity; 4) benefits from eco-innovation.

Frame 1 – Background knowledge

Temporal Tier 1	***Temporal Tier 2***	***Temporal Tier 3***	***Temporal Tier 4***
FIRM_SIZE	RRDIN	ECOPRD	ECOMAT
	ENV_PROACT	ECOPROC	ECOENO
		ECORG	ECOPOL
		ECOMKT	ECOSUB
			ECOREP
			ECOREC
			ECOENU
			ECOPOS
			ECOREA
			ECOEXT
			TURNOVER

Source: authors.

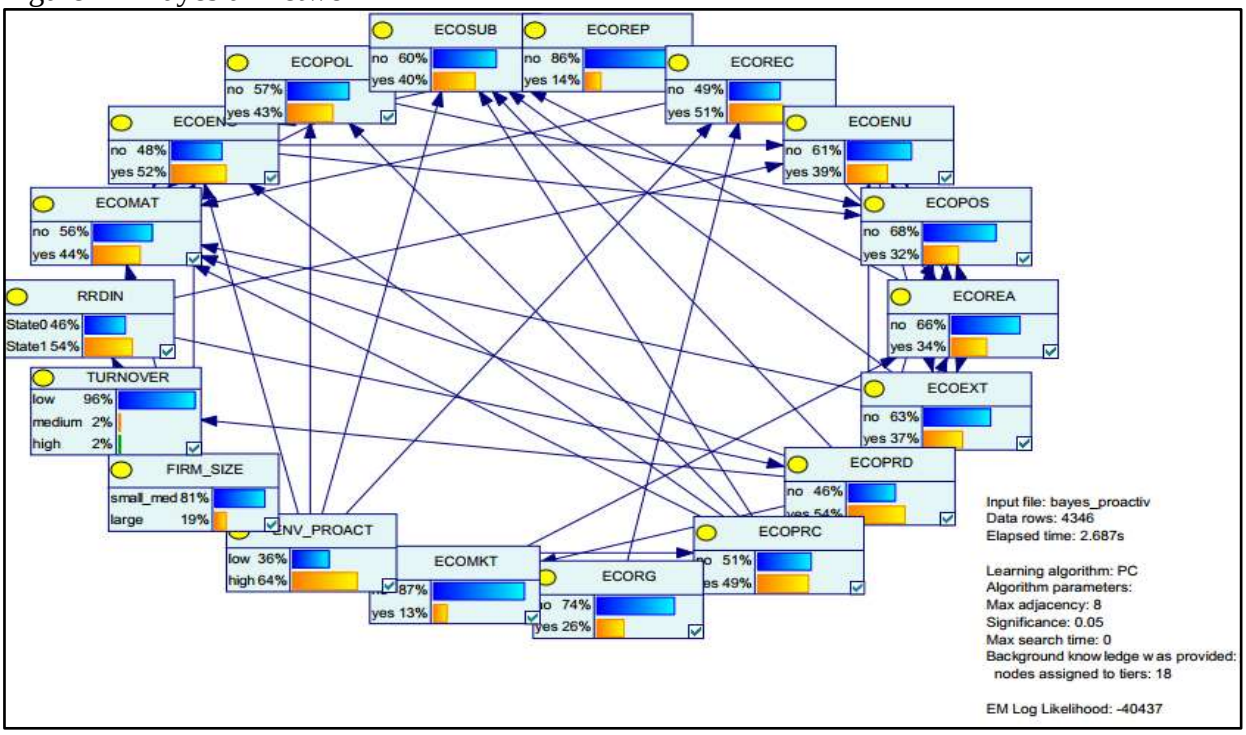
4 RESULTS

Figure 1 shows the Bayesian network provided by the software and its learning parameters. To better understand and respond to the questions developed from the literature review, we have

summarized the probabilities reported by the Bayesian network regarding different evidence for variables ENV_PROACT (Proactive Environmental Strategy) in Table 3 and Table 4. In Table 3, the answer "yes" for PES was evidenced as 100%, and in Table 4, the answer “no” was evidenced as 100%.

We also changed the evidence for other variables (RRDIN; FIRM_SIZE). However, we decided to make these changes to deepen the analysis of the behavior of the variable PES, given the presence of internal RRDIN and taking into account the characteristic of the firms, that is, whether the firm is large (=1) or small and medium (=0).

Figure 1 – Bayesian network



Source: GeNie Software

Regarding question 1, the results from the Bayesian network (Table 3) suggest that the higher probability of having benefits is related to the reduction of materials (ECOMAT), energy (ECOENO) and CO_2, pollution (ECOPOL), and recycling (ECOREC), these benefits are associated to firms. The findings also highlight benefits for end users related to reducing energy and CO_2 (ECOENU).

When analyzing the results given the presence of internal R&D, the findings show that internal R&D, practically, does not impact benefits considering materials reducing (61% for no R&D and 63% if firm have R&d). Therefore, these probabilities are relevant for large firms only. Regarding benefits associated with energy and CO_2 reduction, firm size plays a key role. For smaller firms, the probability of having this benefit is 56%, and 75% for large firms, independent of whether firms have internal R & D or not. The probability of obtaining benefits for recycling is 59%; firm size and R & D are irrelevant.

Interesting to highlight the benefits for end users related to the reduction of energy and CO_2. The results suggest that higher benefits (52%) were found for large firms and if the firm has internal R&D, that is, firm size and R&D matter.

Comparing Tables 3 and 4, we can observe that when firms have a low PES, there are no benefits derived from environmental proactivity, only from internal R&D related to eco-product innovation. This relationship can be confirmed from sensitivity analysis represented by the tornado diagram (APPENDIX D), evidencing that eco-product innovation (ECOPRD) is sensitive to RRDIN and FIRM_SIZE.

For question 2, related to the probability of developing eco-innovation driven by PES, the findings point out that PES impact only processes innovation, where the probabilities are 57% and 58%. This result is not influenced by internal R&D and firm size, and only those firms with high environmental proactivity invested in process innovation with environmental benefits.

Finally, to answer question 3, we analyzed the impact of PES on business performance (TURNOVER), and we found an impact only for low business performance. Hence, to better understand this finding, we conducted a sensitivity analysis (APPENDIX A, B, C); observing the tornado diagram, the results demonstrate that business performance is sensitive to product innovation, internal R&D, and firm size.

5 DISCUSSIONS

Our findings indicate that the main benefits for environmentally proactive firms are material, energy, and pollution reduction, as well as recycling, corroborating the current literature, which shows that the main goals of environmental management are, precisely, reduce pollution, the use of resources, and recycle materials (Potrich, Cortimiglia, & de Medeiros, 2019).

Therefore, these findings go beyond the firm's benefits; we found evidence that when firms are environmentally proactive and invest in internal R&D, they provide benefits for end users. In this sense, we argue that to achieve higher benefits from PES, firms need to combine other resources, for example, internal R&D (Aragón-Correa & Rubio-Lopez, 2007), which is associated with technological innovation and, in turn, highly associated with eco-innovation (Lee & Min, 2015).

Another interesting result is related to competitive advantage in costs by reducing materials, and energy consumption; in this way, building a high PES defined as DC, despite being costly, can contribute to the competitive advantage of the firms, as suggested by DC literature (e. g. Teece et al. 1997)

Different from Menguc and Ozanne (2010), but corroborating Madaleno et al. (2019), our findings did not evidence the relationship between PES and business performance; that is, the strategy of being environmentally proactive did not have the desired effect on sales growth, directly. Although using the same database, we investigated the effect of PES on business performance and the benefits of green innovation on firm performance. Once we found benefits in costs related to the effect of PES, we have distinct arguments about costs. However, we agree with Madaleno et al. (2019) that being environmentally friendly involves more significant financial resources, which might reduce a firm's motivation to invest in eco-innovation.

Nevertheless, we deepen the knowledge related to this result by providing an analysis of the complementarity between PES and the firm's resources, stressing the relevance of internal R&D. Once that business performance is influenced by product innovation and R&D, we can infer that firms can be benefited from the complementarity between R&D and PES. However, we did not verify a clear positive impact from R&D and product innovation on sales growth; the sensitivity test stresses some relationship between them.

Table 3 - Probabilities provided by Bayesian Network (high PES=1)

				FIRM BENEFITS						END-USER BENEFITS				EN
ENV_PROACT	FIRM_SIZE	RRDIN		ECOMAT	ECOENO	ECOPOL	ECOSUB	ECOREP	ECOREC	ECOENU	ECOPOS	ECOREA	ECOEXT	ECPRD
1	0	0	no	54%	44%	50%	56%	86%	41%	65%	67%	64%	65%	53%
			yes	46%	56%	50%	44%	14%	59%	35%	33%	36%	35%	47%
1	1	0	no	39%	25%	44%	53%	86%	41%	58%	65%	64%	64%	53%
			yes	61%	75%	56%	47%	14%	59%	42%	35%	36%	36%	47%
1	0	1	no	53%	44%	50%	53%	86%	41%	55%	62%	62%	60%	39%
			yes	47%	56%	50%	47%	14%	59%	45%	38%	38%	40%	61%
1	1	1	no	37%	25%	44%	51%	86%	41%	48%	60%	62%	59%	39%
			yes	63%	75%	56%	49%	14%	59%	52%	40%	38%	41%	61%

Source: GeNIe Modeler

Table 4 - Probabilities provided by Bayesian Network (low PES=0)

				FIRM BENEFITS						END-USER BENEFITS				
ENV_PROACT	FIRM_SIZE	RRDIN		ECOMAT	ECOENO	ECOPOL	ECOSUB	ECOREP	ECOREC	ECOENU	ECOPOS	ECOREA	ECOEXT	ECPRD
0	0	0	no	68%	63%	73%	73%	86%	63%	72%	77%	72%	69%	53%
			yes	32%	37%	27%	27%	14%	37%	28%	23%	28%	31%	47%
0	1	0	no	58%	55%	71%	72%	86%	63%	70%	76%	72%	68%	53%
			yes	42%	45%	29%	28%	14%	37%	30%	24%	28%	32%	47%
0	0	1	no	66%	62%	72%	72%	86%	63%	62%	72%	70%	63%	39%
			yes	34%	38%	28%	28%	14%	37%	38%	28%	30%	37%	61%
0	1	1	no	45%	54%	70%	70%	84%	63%	60%	72%	70%	63%	39%
			yes	55%	46%	30%	30%	16%	37%	40%	28%	30%	37%	61%

Source: GeNIe Modeler

In general, the benefits of PES are more evinced for firms, independent of the size; however, when considering end user, the benefit is basically for large firms with internal R&D. As argued before, firms can be benefited from the complementarity between PES and R&D. Therefore, we state that in a general way, the positive impact of complementarity on business performance through end users benefits and product innovation is better for large firms. Then, it is essential that "police makers take firm size as crucial into the relationship between eco-innovations and firm performance" (Madaleno et al., 2019).

Viewed from the DC lens, we can infer that PES is relevant, no matter the firm's size. Comparing both networks (high and low PES), it is clear the relevance for firms to invest in proactive environmental strategies, mainly combining with other firm resources.

PES as a type of DC goes beyond cost advantage; it contributes to the process and routine reconfiguration (Teece et al. 1997). On the other hand, it depends on the process and connection with environmental capabilities (Aragon-Correa & Sharma, 2003). PES becomes firms flexible and agile to respond to environmental changes; It is possible that because of the proactivity embedded in firms' processes, they can keep their competitiveness and survive in a context characterized by a high level of turbulence, such as financial crisis or pandemics or even after this period, by reconfiguring and recombining resources (e.g., Garcés-Ayerbe & Cañón-De-Francia, 2017).

6 CONTRIBUTIONS

We advance the literature, contributing to respond to Delmas et al. (2011, p.117) questions: "..are environmental strategies just the tip of the organizational iceberg? Are we missing the essential foundations of their success by focusing solely on environmental strategies? We can state that environmental strategies are, indeed, the "tip of the iceberg" To be successful in this strategy, managers need to be able to orchestrate other capabilities inside the firm, for example, the innovative capability from the R&D team, mainly if they need to achieve benefits to end users.

Regarding PES as a type of DC (Aragon-Correa & Sharma, 2003), this study contributes to the field by suggesting that PES is relevant for firms and end users. However, we state that a complementarity with other firm resources is relevant, such as in-house R&D. Defining PES as DC, we also advance the knowledge, considering that this theory is relatively new (Fraj et al., 2015).

Methodologically, carrying out research from the Bayesian network, we point out this analysis method as a novelty for the field once it is considered relevant for studies in innovation research (Kim & Park, 2008).

Related to practical contributions, this study suggests that managers develop their ability to orchestrate the environmental strategy and resources of the firms if they want higher performance in PES. For an advantage in costs, decision makers can develop environmental strategies considering process innovation, aiming to reduce materials and energy independent from firm size; however, if the objective is new products with environmental benefits for the users, R&D investments might be relevant for large firms.

7 FINAL CONSIDERATIONS

To deepen the understanding of PES and its benefits for the firms, quantitative research was conducted from Bayesian network analysis. The results suggest that PES is relevant for the firms to achieve an advantage in costs by reducing energy and materials; they also can obtain benefits for end users. However, these benefits depend on PES and internal R&D jointly. The findings also stress the

need to combine PES with other firms' resources, such as R&D, to improve environmental proactivity performance through product innovation.

This research contributes to the literature by providing evidence about the possible synergy between PES and the firm's resources, such as R&D. For DC field, this study highlights PES as DC, it contributes to the advantage in costs from process innovation and end-user benefits jointly R&D and also advances the theory once it is still relatively new (Fraj et al., 2015), and given the complexity of PES (Sharma, Aragón-Correa, and Rueda-Manzanares, 2007) the research contributes methodologically providing analysis from the bayesian network.

We conduct this study from Community Innovation Survey that comprises European Countries, considering a survey from 2012 to 2014, which is a limitation of this research. We encourage research to deepen knowledge about the complementarities of PES and other firms' resources in different contexts, such as Latin American countries.

Deeming that PES is contingent on the perceived uncertainty (Sharma et al., 2007), we indicate further qualitative studies to investigate the PES in a context with high levels of turbulence, which is a source of uncertainties, advancing the DC literature aiming to deepen the knowledge about the effect of proactive environmental strategies in periods of turbulence, for example: if firms environmentally proactive have a better performance during this periods.

We also suggest research that investigates the micro-foundations of PES as DC, mainly in times of high levels of uncertainty, and to understand how these capabilities could be complemented by other ones, for example, improvisation capability and operational capability, once there is a need for a study to investigate the interaction between these capabilities (Ma et al., 2021).

REFERENCES

Aragón-Correa, J. A., & Sharma, S. (2003). A contingent resource-based view of proactive corporate environmental strategy. *Academy of management review*, *28*(1), 71-88. https://doi.org/10.5465/amr.2003.8925233

Aragón-Correa, J. A., & Rubio-Lopez, E. A. (2007). Proactive corporate environmental strategies: myths and misunderstandings. *Long range planning*, *40*(3), 357-381. https://doi.org/10.1016/j.lrp.2007.02.008

BayesFusion, L. L. C. (2022). GeNIe Modeler. User Manual. Available online: https://support. bayesfusion. com/docs/

Benitez-Amado, J., & Walczuch, R. M. (2012). Information technology, the organizational capability of proactive corporate environmental strategy and firm performance: a resource-based analysis. *European Journal of Information Systems*, *21*(6), 664-679. https://doi.org/10.1057/ejis.2012.14

Chaminade, C., Intarakumnerd, P., & Sapprasert, K. (2012). Measuring systemic problems in national innovation systems. An application to Thailand. *Research Policy*, *41*(8), 1476-1488. https://doi.org/10.1016/j.respol.2012.04.004

Chan, R. Y., Lai, J. W., & Kim, N. (2022). Strategic motives and performance implications of proactive versus reactive environmental strategies in corporate sustainable development. *Business Strategy and the Environment*. https://doi.org/10.1002/bse.3011

Delmas, M., Hoffmann, V. H., & Kuss, M. (2011). Under the tip of the iceberg: Absorptive capacity, environmental strategy, and competitive advantage. *Business & Society*, *50*(1), 116-154. https://doi.org/10.1177/0007650310394400

Eisenhardt, K. M., & Martin, J. A. (2000). Dynamic capabilities: what are they? *Strategic management journal*, *21*(10-11), 1105-1121. https://doi.org/10.1002/1097-0266(200010/11)21:10/11<1105::AID-SMJ133>3.0.CO;2-E

Fraj, E., Matute, J., & Melero, I. (2015). Environmental strategies and organizational competitiveness in the hotel industry: The role of learning and innovation as determinants of environmental success. *Tourism management*, *46*, 30-42. https://doi.org/10.1016/j.tourman.2014.05.009

Garcés-Ayerbe, C., & Cañón-de-Francia, J. (2017). The relevance of complementarities in the study of the economic consequences of environmental proactivity: analysis of the moderating effect of innovation efforts. *Ecological Economics*, *142*, 21-30. https://doi.org/10.1016/j.ecolecon.2017.06.022

Kim, H., & Park, Y. (2008). The impact of R&D collaboration on innovative performance in Korea: A Bayesian network approach. *Scientometrics*, *75*(3), 535-554. https://doi.org/10.1007/s11192-007-1857-y

Kim, W. J., Hoi, T. V., Tuan, L. N., & Trung, N. N. (2019). R&D, training, and accessibility to finance for innovation: a case of Vietnam, the country in transition. *Asian Journal of Technology Innovation*, 27(2), 172-193. https://doi.org/10.1080/19761597.2019.1618720

Lee, K. H., & Min, B. (2015). Green R&D for eco-innovation and its impact on carbon emissions and firm performance. *Journal of Cleaner Production*, *108*, 534-542. https://doi.org/10.1016/j.jclepro.2015.05.114

Ma, H., Lang, C., Sun, Q., & Singh, D. (2021). Capability development in startup and mature enterprises. *Management Decision*, *59*(6), 1442-1461. https://doi.org/10.1108/MD-03-2020-0313

Madaleno, M., Robaina, M., Dias, M. F., & Meireles, M. (2020). Dimension effects in the relationship between eco-innovation and firm performance: A European comparison. *Energy Reports*, *6*, 631-637. https://doi.org/10.1016/j.egyr.2019.09.038

McWilliams, A., & Siegel, D. (2000). Corporate social responsibility and financial performance: correlation or misspecification? *Strategic management journal*, *21*(5), 603-609. https://doi.org/10.1002/(SICI)1097-0266(200005)21:5<603::AID-SMJ101>3.0.CO;2-3

Menguc, B., Auh, S., & Ozanne, L. (2010). The interactive effect of internal and external factors on a proactive environmental strategy and its influence on a firm's performance. *Journal of Business Ethics*, *94*(2), 279 298. https://doi.org/10.1007/s10551-009-0264-0

Mishra, P., & Yadav, M. (2021). Environmental capabilities, proactive environmental strategy, and competitive advantage: A natural-resource-based view of firms operating in India. *Journal of cleaner production*, *291*, 125249. https://doi.org/10.1016/j.jclepro.2020.125249

Moreno, C. E., & Reyes, J. F. (2013). The value of proactive environmental strategy: An empirical evaluation of the contingent approach to dynamic capabilities. *Cuadernos de Administración*, *26*(47), 87-118.

Potrich, L., Cortimiglia, M. N., & de Medeiros, J. F. (2019). A systematic literature review on firm-level proactive environmental management. *Journal of environmental management*, *243*, 273-286. https://doi.org/10.1016/j.jenvman.2019.04.110

Reyes-Santiago, M. D. R., Sánchez-Medina, P. S., & Díaz-Pichardo, R. (2019). The influence of dynamic environmental capabilities on the organizational and environmental performance of hotels: Evidence from Mexico. *Journal of Cleaner Production*, *227*, 414-423. https://doi.org/10.1016/j.jclepro.2019.04.245

Sharma, S., Aragón-Correa, J. A., & Rueda-Manzanares, A. (2007). The contingent influence of organizational capabilities on proactive environmental strategy in the service sector: An analysis of North American and European ski resorts. *Canadian Journal of Administrative Sciences/Revue Canadienne des Sciences de l'Administration*, *24*(4), 268-283 https://doi.org/10.1002/cjas.35

Spirtes, P., Glymour, C., & Scheines, R. (1993). Causation, Prediction, and Search. The MIT Press. https://doi.org/10.1007/978-1-4612-2748-9

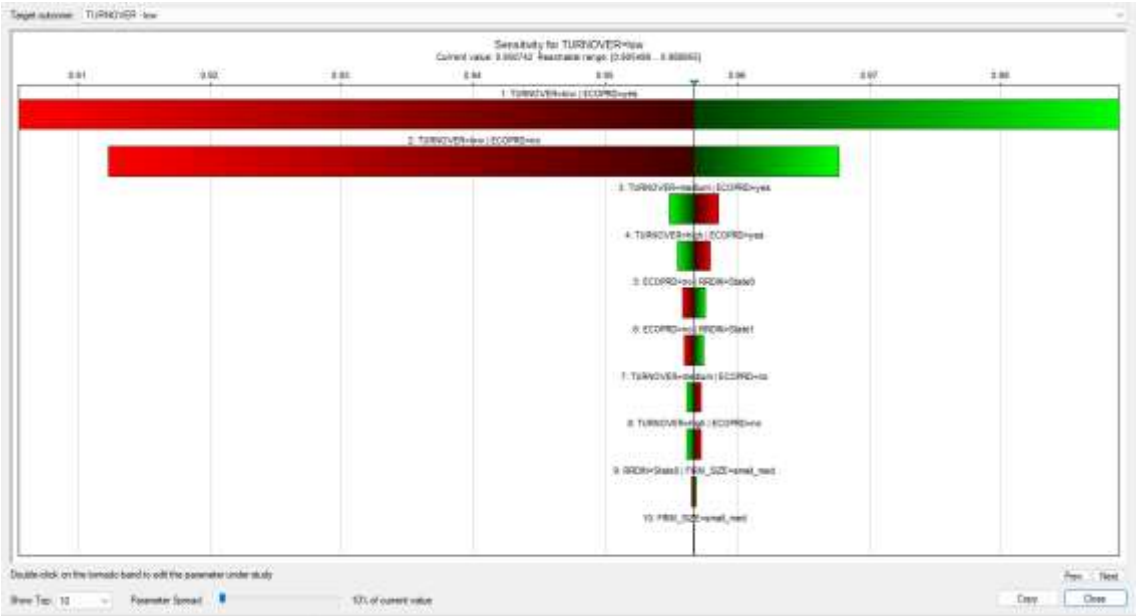
Teece, D. J., Pisano, G., & Shuen, A. (1997). Dynamic capabilities and strategic management. *Strategic management journal*, *18*(7), 509-533. https://doi.org/10.1002/(SICI)1097-0266(199708)18:7<509::AID-SMJ882>3.0.CO;2-Z

Tsai, K. H., & Liao, Y. C. (2017). Sustainability strategy and eco-innovation: A moderation model. *Business Strategy and the Environment*, *26*(4), 426-437. https://doi.org/10.1002/bse.1926

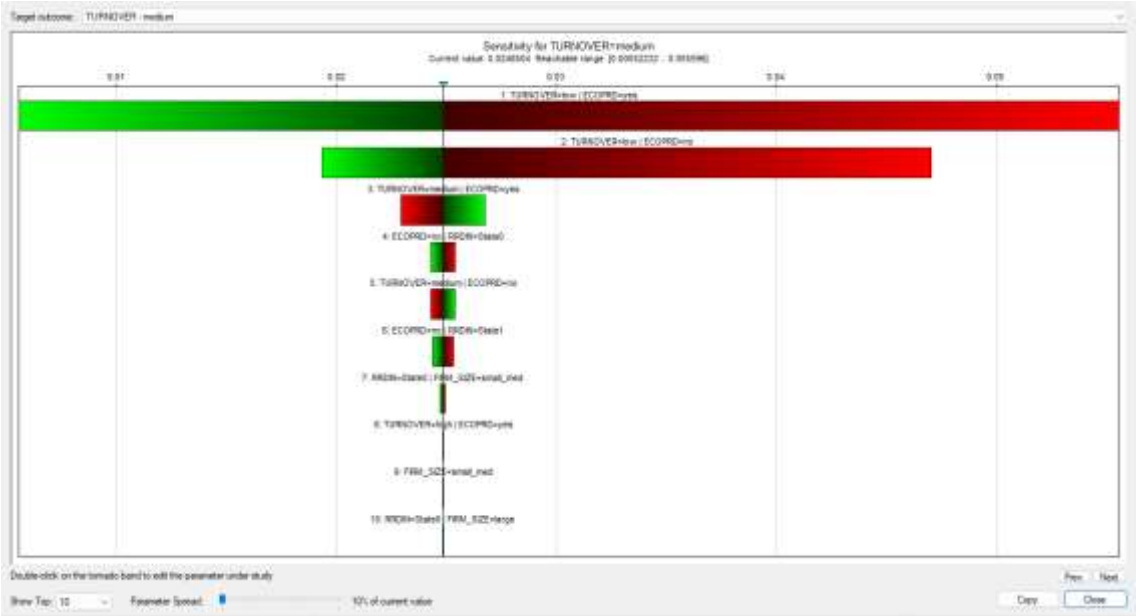
Yang, D., Jiang, W., & Zhao, W. (2019). Proactive environmental strategy, innovation capability, and stakeholder integration capability: A mediation analysis. *Business Strategy and the Environment*, *28*(8), 1534-1547. https://doi.org/10.1002/bse.2329

Zhang, K., Schölkopf, B., Spirtes, P., & Glymour, C. (2018). Learning causality and causality-related learning: some recent progress. *National science review*, *5*(1), 26-29. https://doi.org/10.1093/nsr/nwx137

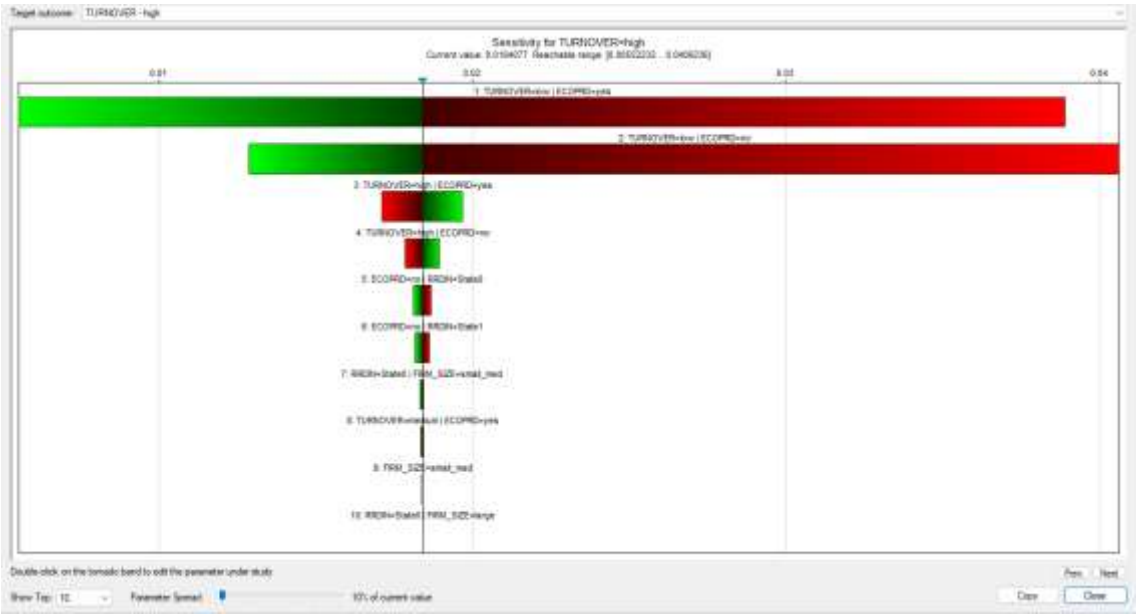
APPENDIX A



APPENDIX B



APPENDIX C



APPENDIX D


Sensitivity for ECOPRD=yes
Current value: 0.544839 Resample range: [0.520941 ... 0.569236]
0.53
0.54
0.55
0.56
1: ECOPRD=no | WRDH=State0
2: ECOPRD=no | WRDH=State1
3: WRDH=State0 / FIRM_SIZE=small, med
4: FIRM_SIZE=small, med
5: WRDH=State0 / FIRM_SIZE=large
Double-click on the tornado band to edit the parameter under study
Prev
Next
Show Top: All (5)
Parameter Spread:
100 of current value
Copy
Close