Combinatorial analysis of eco-innovation drivers in slaughterhouses

Marcelo Fernandes Pacheco Dias and Juliany Souza Braga
Departamento de Ciências Sociais Rurais, Universidade Federal de Pelotas, Pelotas, Brazil

Received 11 July 2020
Revised 2 October 2020
Accepted 2 December 2020

Abstract

Purpose – Literature on eco-innovation brings insights that help to understand which factors trigger innovation focused on sustainability in companies. However, when analyzing the studies that comprise such drivers, it appears that most of them were focused only on describing them in isolation. Therefore, this study aims to understand which are the combinations of drivers that favor the adoption of eco-innovation in slaughterhouses located in the Brazilian state of Rio Grande do Sul.

Design/methodology/approach – This study has used the crisp-set qualitative comparative analysis (csQCA) as the data analysis technique, in addition to the previous application of Most Similar Different Outcome/Most Different Same Outcome (MSDO/MDSO).

Findings – This study identified eight internal and external drivers that explain the differences in performance of eco-innovative and non-innovative slaughterhouses. These drivers generate 13 combinations of factors capable of favoring the adoption of five types of eco-innovation.

Research limitations/implications – A limitation identified was the difficulty to obtain information held by companies on environmental issues. In addition, in each company the authors only approached one respondent.

Practical implications – The use of combinations is identified by companies and governmental and non-governmental organizations to promote eco-innovation in slaughterhouses.

Originality/value – This study may be considered original for its contribution to the improvement of eco-innovation literature by describing how the drivers identified combine to favor the adoption of certain types of eco-innovation. In addition, the authors also made an original use of csQCA, linked with MSDO/MDSO, in the field of eco-innovation.

Keywords Eco-innovation, Drivers, Eco-innovation types, Qualitative comparative analysis, Análise Qualitativa Comparativa., Direcionadores., Ecoinovação, Tipos de ecoinovação

Paper type Research paper

1. Introduction

In the agro-industrial sector, the discussion on sustainability and the need for innovation becomes quite obvious because the sector makes strong use of natural resources, in addition to playing an important role in the world economy and people's quality of life. In Brazil, the slaughterhouse industry has a considerable prominence due to its increasing productive

Innovation & Management Review
Vol. 19 No. 4, 2022
pp. 306-321
Emerald Publishing Limited
2515-8961
DOI 10.1108/INMR-07-2020-0094

capacity. The activities in this industry deeply influence the society (farmers, industries, governments, communities and consumers) and provide economic benefits for several communities and farmers, whether in small-, medium- or large-scale farming. Moreover, the industry is responsible for the commercialization of beef – among other animal-derived products – an important source of high-quality protein consumed by many people.

This is where the concept of eco-innovation, as an alternative for environmental policies and management, comes in Breier (2015). According to OECD, eco-innovation can be defined as:

> [. . .] the creation of products (goods and services), processes, marketing methods, organizational structures and new or significantly improved institutional arrangements that, intentionally or not, lead to environmental improvements in comparison to relevant alternatives. (OECD, 2009, p. 2).

Díaz-García, González-Moreno and Sáez-Martínez (2015) claim that, although the studies on eco-innovation are quite recent, they have been increasing since the late 1990s. When analyzing the main research on eco-innovation, Díaz-García, González-Moreno and Sáez-Martínez (2015) found six main categories, namely, performance, drivers, processes, types, policy and others. In the same study, they concluded that the main research topic are the drivers of eco-innovation (Díaz-García, González-Moreno and Sáez-Martínez., 2015). However, most of the studies were only focused on describing such drivers; there was, therefore, no analysis of possible combinations among them that could favor the development of certain types of eco-innovation by companies.

Considering the lack of studies on how these drivers combine in order to favor the development of several types of eco-innovation, our research sought to answer the following research question:

RQ. Which combinations of eco-innovation drivers favor the adoption of eco-innovation in slaughterhouses?

To address this issue, we intend to understand which combinations of eco-innovation drivers favor the adoption of certain types of eco-innovation in slaughterhouses. The research was carried out in the state of Rio Grande do Sul and surveyed nine slaughterhouses. Seven of them are provided with federal inspection service, which means these establishments can sell products to other Brazilian states or to other countries (exports). The other two count on state inspection service, indicating they can only commercialize products within the state of Rio Grande do Sul.

The main contribution of this article is the advancement in eco-innovation literature as it relates the drivers to the types of eco-innovation and describes how these drivers combine in order to favor the adoption of certain types of eco-innovation by companies. In addition, we also expect to contribute to the dissemination of the qualitative comparative analysis (QCA) method in the field of eco-innovation. The QCA method is based on the binary logic of Boolean algebra, including binary variables, combinatory logic and application of Boolean operators, thus enabling the understanding of how variables combine to generate certain results (Fiss, 2009; Greckhamer, Furnari, Fiss and Aguilera, 2018) in a small sample (Rihoux and Meur, 2009), as will be discussed with further detail in the methodology.

2. Types of eco-innovation

Before properly discussing the types of eco-innovation, it is important to initially revisit the concept of eco-innovation. Schiederig, Tietze and Herstatt (2012) identified that there are several terms and definitions that are used to describe eco-innovation, namely, eco-innovation, environmental innovation and green innovation. When analyzing these terms and definitions, Schiederig et al. (2012, p. 182) state that the several definitions are similar as they cover six analogous aspects:

(1) Innovation object: product, process, service, method.
(2) Market orientation: internal/external focus.
(3) Environmental aspect: reduction of negative impacts.
(4) Stage: the complete lifecycle must be considered.
(5) Impulse: the intention for reduction may be either economic or ecologic.
(6) Level: new innovation/green standards.

Despite the similarity among terms and definitions, the focus of this section is to describe and compare the types of eco-innovation proposed by Kemp and Pearson (2007) and Andersen (2008). The choice for the types of eco-innovation indicated in Kemp and Pearson (2007) relates to the breadth of the concept in relation to the six above-mentioned aspects, as analyzed by Schiederig et al. (2012). Kemp and Pearson (2007) define that eco-innovation focuses on products, processes and services that aim at reducing environmental impacts while considering the innovation life cycle. Furthermore, the definition created by Kemp and Pearson (2007) was used in the final report of the MEI project (Measuring Eco-innovation), a project for DG Research of the European Commission.

Yet, regarding Andersen's (2008) types of eco-innovation, the author defines eco-innovation from the perspective of attracting green rents on the market and competitiveness, associating eco-innovation to the economic process itself. In addition, the proposition of Andersen's (2008) types of eco-innovation was acknowledged in the field after its publication in the 25th Celebration DRUID Conference Entrepreneurship and Innovation. Finally, it is important to mention that Kemp and Pearson (2007) are still the most cited authors in most recent articles on eco-innovation (Albort-Morant, Henseler, Leal-Millan and Cepeda-Carrion, 2017; Calza, Parmentola and Tutore, 2017; Rabêlo and Melo, 2018), as well as Andersen (2008) (Bitencourt, Oliveira, Zanandrea, Froehlich and Ladeira, 2020; Pakura, 2020).

According to Kemp and Pearson (2007), eco-innovations can be of the following types:

- Environmental technologies including pollution control, waste water treatment, treatment of pollution released into the environment, new manufacturing processes that are less polluting and/or more resource efficient, waste management equipment, environmental monitoring and instrumentation, green energy, water supply and noise and vibration control.
- Organizational innovation for the environment that introduces organization methods and management systems to deal with environmental issues in production and products.
- Product and service innovation offering environmental benefits through new or improved products and environmentally beneficial services.
- Green system innovations, which are characterized as alternative systems of production and consumption that are environmentally more benign than the existing systems.

Yet, Andersen (2008) proposed a taxonomy that involves key types of eco-innovations, reflecting their different roles in a green market. She suggests five categories of eco-innovation, which will be further analyzed below.

Add-on eco-innovations refer to products (artifacts or services) that improve the customer's environmental performance (Andersen, 2008). Products or services that improve the customer's environmental performance include technologies and services that clean up, dilute, recycle, measure, control and transport pollution, as well as the ones that improve the supply of natural resources and energy (Andersen, 2008). Technologies and services typically have limited systemic effect as they are usually added on existing production and consumption practices (which is profitable) without significantly influencing these (Andersen, 2008).

Integrated eco-innovations are innovations that make the production process or the product more eco-efficient than similar processes or products (Andersen, 2008). Therefore, the companies that invest in integrated innovations (through its purchase and/or development) intend to appear more eco-efficient than similar competitors, either in the global environmental performance of the company or in the environmental impact of the product (Andersen, 2008). The innovations are mainly technical, but they can also be organizational, entailing changes in the organization of production and management within an organization (Andersen, 2008).

Alternative product eco-innovations represent a radical technological discontinuation (Andersen, 2008). They are not cleaner than similar products but offer more beneficial solutions for existing products. These radical innovations have major systemic effects; constitute new theories, capacities and practices and may demand a change of both standard of production and consumption (Andersen, 2008). Some examples are the renewable energy technologies (opposing to technologies based on fossil fuels) and the biological agriculture (opposing to conventional agriculture) (Andersen, 2008).

Macro organizational eco-innovations imply new solutions for an eco-efficient form of organization of society. This means new forms of organizing our production and consumption towards a more systemic level, implying new functional interactions among organizations, for instance, among companies (industrial symbiosis), among families and workplaces and new forms of organization of cities and their technical infrastructure ("urban ecology") (Andersen, 2008).

General purpose eco-innovations are technologies of general use that deeply affect the economy and, more specifically, the process of innovation, lying behind a series of technological innovations and, therefore, defining the dominant technological-economical paradigm, such as the positive effects of information and communication technology, biotechnology and nanotechnology (Andersen, 2008).

Based on the comparative analysis of the types of eco-innovation proposed by Kemp and Pearson (2007) and Andersen (2008), a synthesis regarding the types of eco-innovation found in literature is presented below (Table 1).

3. Eco-innovation drivers

When analyzing which drivers affect eco-innovation, two broad literature reviews are highlighted. The first concerns the publication of Díaz-García, González-Moreno and Sáez-Martínez (2015), in which data were collected from the Scopus database – the search offered 384 articles. The second review was carried out by Bossle, Dutra de Barcellos, Vieira and Sauvée (2016), who had identified initially in their literature review 658 articles in the ISI Web of Knowledge database. Considering the range of the two literature reviews and the importance of the two research databases for science, the aim of this section is to describe and compare the two above-mentioned research.

Díaz-García, González-Moreno and Sáez-Martínez (2015) proposed a multi-level framework of eco-innovation drivers classifying them in three levels: micro (particular characteristics of the individual or company), meso (characteristics that involve multi-stakeholders) and macro (national and international political characteristics).

Type	Definition	Author	Abbreviation
Integrated eco-innovations	They relate to integrated innovations that make the process of production or the product more eco-efficient than similar processes or products.	Andersen (2008); Kemp and Pearson (2007)	ITEC
Environmental technologies of pollution control	They pollution control-related technologies, such as wastewater treatment, clean-up of pollution released in the environment, new cleaner manufacturing processes and/or that use the resources more efficiently, equipment to treat waste, and noise control.	Kemp and Pearson (2007)	TAMB
Organizational and macro-organizational innovation	It introduces organization methods and management systems to deal with environmental issues in the production and products. It includes systemic solutions among organizations	Kemp and Pearson (2007); Andersen (2008)	IORG
Add-on eco-innovations	They are products (artifacts or services) that improve the customer's environmental performance, including technologies and services that clean, dilute, recycle, measure, control and transport the pollution as well as the ones that improve the supply of natural resources and energy.	Andersen (2008)	IADI
Green innovation systems – alternative products	Alternative production and consumption systems that are environmentally more benign than the existing ones.	Kemp and Pearson (2007); Andersen (2008)	ISIS
General Purpose	Technologies of general use that affect the economy and may contribute for a series of other innovations	Andersen (2008)	EPG

Notes: ITEC (Integrated ecologic innovations); TAMB (Environmental technologies of pollution control); IORG (Organizational and macro-organizational innovation); IADI (Add-on eco-innovations); ISIS (Green innovation systems – alternative products); EPG (General Purpose)
Source: Research data

Table 1.
Types of eco-innovations applied in the survey

From a macro level perspective, Díaz-García, González-Moreno and Sáez-Martínez (2015) affirm that there is some agreement in literature that regulation fosters eco-innovation and helps its dissemination. In addition, they concluded that there is no trade-off between eco-innovation and higher profit margins, which suggests that political decision-makers may stimulate growth and create a greener society. Concerning the political instruments, they propose, for example, that more flexible forms of regulatory governance as well as direct regulation are efficient in the induction of eco-innovations, as the companies behave differently when faced with peculiar forms of regulation (Díaz-García, González-Moreno and Sáez-Martínez2015). Still at the macro level, the authors consider rurality as very important for the performance of eco-innovation, due to its closeness to climate changes and the exposure of companies in their local communities.

At the meso level, Díaz-García, González-Moreno and Sáez-Martínez (2015) realized that several studies observe that the customers' perception or demands may explain the company decision to engage in eco-innovation. In addition to customers, lobby groups or interested parties were pointed out as another force that influences the engagement of companies in eco-innovation practices. Building networks with other companies and institutions, authorities and research institutions was also pointed out as an important driver. It is noted that entrepreneurs that give importance to collaboration with research institutes, agencies and universities are more active in all types of eco-innovations. Finally, another factor identified by the authors is the sector the company operates in, as they affirm that assuring safe production, transport, handling of its products and caring for the environment and being in full compliance with the regulations is of fundamental importance for the image and the reputation of the industry nowadays (Díaz-García, González-Moreno and Sáez-Martínez, 2015).

At the micro level, the drivers identified were the company's size, age, strategy, business logic (for example, cost savings, market expansion) or its technological competences (for instance, R&D, path dependence) (Díaz-García, González-Moreno and Sáez-Martínez, 2015).

Unlike Díaz-García, González-Moreno and Sáez-Martínez (2015), Bossle, Dutra de Barcellos, Vieira and Sauvée (2016) divided the drivers for eco-innovation in two categories, namely, internal and external. The external drivers are those determined by circumstances outside the company. They are as follows:

- Regulatory pressures, determined by the governments, considering that the non-compliance of regulations can be very costly for the company (at the local, regional and international level).
- Normative pressures related to legitimacy as the organizations compare themselves to their peers and try to behave according to prevailing standards or rules in the same institutional field; market and society demand through environmentalists, customers and suppliers.
- Cooperation with suppliers, customers, competitors, consultants, universities, R&D public laboratories and technology centers.
- Market expansion that may work as an incentive for companies to invest in eco-innovation.
- Technology associated with the characteristics of the technologic environment at the industry level.
- Governments are pressed to develop campaigns aimed at increasing the level of the market environmental awareness.

Yet the internal drivers are those determined by circumstances within the company (Bossle, Dutra de Barcellos, Vieira and Sauvée, 2016). They are as follows:

- Efficiency by reducing costs due to environmental improvements, updating equipment and making investments in R&D.
- Certifications, for example, ISO 14001, which leads to the adoption of an Environmental Management System (EMS).
- Environmental management concerns, as the main executives play an important role for choosing eco-innovation and for the integration of innovation and sustainability into the company's strategy.
- Environmental leadership, as a dynamic process, in which an individual influences others to contribute to the implementation of environmental management and environmental innovations.
- Environmental culture as a symbolic context of environmental management and environmental innovations in which the interpretations guide the behavior and the processes of members' sensemaking.

- Company environmental capability to integrate, coordinate, build and reconfigure its competences and resources to carry out environmental management and environmental innovations.
- Human resources through employee participation in the innovation process and training for employees; thus the company can rely on high skilled personnel.
- Performance through measures, such as sales growth, market share and return on investment.

Still according to Bossle, Dutra de Barcellos, Vieira and Sauvée (2016), there are some factors that may influence the use or not of eco-innovations by the company; they are known as control variables. They are as follows:

- Company size, i.e. the structural characteristics that trigger eco-innovations.
- Public funding, which is relevant to promote the introduction of eco-innovation through training and subsidizing.
- Sector influence, according to its impact on the environment.

To summarize the information presented in this section, we elaborated Table 2, which illustrates a comparative analysis of the drivers proposed by Díaz-García, González-Moreno and Sáez-Martínez (2015) and Bossle, Dutra de Barcellos, Vieira and Sauvée (2016). For Bossle, Dutra de Barcellos, Vieira and Sauvée (2016), company size, public funding and the sector in which the company operates are considered variable controls. However, we decided to include them in the categories internal (company size) and external (funding and sector).

4. Method and procedures

We will present in this section relevant information regarding the method we used to develop our article.

4.1 Qualitative comparative analysis and its features

The research technique used in this study was the QCA. This method was designed to solve a problem found in comparative case studies, which is to preserve the cases with complex configurations of explanatory factors while enabling the analysis of similarities and differences (Ragin, 2014).

One characteristic of QCA and its application is that it is a technique meant to be applied in small- and medium-sized samples. Technically speaking, the small-N zone is often associated with a very small number of cases – let us say, between 2 and 10 (despite being a "very small N", it still allows for some form of binary comparison). The intermediate zone comprises approximately 10 to 15 cases, yet it is still a very small number of cases in comparison to the demands of most quantitative techniques (Ragin, 2014).

4.2 Methodological procedures

Before describing the methodological procedures used in this article, it is important to mention that there is a detailed manual of all steps of the QCA method and its mathematical reasons including orientation for the use of support software in Ragin (2009). According to Dias and Pedrozo (2015), several articles have been published in the last few years that describe and clarify the QCA technique (Fiss, 2009; Greckhamer et al., 2018), but articles originating from Latin America are still scarce.

Drivers	Definition	Author	Abbrev.
Regulatory pressures	Determined by the governments, the non-compliance of regulations can be very costly for the company (at the local, regional, and international level)	Díaz-García, González-Moreno and Sáez -Martínez (2015) and Bossle, Dutra de Barcellos, Vieira and Sauvée (2016)	REG
The role of the governments	The government is pressed to develop campaigns aimed at increasing the level of market environmental awareness	Bossle, Dutra de Barcellos, Vieira and Sauvée (2016)	GOV
Cooperation	Cooperation with suppliers, clients, competitors, consultants, universities, R&D labs, technology centers, stakeholders, and network participation	Díaz-García, González-Moreno and Sáez -Martínez (2015) and Bossle, Dutra de Barcellos, Vieira and Sauvée (2016)	STA
Market expansion	The expansion of participation in the market may work as an incentive for the companies to invest in eco-innovation, considering increasing demands by stakeholders.	Díaz-García, González-Moreno and Sáez-Martínez (2015) and Bossle, Dutra de Barcellos, Vieira and Sauvée (2016)	EXM
Technologic Environment at the industry level	Characteristics of the technologic environment at the industry level	Bossle, Dutra de Barcellos, Vieira and Sauvée (2016)	TEC
Public funding	Public funding is significant to promote the introduction of eco-innovation through training and subsiding	Bossle, Dutra de Barcellos, Vieira and Sauvée (2016)	FIN
Business System	Sector and cluster influence according to their impact on the participating organizations	Díaz-García, González-Moreno and Sáez -Martínez (2015) and Bossle, Dutra de Barcellos, Vieira and Sauvée (2016)	SFR
Efficiency	I) Cost savings due to environmental improvements; II) Motivations for equipment updating; III) Investments in R&D and EMS Systems (Organizational Capability)	Bossle, Dutra de Barcellos, Vieira and Sauvée (2016)	EFI
Certifications	Certifications, for instance, ISO 14001, lead to the adoption of an Environmental Management System (EMS)	Díaz-García, González-Moreno and Sáez -Martínez (2015) and Bossle, Dutra de Barcellos, Vieira and Sauvée (2016)	CER
Environmental management concerns	The main executives play an important role in the establishment of eco-innovation and the integration of innovation and sustainability in the company's strategy	Bossle, Dutra de Barcellos, Vieira and Sauvée (2016)	GER
Environmental culture	A symbolic context of environmental management and environmental innovations in which the interpretations guide the behavior and process of members "sensemaking"	Díaz-García, González-Moreno and Sáez -Martínez (2015)	CUL
Qualified Human Resources	Participation of employees in the innovation and training for employees, so the company can rely on high skilled personnel	Bossle, Dutra de Barcellos, Vieira and Sauvée (2016) Díaz-García, González-Moreno and Sáez -Martínez (2015)	QUAL
Company size	Structural characteristics that provide eco-innovations	Bossle, Dutra de Barcellos, Vieira and Sauvée (2016) Díaz-García, González-Moreno and Sáez -Martínez (2015)	TAM

Notes: REG (Regulatory pressures); GOV (The role of the governments); STA (Cooperation); EXM (Market expansion); TEC (Technologic Environment at the industry level); FIN (Public funding); SFR (Business System); EFI (Efficiency); CER (Certifications); GER (Environmental management concerns); CUL (Environmental culture); QUAL (Qualified Human Resources); and TAM (Company size)
Source: Based on Bossle, Dutra de Barcellos, Vieira and Sauvée (2016) and Díaz-García, González-Moreno and Sáez -Martínez (2015)

Table 2. Drivers used in the survey

In this article, we used the crisp set QCA (csQCA) technique. According to Dias and Pedrozo (2015), the method involves three distinct phases: definition of cases and causal conditions; identification of the explanatory causal conditions and combinations of causal conditions; and, finally, assessment and interpretation of the results, which is the presentation and data analysis itself (Section 4).

4.2.1 Definition of cases, causal conditions and performances. The selection of slaughterhouses took into consideration the companies that could sell their products among Brazilian states and/or to other countries through exports in order to cover the drivers associated with domestic and foreign markets. For this reason, we adopted herein a convenience sampling. Thus, nine slaughterhouses were interviewed; seven of those are provided with federal inspection service and the other two with state inspection service. Five companies have more than 500 employees and can be ranked as large-sized, three are medium -sized (between 100 and 499 employees), and only one company could be classified as small-sized, as it has between 20 and 99 employees. For each slaughterhouse we identified the general manager or chief operating director as we understand that these professionals deal with the pressures the organizations must face and are the ones responsible for implementing strategic actions linked to production/operations and market innovations.

For the data collection, we used closed-ended questions designed and based on internal and external drivers that affect the company (Table 2) and on the types of eco-innovation (Table 1) in order to identify causal combinations for each type of eco-innovation (Figure 1).

The questionnaire elaborated according to the multi-value Qualitative Comparative Analysis (mvQCA), but for the analysis of results an adaptation was made in the answer options in order to transform the variables to be used in csQCA. Originally, the answers were based on a five-point scale, ranging from 1 to 5 in each question referring to eco-innovation drivers: None (1), Very Little (2), Little (3), Some (4) and Much (5). The answers none (1), very little (2) and little (3) were regrouped into a new category called absence (0) to enable the analysis through the csQCA technique. The answers Some (4) and Much (5) were regrouped into a new category called presence (1) also with the purpose of enabling the analysis through the csQCA technique. For the types of eco-innovation (Table 1) presented in this article, values of 0 were assigned for absence and 1 for presence of eco-innovation in the company. This decision was made due to the numbers of answers obtained hat met the selection criteria and to enable the application of the csQCA technique.

The questionnaire was submitted to a pilot test to check its validity. For such, we required two consultants of the environmental department of the slaughterhouses, i.e. members of the relevant

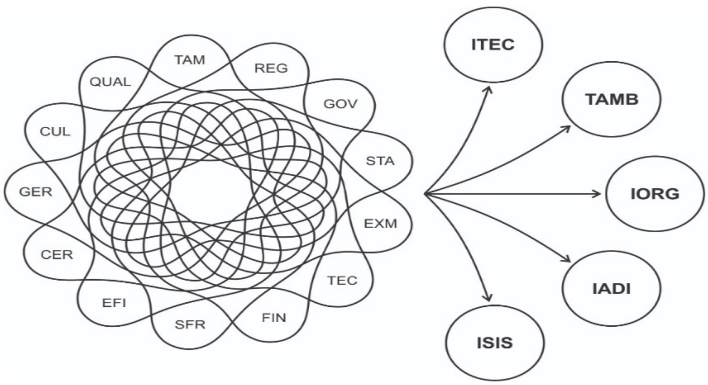

Figure 1.
Relations to be analyzed: combination of drivers for each type of eco-innovation

Notes: Legend: ITEC (Integrated ecologic innovations); TAMB (Environmental technologies of pollution control); IORG (Organizational and macro-organizational innovation); IADI (Add-on eco-innovations); ISIS (Green innovation systems – alternative products); EPG (General Purpose)
Source: Research data

population, to give feedback on the questionnaire. All questions were carried out and assessed through the interpretation of how far they understood the questionnaire and the vocabulary used and whether the drivers and types of eco-innovation were applied in the respective slaughterhouse sector. In this phase, we excluded from the analysis the general purpose eco-innovation (Andersen, 2008), as the interviewees had difficulty recognizing this type of eco-innovation due to its generalist character. These specific respondents were not considered in the sample. The final questionnaire was sent to the respondents through Google Forms. After that, a telephone call was made to each participant to clarify possible doubts regarding the questions.

4.2.2 Identifying combinations of causal conditions – crisp-set qualitative comparative analysis. A preliminary phase was carried out before the application of QCA, as the causal conditions analyzed are numerous and therefore limit the use of csQCA. Thus, the Most Similar Different Outcome/Most Different Same Outcome (MSDO/MDSO) analysis was preliminarily used aiming to identify the main causal conditions that explain the different performances between two groups of cases (Meur and Beumier, 2015).

With the implementation of the preliminary phase (MSDO), the resulting explanatory causal conditions were analyzed using the variant csQCA of the QCA. The analysis was carried out with the aid of Tosmana (Tool for Small-N Analysis), a free tool for comparative analysis (Cronqvist, 2017).

The results provided by Tosmana that indicate more frugal solutions are presented in Section 5.2, Table 4. From then on, the researcher's interpretation begins with the formulae found in accordance with the theories used (Section 5.2).

5. Results and discussion

In this section, we discuss the explanatory drivers responsible for performance differences in the different types of eco-innovation – resulting from the MSDO analysis – and the combinations of drivers stemming from the csQCA technique.

5.1 Explanatory drivers for performance differences by type of eco-innovation

This topic describes the results provided by the MSDO/MDSO software. All causal conditions were tested (Table 2) in relation to all types of eco-innovation (Table 1). Of the results obtained by MSDO/MDSO, the pairs found in zone 3 were used as they represent the comparison between the cases with outcome 1 (success) and the cases with outcome 0 (failure). This enabled the comparison of the pairs and identification of which would be the causal conditions that could explain the differences in performance of successful and failing cases. Table 3 summarizes the internal and external causal conditions resulting from the MSDO analysis.

Types of	Internal causal conditions			External causal conditions				
Eco-innovation	CUL	QUAL	EFI	GOV	EXM	FIN	REG	TEC
TAMB			X	X		X		
ITEC			X	X	X	X		
IORG	X	X		X	X	X		
IADI			X	X	X	X		
ISIS	X	X		X			X	X

Notes: ITEC (Integrated ecologic innovations); TAMB (Environmental technologies of pollution control); IORG (Organizational and macro-organizational innovation); IADI (Add-on eco-innovations); ISIS (Green innovation systems – alternative products)
Source: Research data

Table 3. Explanatory causal conditions of eco-innovations in slaughterhouses

As a partial conclusion of the results obtained through MSDO/MDSO, it is possible to affirm that the drivers mentioned in Table 3 are those that explain the performance differences of the different types of eco-innovation analyzed in the slaughterhouse industry. For this reason, these are the eight drivers used in the combinatorial analysis, whose outcomes are shown in the following section (Section 5.2). Complementarily, it is possible to notice that environmental innovation is driven by several internal and external factors to the company, reinforcing the findings of Triguero, Cuerva and Alvarez-Aledo (2017).

5.2 Combinations of drivers and types of eco-innovations

From the implementation of the preliminary phase (MSDO), data were analyzed according to the variant csQCA provided by Tosmana. This software uses the following logical operators: signal "*" is interpreted as "and" –, which indicates the joint presence of two conditions, such as the expression AB → Y or A × B → Y, which is displayed as A and B jointly for the result Y. The alternative presence of one or another condition is indicated by "+", a symbol that corresponds to "or". This means that for the expression A + B → Y there is more than one sufficient condition (A or B) for the result Y. The arrow "→" represents that the formula is a result of the examination of sufficient conditions (A or B implies Y). Capital letters represent the presence of the driver. Lowercase letters represent the absence of the driver.

In Table 4, we present the 13 combinations of drivers capable of favoring the use of five types of eco-innovations.

The environmental technologies of pollution control (TAMB), such as water waste treatment (end of pipe), were explained by two isolated drivers, which were sufficient to explain the adoption of such type of eco-innovation: GOV + EFI. According to the results, it is possible to affirm that the presence of the causal condition technological competences (EFI) or the presence of the government (GOV) are sufficient to adopt an environmental technology by the company.

Concerning the driver government (GOV), its importance is attributed to the government support for the international promotion of environmentally responsible exports companies, which can be explained by the interest in increasing exports, as meat is one of the most

Type of eco-innovation	Denomination	Combinations of drivers that favor their use
TAMB	Environmental technologies of pollution control	GOV + EFI
ITEC	Integrated ecologic innovations	GOV * EXM * fin
IORG	Organizational and macro-organizational innovation	GOV * EXM * CUL * QUAL + gov * EXM * FIN * CUL + GOV * EXM * FIN * cul * qual + gov * exm * fin * cul * qual
IADI	Add-on eco-innovations	EXM * FIN * EFI + GOV * EXM * EFI + GOV * EXM * fin + GOV * exm * FIN * efi + gov * exm * fin * EFI
ISIS	Green innovation systems – alternative products	REG * TEC * CUL * QUAL + REG * GOV * TEC * cul * qual

Notes: ITEC (Integrated ecologic innovations); TAMB (Environmental technologies of pollution control); IORG (Organizational and macro-organizational innovation); IADI (Add-on eco-innovations); ISIS (Green innovation systems – alternative products)
Source: Research data

Table 4. Combinations of drivers and the adoption of types of eco-innovations in slaughterhouses

relevant goods for the Brazilian commercial balance. These exports can leverage the use environmental control technologies in this industry. Concerning the driver efficiency (EFI), Bossle, Dutra de Barcellos, Vieira and Sauvée (2016) argue that cost reduction is an important indicator for this driver and one of the most relevant factors for eco-innovation. Triebswetter and Wackerbauer (2008) state that cost reduction is determinant to introduce product and process innovation, but not generally for end of pipe technologies, such as eco-innovations related to environmental technologies of pollution control (TAMB). The results of this research show that the pursue of efficiency through cost reduction is also a driver for end of pipe technologies, which is a new finding identified in our research.

With regard to integrated ecologic innovations (ITEC), related to product and process simultaneously, four causal conditions were tested: GOV, EXM, FIN and EFI, which were explained by a combination of three drivers: GOV * EXM * fin. The findings indicate that to develop integrated technological innovations in companies it is necessary, concomitantly, to rely on the government (GOV) and to have the intention of market expansion (EXM), with no public funding (fin).

A possible explanation for the combination of the two drivers (GOV * EXM) associated with the presence of integrated ecologic innovations is that slaughterhouses with such configuration are qualified to export meat products, which may justify the presence of the driver market expansion (EXM). The importance of market expansion is in line with the findings of Cleff and Rennings (1999) and Triguero et al. (2017) for whom environmental product innovation is related mainly to the strategic behavior of corporate market and the quest for competitiveness. Such affirmation is reinforced by Triebswetter and Wackerbauer (2008), who believe that companies introduce eco-innovative products or services in the market when they are somehow rewarding. Regarding the driver government (GOV), it is justified by the same reason presented for environmental technologies of pollution control (TAMB), which is the promotion of environmentally responsible export trading in the international market due to government's interest in increasing exports.

Organizational and macro-organizational innovations (IORG), the ones referring to methods of organization, management systems, within and between the organizations, were explained by four combinations: GOV * EXM * CUL * QUAL + gov * EXM * FIN * CUL+ GOV * EXM * FIN * cul * qual + gov * exm * fin * cul * qual. These four configurations indicate that there is not only one combination of drivers that favor this type of eco-innovation, i.e. there is a certain interchangeability among the four drivers. However, it can be noticed that the absence of all drivers leads to the use of some type of organizational or macro-organizational innovation. This case refers to a small-sized company, which had not identified government influence nor business fundings; the interviewee claimed that the company had no environmental culture or perspective of expanding its market and that there were no qualified employees to contribute to improvements of environmental nature.

One possible explanation for the drivers market expansion (EXM), public funding (FIN) and government (GOV) may be related to the need of implementing environmental management systems capable of managing a complex group of social-environmental practices and rules that support the elaboration of accountability reports required by international customers and banks (Masudin, Wastono and Zulfikarijah, 2018; Goularte and Dias, 2019), and that provide information about promotion activities carried out by the government for companies operating in this industry. Regarding qualified human resources (QUAL), they are necessary to conduct environmental management systems, trainings and dissemination of information aiming at improving the absorptive capacity of other human resources in the company and, therefore, encouraging and stimulating the development of other eco-innovations (Horbach, 2014; Díaz-García, González-Moreno and Sáez-Martínez, 2015; Bossle, Dutra de Barcellos, Vieira and Sauvée, 2016). There is an association between human resources and environmental culture (CUL) considering that organizational values must support the implementation of new organizational methods and management systems aiming at the integration between environmental awareness and corporate management. The incorporation of environmental issues in the management agenda requires explicit support from the directing board (Díaz-García, González-Moreno and Sáez-Martínez, 2015; Bossle, Dutra de Barcellos, Vieira and Sauvée, 2016; Goularte and Dias, 2019).

Add-on (IADI) eco-innovations, which improve the customer's environmental performance with little systemic effect and are added to current practices of production and consumption, were explained by five combinations: EXM * FIN * EFI + GOV * EXM * EFI + GOV * EXM * fin + GOV * exm * FIN * efi + gov * exm * fin * EFI. It can be noticed that the last combination is only composed of the driver efficiency (EFI), which would be sufficient for adopting product or service eco-innovation (IADI). In this case, based on the slaughterhouses analyzed in this article, we mention as example the motivation to acquire new equipment that produce packages that can be more easily be discarded and, thus, improves the customer's environmental performance. We emphasize that this type of innovation is completely oriented to the improvement of customers' environmental practices and pursue of efficiency, even if the first is not an intention of the company.

The explanation for the presence of the drivers market expansion (EXM) and government (GOV) relates to the main focus of an innovation, i.e. the customer, as both are associated with market making strategies, as previously discussed in the paragraph about environmental control technologies (TAMB) in this section. In the same line of thought, the driver public funding (FIN) can be associated with the customer, as it is another important part of the national policy for export incentives (Goes, 2020). The same arguments presented on environmental control technologies (TAMB) can be used to justify the importance of the driver efficiency (EFI), in which the quest for efficiency through cost reduction is determinant for the introduction of eco-innovations (Bossle, Dutra de Barcellos, Vieira and Sauvée, 2016). However, it was expected that they (FIN and EFI) were more linked to the integrated ecologic innovation (ITEC) (Triebswetter and Wackerbauer, 2008), but these findings confirm the association with add-on eco-innovations (IADI).

Green innovations systems (ISIS), which imply alternative systems of production and consumption that are more environmentally-benign, substantially different from existing ones, they, more complex and characterized by radical changes, were explained by two combinations: REG * TEC * CUL * QUAL + REG * GOV * TEC * cul * qual.

Green innovations systems (ISIS) are provided with more radical characteristics of innovation and are more knowledge-intensive, which can explain the need for higher qualification of human resources (QUAL) and the existence of an environmental culture in the company (CUL). The role played by the government (GOV) is also relevant for the promotion of alternative products resulting from the green innovations systems (ISIS). Horbach (2008), for example, considers that the participation of highly qualified employees, guided by the company's environmental culture, encourage the introduction of environmental product innovations and the participation of the government in the dissemination of environmental thinking in the market. More radical characteristics of innovation also requires the contribution of the technological environment of which the company is part (TEC) to implement this type of eco-innovation, as they may demand the participation of external sources of knowledge and information and even cooperation in research and development (Dias and Pedrozo, 2012; Tariq, Badir, Tariq and Bhutta, 2017).

In addition, it is worth mentioning the presence of the driver regulatory pressures (REG) as a driver associated with technologies of green innovations systems (ISIS). There is some controversy whether the regulatory pressures affect or not the adoption of environmental technologies, which is known as Porter's hypothesis. Triebswetter and Wackerbauer (2008) claim that there is scarce evidence in literature that this type of pressure affects the adoption of environmental technology by the companies. Nonetheless, our findings confirm Porter's hypothesis, at least considering green innovation systems (ISIS). Ambec and Barla (2005) argue that it only takes one market imperfection for Porter's hypothesis to be valid, such as knowledge spill overs, learning by doing, among others. In accordance with Ambec and Barla (2005), it is possible to state that market regulations contribute to eco-innovation, more especially to the type green innovations systems (ISIS), due to market imperfections.

6. Final considerations

The general research aim was to understand which combinations of eco-innovation drivers favor the adoption of eco-innovations in slaughterhouses located in the state of Rio Grande do Sul. The results identified the presence of eight explanatory drivers concerning performance differences between eco-innovative and non-eco-innovative slaughterhouses (Table 3), suggesting there are specific drivers affecting the slaughterhouse industry.

When analyzing the drivers simultaneously, 13 new combinations capable of favoring the adoption of five types of eco-innovations were found, which are new insights for eco-innovation literature (Table 4). We also present contributions based on the individual analysis of each driver considering previous results, which are detailed in Section 5.2.

Finally, in addition to the theoretical contributions discussed in Sections 5.1 and 5.2, these results also contribute to companies operating in this business and government, as we demonstrated herein which drivers or combinations of drivers must be incorporated in business strategies. Therefore, based on this research, it is possible to discuss which public policies shall be simultaneously encouraged to promote the adoption of eco-innovation.

As a suggestion for future studies, we recommend the reapplication of this research in different market segments in order to compare combinations of drivers found in different industries. In methodological terms, we suggest the use of other software for Qualitative Comparative Analysis (QCA) to incorporate new concepts into this research methodology, such as necessity, consistency and coverage (Ragin and Davey, 2017).

As for limitations, it was difficult to gather information from the companies concerning environmental issues because it is a delicate subject and all information provided is always carefully passed on to avoid possible consequences. In addition, only one interviewee represented each company; no additional employees from the same company were interviewed. Despite trying to find an interviewee that had broad knowledge of the pressures the company undergoes and implementation of eco-innovations, the more likely it is that a single employee of the organization does not have all the necessary information about the research issue. Besides, all cases studied refer to slaughterhouses operating in the state of Rio Grande do Sul; therefore, it is not possible to generalize the results of this research to other Brazilian regions.

References

Albort-Morant, G., Henseler, J., Leal-Millan, A., & Cepeda-Carrion, G. (2017). Mapping the field: A bibliometric analysis of green innovation. *Sustainability*, *9*(6). doi: https://doi.org/10.3390/su9061011.

Ambec, S., & Barla, P. (2005). Quand la réglementation environmentale profite aux pollueurs: Survol des fondements théoriques de l'hypothèse de porter [When environmental regulations benefit polluters: Overview theoretical foundations of the hypothesis of carrying]. *Cahiers de Recherche*, *505*.

Andersen, M. M. (2008). *Eco-innovation – Towards a taxonomy and a theory. Paper present at the Conference Entrepreneurship and Innovation: Organizations, institutions, systems and regions*. Copenhagen, 17-20 June, CBS, Denmar. Retrieved from https://www.researchgate.net/profile/Maj_Andersen/publication/228666208_Eco-innovation-towards_a_taxonomy_and_a_theory/links/0046351b23e208fec8000000/Eco-innovation-towards-a-taxonomy-and-a-theory.pdf (accessed 10 March 2020).

Bitencourt, C. C., Oliveira, S. F., Zanandrea, G., Froehlich, C., & Ladeira, W. J. (2020). Empirical generalizations in eco-innovation: A meta-analytic approach. *Journal of Cleaner Production*, *245*. doi: https://doi.org/10.1016/j.jclepro.2019.118721.

Bossle, M. B., Dutra de Barcellos, M., Vieira, L. M., & Sauvée, L. (2016). The drivers for adoption of eco-innovation. *Journal of Cleaner Production*, *113*, 861–872. doi: https://doi.org/10.1016/j.jclepro.2015.11.033.

Breier, G. P. (2015). *Abordagens ecoinovadoras para o desenvolvimento de novos produtos*. (Tese de Doutorado). Universidade Federal do Rio Grande do Sul, Rio Grande do Sul, Porto Alegre, Brasil.

Calza, F., Parmentola, A., & Tutore, I. (2017). Types of green innovations: Ways of implementation in a non-green industry. *Sustainability*, *9*(8), doi: https://doi.org/10.3390/su9081301.

Cleff, T., & Rennings, K. (1999). Determinants of environmental product and process innovation. *European Environment*, *9*(5), 191–201. doi: https://doi.org/10.1002/(SICI)1099-0976(199909/10)9:5<191::AID-EET201>3.0.CO;2-M.

Cronqvist, L. (2017). Tosmana: Tool for Small-N analysis. (Software Version 1.54). Trier: University of Trier. Retrieved from www.tosmana.net (accessed 10 March 2020).

Dias, M. F. P., & Pedrozo, E. A. V. (2012). Desenvolvimento sustentável nas inovações tecnológicas da indústria alimentícia brasileira: Em qual estágio estamos? [Technological innovations and sustainable development in the Brazilianfood industry: At what stage are we?] *Organizações Rurais and Agroindustriais*, *14*(3), 297–311. Retrieved from www.spell.org.br/documentos/ver/9551/desenvolvimento-sustentavel-nas-inovacoes-tecnologicas-da-industria-alimenticia-brasileira–em-qual-estagio-estamos-/i/pt-br (accessed 30 September 2020).

Dias, M. F. P., & Pedrozo, E. A. (2015). Metodologia de estudo de caso com múltiplas unidades de análise e métodos combinados Para estudo de configurações. *Revista Ibero-Americana de Estratégia*, *14*(2), 23–39. doi: https://doi.org/10.5585/ijsm.v14i2.2015.

Díaz-García, C., González-Moreno, Á., & Sáez-Martínez, F. J. (2015). Eco-innovation: Insights from a literature review. *Innovation*, *17*(1), 6–23. doi: https://doi.org/10.1080/14479338.2015.1011060.

Fiss, P. C. (2009). Case studies and the configurational analysis of organizational phenomena. In C. C. Ragin, & D. S. Byrne (Eds.), *The SAGE handbook of case-based method*, London: Sage publications. doi: https://doi.org/10.4135/9781446249413.n26.

Goes, F. L. (2020). *Uma cartografia do financiamento do BNDES Para exportação* [A map of BNDES financing for exporting]. Rio de Janeiro: IPEA. Retrieved from www.ipea.gov.br/portal/images/stories/PDFs/TDs/td_2542.pdf (accessed 26 January 2020).

Goularte, G. N., & Dias, M. F. P. (2019). Cadeia verde de suprimentos: Associações entre direcionadores, práticas e desempenho [Green supply chain: Associations among drivers, practices and performance]. *Contextus – Revista Contemporânea de Economia e Gestão*, *17*(2), 190–221. doi: https://doi.org/10.19094/contextus.v17i2.41193.

Greckhamer, T., Furnari, S., Fiss, P. C., & Aguilera, R. V. (2018). Studying configurations with qualitative comparative analysis: Best practices in strategy and organization research. *Strategic Organization*, *16*(4). doi: https://doi.org/10.1177/1476127018786487.

Horbach, J. (2008). Determinants of environmental innovation – New evidence from German panel data sources. *Research Policy*, *37*(1), 163–173. doi: https://doi.org/10.1016/j.respol.2007.08.006.

Horbach, J. (2014). Do eco-innovations need specific regional characteristics? An econometric analysis for Germany. *Review of Regional Research*, *34*(1), 23–38. doi: https://doi.org/10.1007/s10037-013-0079-4.

Kemp, R., & Pearson, P. (2007). *Final report MEI project about measuring eco-innovation*. Netherland: UM Merit.

Masudin, I., Wastono, T., & Zulfikarijah, F. (2018). The effect of managerial intention and initiative on green supply chain management adoption in Indonesian manufacturing performance. *Cogent Business & Management*, *5*(1). doi: https://doi.org/10.1080/23311975.2018.1485212.

Meur, G. D., & Beumier, J.-C. (2015). *MDSO/MSDO* (Version 1.1). Software.

OECD (2009). *Sustainable manufacturing and eco-innovation: Framework, practices, and measurement*. Retrieved from https://www.oecd.org/innovation/inno/43423689.pdf (accessed 30 September 2020).

Pakura, S. (2020). Open innovation as a driver for new organisations: A qualitative analysis of green-tech start-ups. *International Journal of Entrepreneurial Venturing*, *12*(1), 109–142. doi: https://doi.org/10.1504/IJEV.2020.105135.

Rabêlo, O. S., & Melo, A. S. S. A. (2018). Drivers of multidimensional eco-innovation: Empirical evidence from the Brazilian industry. *Environmental Technology*, *40*(19), 2556–2566, doi: https://doi.org/10.1080/09593330.2018.1447022.

Ragin, C. C. (2009). Qualitative comparative analysis using fuzzy sets (fsQCA). In B. Rihoux, & C. C. Ragin (Eds.), *Configurational comparative methods: Qualitative comparative analysis (QCA) and related techniques*, Sage Publications. doi:https://doi.org/10.4135/9781452226569.n5.

Ragin, C. C. (2014). *The Comparative method social science, moving beyond qualitative and quantitative strategies*. University of California Press. Retrieved from www.jstor.org/stable/10.1525/j.ctt1pnx57.1 (accessed 10 march 2020).

Ragin, C., & Davey, S. (2017). *fs/QCA Version 3.0 (Version Version 3.0)*. Irvine, CA: University of California.

Rihoux, B., & Meur, G. (2009). Crisp-set qualitative comparative analysis (csQCA). In B. Rihoux, & C. C. Ragin (Eds.), *Configurational comparative methods: Qualitative comparative analysis (QCA) and related techniques. Applied social research methods, 51*, Thousand Oaks, CA: SAGE Publications. Retrieved from www.doi.org/10.4135/9781452226569 (accessed 17 December 2020).

Schiederig, T., Tietze, F., & Herstatt, C. (2012). Green innovation in technology and innovation management – An exploratory literature review. *R&D Management*, *42*(2), 180–192. doi: https://doi.org/10.1111/j.1467-9310.2011.00672.x.

Tariq, A., Badir, Y. F., Tariq, W., & Bhutta, U. S. (2017). Drivers and consequences of green product and process innovation: A systematic review, conceptual framework, and future outlook. *Technology in Society*, *51*, 8–23. doi: https://doi.org/10.1016/j.techsoc.2017.06.002.

Triebswetter, U., & Wackerbauer, J. (2008). Integrated environmental product innovation in the region of Munich and its impact on company competitiveness. *Journal of Cleaner Production*, *16*(14), 1484–1493. doi: https://doi.org/10.1016/j.jclepro.2007.09.003.

Triguero, A., Cuerva, M. C., & Alvarez-Aledo, C. (2017). Environmental innovation and employment: Drivers and synergies. *Sustainability*, *9*(11). doi: https://doi.org/10.3390/su9112057.

Corresponding author
Marcelo Fernandes Pacheco Dias can be contacted at: marcelo.dias@ufpel.edu.br