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ECO-INNOVATION MEASUREMENT: A MULTIDIMENSIONAL ANALYSIS AND EMPIRICAL EVIDENCES FROM SPANISH AGRI-FOOD SECTOR

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ECO-INNOVATION MEASUREMENT: A MULTIDIMENSIONAL ANALYSIS AND EMPIRICAL EVIDENCES FROM SPANISH AGRI-FOOD SECTOR

MEDICIÓN DE LA ECO-INNOVACIÓN: UN ANÁLISIS MULTIDIMENSIONAL Y EVIDENCIAS EMPÍRICAS DEL SECTOR AGROALIMENTARIO ESPAÑOL

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“La unidad es la variedad, y la variedad en la unidad es la ley suprema del universo”

(Isaac Newton)

a Enzo y Marco

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ABSTRACT

ABSTRACT

The shift towards sustainability has influenced business organizations to improve their environmental performance and efficiency. In this sense, understanding eco-innovation (EI) is essential to obtain a holistic view in order to achieve economies' sustainable development. This is speciallly important in the agri-food sector as its daily activities cause environmental deterioration (use of natural resources, greenhouse emissions, waste generation and land degradation). A literature review indicates that most previous EI investigations are focused on product and process dimensions, despite organizational and marketing dimensions play a significant role in the management of eco-innovation. Thus, this study complements the literature by specifying the multi-dimensional aspect of EI (product, process, organization and marketing). Through a systematic literature review, this study aims to present an analytical framework in order to explore the diversity of eco-innovation indicators in each dimension, regarding to the trend toward empathising with 'Agroecology', 'Biodiversity' and 'Environmental economics'. The framework is used to analyse Spanish agri-food case of study. For this purpose, a combination of bibliometric analysis, cluster analysis, partial least-squares technique, and structural equations have been applied to the empirical context. The results reveal the existence of two well-differentiated groups of eco-innovative firms, depending on the operating income volume, number of employees and commercialization volume. This research also confirms the positive effect that environmental corporate culture and commercial orientation drivers have in the adoption of EI, being environmental quality certifications one of the green indicators that contribute most to the distinction between these two groups. The findings also reinforce the importance of organizational and marketing EI dimensions have on corporate EI implementation, suggesting neccesary that theorists and practitioners contemplate EI from a multidimensional perspective in order to achieve an efficient analysis. This paper also identifies business opportunities to embed green practices in three environmental strategies including biodegradable packaging, environmental advisory or environmental audits. Subsequently, this work carries some theoretical conclusions and implications for research and practice with the aim to promote the achivement of circular economy principles.

RESUMEN

RESUMEN

El cambio hacia la sostenibilidad ha influido en las organizaciones empresariales para mejorar su rendimiento y eficiencia ambiental. En este contexto, el análisis de la eco-innovación (EI) es esencial para obtener una visión holística con el fin de lograr el desarrollo sostenible de las economías. Esto es especialmente importante en el sector agroalimentario, ya que sus actividades diarias causan deterioro ambiental (uso de recursos naturales, emisiones de efecto invernadero, generación de residuos y degradación de la tierra). La revisión bibliográfica sobre EI indica que la mayoría de las investigaciones anteriores se centran en las dimensiones de producto y proceso, a pesar del papel fundamental que las dimensiones de organización y de marketing desempeñan en su desarrollo. Así, este estudio complementa la literatura reivindicando el aspecto multidimensional de la EI (producto, proceso, organización y marketing). A través de una revisión sistemática de la literatura, este estudio tiene como objetivo presentar un marco analítico para explorar la diversidad de indicadores de eco-innovación en cada dimensión, de acuerdo con la tendencia hacia la 'Agroecología', 'Biodiversidad' y 'Economía ambiental'. El marco teórico desarrollado se utiliza para analizar el caso de estudio agroalimentario español. Para ello, una combinación de análisis bibliométrico, análisis clúster, técnica de mínimos cuadrados parciales y ecuaciones estructurales se ha aplicado al contexto empírico. Los resultados revelan la existencia de dos grupos bien diferenciados de empresas eco-innovadoras dependiendo de su volumen de ingresos de explotación, del número de empleados y del volumen de comercialización. Esta investigación también confirma el efecto positivo que tiene la cultura corporativa ambiental y la orientación comercial como factores motivadores en la adopción de EI, siendo las certificaciones de calidad ambiental uno de los indicadores verdes que más contribuyen a distinguir a estos dos grupos. Los hallazgos también refuerzan la importancia que las dimensiones de organización y marketing desempeñan en la implementación corporativa de la EI, lo que sugiere que tanto teóricos como profesionales deben contemplar la EI desde una perspectiva multidimensional para lograr un análisis eficiente. Además, esta investigación identifica oportunidades de negocio para incorporar prácticas ecológicas en relación a tres estrategias ambientales (envases biodegradables, asesoramiento ambiental o auditorías ambientales). Consecuentemente, este trabajo

presenta algunas conclusiones e implicaciones teóricas para la investigación y la práctica con el objetivo de promover la consecución de los principios de economía circular.

CHAPTER 1

INTRODUCTION

INTRODUCTION

1. Eco-innovation and Sustainability

In the current global landscape, the economies are characterized for a trend change towards production methods more efficient not only economically, but also in the environmental field. According to OECD (2012), the incessant increment in the world population is going to surpass 9,000 million in 2050, at the same time that insufficient resources is a limit to any economy. Moreover, the increasing concern about the global warming, deforestation and biodiversity loss are problems closely linked to loss of economic, social and environmental welfare.

The growing awareness about human extensively and intensely intervention in natural ecosystems and the negative externalities that comes with, put the development of more sustainable production methods by companies and industries in the spotlight since they are considered to be those that contribute most to extend or perpetuate these problems (Remacha, 2017). In this context, eco-innovations (EI), also known as green innovations or environmental innovations, are attracting increasing interest among researchers as a key factor for achieving economic, social and environmental objectives (Läpple et al., 2015).

Several definitions have been given to describe EI. According to Kemp and Pearson (2007, p.7), EI is “the production, assimilation or exploitation of a product, production process, service or management or business method that is novel to the organisation (developing or adopting it) and which results, throughout its life cycle, in a reduction of environmental risk, pollution and other negative impacts of resources use (including energy use) compared to relevant alternatives”. Oltra and Saint Jean (2009, p.1) defined it as “innovations that consist of new or modified processes, practices, systems and products which benefit the environment and so contribute to environmental sustainability”. The Eco-Innovation Observatory (EIO) (2012, p.8) considers it the “introduction of any new or significantly improved product, process, organizational change or marketing solution that reduces the use of natural resources and decreases the release of harmful substances across the whole life-cycle.” Other definitions are also found in other works such as Carrillo-Hermosilla et al. (2010), Jänicke (2012) or Tamayo-Obergozo et al. (2017). Each definition considers different points of view, but all of them include an environmental component and reflect the two main effects of EI: fewer adverse impacts on the environment and more efficient use of resources (Hojnik and Ruzzier, 2016b).

Since EI has been argued to be a key element in the transition toward sustainability, numerous studies on EI concepts, consequences and drivers have been developed. Nevertheless, studies on its implementation are scant (Kemp, 2009). Regarding the EI implementation perspective, the majority of studies in this area considers the EI implementation analysis from the product and process dimensions, regardless the importance of marketing and organization one (Doran and Ryan, 2016; Castellacci and Lie, 2017; Rodríguez and Wiengarten, 2017). Very few studies contemplate the four EI dimensions, i.e., product, process, organizational and marketing (Marcon et al., 2017; Astuti et al., 2018). The Inter-American Development Bank recognizes that organizational and marketing EI practices are a key point to develop more sustainable economies (BID, 2007). Thus, there is not any prior research that provides insights about related to a complete and efficient EI measurement which provide a comprehensive framework for the analysis of EI in its four dimensions.

In addition, the vast majority of the EI studies are focused on the industrial sector (Hollenstein, 1996; Crabbé et al., 2013), being necessary to expand the sectorial scope of this empirical research topic to develop a body of knowledge on this subject, especially due to the increased awareness about of the importance that green marketing and organizational practices have on the company environmental performance (BID, 2007; Marcon et al., 2017).

In this sense, EI is especially important in the agri-food sector, as agricultural activities have a strong impact on the environment. On the one hand, greenhouses are an important feature of production (Rodríguez-Rodríguez et al., 2012), and they require intensive use of resources and generate considerable amounts of waste and residues, e.g., packaging materials, fertilizers, plastics, etc. (CIAA, 2010). On the other hand, the use of pesticides, insecticides and fertilizers by this sector causes negative externalities in population health (OECD, 2008). However, this sector has been evolving towards environmental adaptation in order to contribute to resource conservation and biodiversity maintenance, as well as human wellbeing, reducing the negative externalities and fulfilling the most basic needs of human beings, namely food.

2. Purpose and Structure of the Research

The general aim of this investigation is to analyse the EI key performance indicators and assess the EI implementation in a sector with great environmental relevance, such as agri-food sector, from a multidimensional perspective, in order to fill the gap existing in the literature. The majority of the research about EI is mainly focused in the bidimensional product-process perspective, and in high-tech sectors or multinational companies too. In this sense, the study identifies the following specific objectives:

- To provide an overview of the EI literature to identify key features and specific characteristics.
- The identification of potential EI indicators in order to develop an accurate frame of reference to achieve sustainable development.
- The elaboration of a framework to analyze the EI from a multidimensional approach.
- To offer a multidimensional EI measurement.
- The analysis of the EI phenom in the high environmental impact context: the agri-food sector.
- The investigation of the effect that environmental corporate culture and commercial orientation have on the EI level.
- The contribution that the environmental-friendly practices have on the achivement of circular economy principles.

In a scenery where "you cannot manage what you do not measure" (Cooper and Edgett, 2008; Ehrenfeld, 2008), Chapter 2 presents a framework of the green indicators and practices which measure EI levels, particularly at firm level. To this end, an analysis about the academic emerging literature on EI indicators had been carried out.

Provide a comprehensive analysis of the green indicators helps to understand which practices add more value in the path towards achieving a sustainable development. It can also help to develop efficient indicators for measuring the EI level. This point is especially important to examine the evolution of the EI in different countries or sectors in order to evaluate which green practices should be implemented with the aim to reach the current environmental requeriments. In this line, Chapter 3 goes further carrying out a bibliometric analysis. It contributes to the understanding of the EI phenom by identifying the structures and the directions in the agri-food EI literature.

The analysis of the previous chapters provided a starting point to apply a multidimensional study in any sector. Thus, Chapter 4 examines the EI implementation in the fresh fruit and vegetable Spanish wholesale sector including not only product and process EI dimension, but also the organizational and marketing ones. This chapter contributes to the literature in two main ways. On the one hand, it provides further research on EI implementation to go beyond the nowadays boundaries, being a key tool in the way to achieve the global sustainable development goals. On the other hand, investigations focused on agri-food sector are needed due to the particular relationship between this sector and the environment, because of its high level of use of natural resources and environmental externalities. To face this, three statistical techniques were applied. Firstly, a descriptive analysis which provides a better understanding of the companies´ profile in the sector. Secondly, a cluster analysis that allows separating the sample into different groups. Finally, chi-squared tests checked the relationship between the compositions of Groups 1 and 2 and the following profile variables: age of the company, operating income, number of employees, commercialization volume and percentage of commercialization volume in vegetables. This gives a leg up to understand the differences between both groups.

Chapter 5 deals with a main objective: developing a holistic EI implementation level model, regardless of firm size in agri-food sector. For this purpose, a novel second-order structural model was developed including multifarious practice in eco-product, eco-process, eco-organizational and eco-marketing dimensions. This contributes to the stream of research offering an effectiveness EI level measurement. What it is more, this research also tests a more complex relationship between environmental corporate culture, commercial orientation and multidimensional EI level.

Furthermore, Chapter 6 evaluates the current eco-efficiency performance on Spanish agri-food sector. To this aim, a wide variety of circular indicators related to EI practices have been analysed with the aim to investigate its contribution to the achievement of circular economy principles.

Finally, Chapter 7 sums up the main outcomes of the research, identifies the limitations and provides recommendations for future research.

CHAPTER 2

ECO-INNOVATION MEASUREMENT: A REVIEW OF FIRM PERFORMANCE INDICATORS

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ECO-INNOVATION MEASUREMENT: A REVIEW OF FIRM PERFORMANCE INDICATORS

Abstract

Increased awareness on sustainability has influenced business organizations to improve their environmental performance and efficiency. In this context, eco-innovation implementation is positioned as a target for organizations to be more sustainable in order to reduce negative externalities and reach governments' green requirements and consumers' demands. The aim of this paper is to provide a critical review of literature on eco-innovation performance indicators. This study identifies the 30 firm performance indicators most cited by researchers and classifies them into four different green innovation types, i.e. product, process, organizational and marketing. A substantial gap has been found throughout the literature on this issue as studies do not include a complete combination of the key performance indicators across the four types of eco-innovation. This information is necessary to obtain an accurate measurement of eco-innovation level and it is useful to companies and stakeholders for performance evaluation. Moreover, understanding which performance indicators are more suitable for measuring the level of environmental innovation affords governments the possibility to draft policies that encourage companies to be more sustainable and firms to implement green practices in a more efficient way.

Keywords: eco-innovation, indicator, literature review, business implementation.

1. Introduction

In recent years, a great deal of research has focused its attention on the impact that the improper use of natural resources has on the environment. This trend, along with the heightened awareness about environmental problems, the limitation of natural resources and the increasing world population, highlights the need to discover new ways of using these resources more efficiently in order to achieve a balance between consumption requirements and sustainability.

According to the OECD (2012), the world population will surpass 9,000 million in 2050. Thus, at a time when it will be necessary to increase production of food and other products, topical problems like global warming, deforestation, water pollution, biodiversity loss, excessive generation of waste, and the use of chemical substances will imply a decrease in both productivity and the availability of goods and services. In this context, firms and industries receive special attention as they are considered to contribute most to perpetuating these problems, yet they have the capacity to provide appropriate solutions instead (Remacha, 2017). However, in order to do so, new environmental-friendly production methods as well as improvements in product characteristics, organizational capabilities and marketing practices are required to achieve greater respect for the environment. This objective can be reached by encouraging firms and countries to implement eco-innovations, especially in sectors with considerable environmental impacts in terms of pollution and water and energy consumption, such as agriculture (FAO, 2017).

These innovations, also known as green innovations or environmental innovations, are attracting increasing interest among researchers as a key factor for achieving economic, social and environmental objectives (Läpple et al., 2015). Defining eco-innovation (EI) is not an easy task, although several authors address this topic. According to Kemp and Pearson (2007, p.7), EI is "the production, assimilation or exploitation of a product, production process, service or management or business method that is novel to the organization (developing or adopting it) and which results, throughout its life cycle, in a reduction of environmental risk, pollution and other negative impacts of resources use (including energy use) compared to relevant alternatives". Oltra and Saint Jean (2009, p.1) defined it as "innovations that consist of new or modified processes, practices, systems and products which benefit the environment and so contribute to environmental sustainability", while Kemp and Arundel (1998) and Rennings and Zwick (2003) define environmental innovations as new and modified processes, equipment, products, techniques and management systems that avoid or reduce harmful environmental impacts. For Fussler and James (1996), eco-innovation is the process of developing new products, processes or services which provide customer and business value but significantly decrease environmental impact. Other definitions are also found in works such as Carrillo-Hermosilla et al. (2010), Jänicke (2012) and Tamayo-Obergozo et al. (2017). But, the discussion relative to the definition of EI not only concern researchers, also world organizations discuss this topic. The Eco-Innovation Observatory (EIO) (2012, p.8) considers it the "introduction of any new or significantly improved product, process, organizational change or marketing solution that reduces the use of natural resources and decreases the release of harmful substances across the whole life-cycle." In the case of the European Commission (2013, p.4), "eco-innovation projects will therefore aim to produce quality products with less environmental impact, whilst innovation can also include moving towards more environmental- friendly production processes and services. Ultimately, they will contribute towards the reduction of greenhouse gases or the more efficient use of various resources." The Oslo Manual (OECD, 2005) defines innovation as the implementation of a new or significantly improved product (good or service) or process, a new marketing method, or a new organizational method in business practice. According to Europa INNOVA (2006), eco-innovation is the creation of novel and competitively priced goods, processes, systems, services, and procedures designed to satisfy human needs and provide a better quality of life for all, with a minimal life-cycle use of natural resources (materials including energy, and surface area) per unit output, and a minimal release of toxic substances. Furthermore, it is necessary to mention that each author and organization considers different points of view, but all the definitions include two main effects of EI (Hojnik and Ruzzier, 2016b): fewer adverse effects on the environment and more efficient use of resources. These common issues are taken into consideration in this study as the eco-innovation concept.

A wide range of studies on eco-innovation concepts, consequences and drivers have been published, primarily because EI is commonly believed to play a key role in the quest for greater efficiency and sustainability. Nevertheless, studies on its implementation are rather scant (Kemp, 2009). Implementation refers to realization for use according to a European project entitled "Measuring eco-innovation (MEI)" (Kemp and Pearson, 2007, p.7). Therefore, this study focuses on those indicators that measure the implementation of eco-innovations in economic activity. A great deal more of comprehensive research on EI implementation is considered essential in order to identify those eco-innovation performance indicators (EIPI) which allow it to be efficiently measured. In consequence, it would promote progress towards the constitution of a body of knowledge that facilitates not only companies but also governments to implant environmental plans that ensure higher sustainability. As Triguero et al. (2013) mention, a lack of effectiveness of environmental regulation exists. For this reason, a change in the current regulatory framework is needed to enhance EI because environmental regulations play an important role in stimulating EI and combating negative environmental externalities (Ekins, 2010; Demirel and Kesidou, 2011).

The main aim of this article is to offer an overview of the key performance indicators which measure EI at firm level, particularly from the product, process, organizational and marketing perspectives, according to the classification introduced by Marcon et al. (2017). To this end, we review the academic literature on EIPI utilizing 104 full articles. No studies were found which provided a comprehensive analysis of the subject from the four EI perspective types. Thus, the paper contributes to the literature in three ways. Firstly, this study provides an academic contribution. As Cooper and Edgett (2008) and Ehrenfeld (2008) note, you cannot manage what you do not measure. In this line, this study offers an overview of key EIPI, contributing to develop a body of knowledge to analyze the level of EI implementation from the point of view of product, process, organizational and marketing perspectives and helping to fill the existing gap concerning this subject. Furthermore, an overview of EIPI makes it possible to create compound indicators for measuring level of environmental innovation and, subsequently, comparing said levels between countries, sectors or companies (Angelo et al., 2012). Secondly, providing a set of EIPI is a useful base for managers to know which of them should be used to evaluate its performance and diagnose in which EI perspective improvements could be introduced to reduce negative externalities and at the same time add more environmental value and provide a competitive advantage. Finally, due to the fact that EI policies require a holistic view according to Cheng et al. (2014), the current study helps to understand the possible performance indicators for implementing EI.

The remainder of this paper is organized as follows. Section 2 explains the research method and the lines of research used to find and select the publications analyzed. Section 3 shows a descriptive analysis of the findings highlighting the evolution of the research on this subject. In addition, this section analyzes the countries, journals and sectors in which the topic is most widely discussed. Next, Section 4 presents the discussions and contains reviews on EIPI, grouping them into four types of green innovation. This section also introduces a set of key EIPI. Finally, Section 5 concludes the study, discussing the main findings and giving suggestions for future research.

2. Research Method

The manner by which EI is measured is evaluated to identify the potential performance indicators necessary for achieving greener and more sustainable procedures. Thus, a systematic literature review has been carried out following the methodology suggested by Tranfield et al. (2003). This approach is also in line with the previous systematic reviews on eco-innovation (e.g., De Medeiros et al., 2014, De Jesús Pacheco et al., 2017; or Hojnik and Ruzzier, 2016b).

This method was chosen as it makes it possible to include large amounts of information contributing to provide a comprehensive view of the field for researchers, answers questions regarding this specific topic and discover new opportunities for future research (De Jesús Pacheco et al., 2017). Furthermore, a systematic review effectively provides a practical perspective as an overall view of EIPI, contributing to create a body of knowledge on this subject in order to determine how to implement ecological practices and policies in the future.

The methodology followed for the literature review included two main phases: Firstly, the extraction and selection of publications in the desired areas; and, secondly, the analysis of the publications retrieved to identify key EIPI. In particular, the systematic literature review followed a five-step scheme according with Tranfield et al. (2003) that included: (i) problem definition; (ii) selection of sources; (iii) selection of studies; (iv) critical appraisal and evaluation; and (v) synthesis.

First, the problem is defined: in line with the overall objective of the research, the aim of the systematic review was to identify the most cited performance indicators used for measuring the level of EI implementation. Then, the selection of sources and studies is conducted, followed by the description.

Taking into consideration that a systematic literature review must be focused not only on published articles in journals but also on "gray literature" as well (Petticrew and Roberts, 2012), we based the bibliometric analysis on Scopus and Web of Science (WoS) databases in the first stage (Díaz-García et al., 2015; Morioka and de Carvalho, 2016). These databases are considered the most important source of data for scientific research and include titles from Emerald, Elsevier, Springer, Willey, Taylor & Francis or JStor (Bonisoli et al., 2018). Then, a cross-reference analysis and a search in the databases of the main international organizations were conducted with the two-fold aim of analyzing those references that are of interest to the present subject of study and completing the literature review.

Table 1. Keyword combinations used for the search mechanism and the results for each database.

Key Concept	Search String	Scopus	WoS
Eco-innovation	“Eco-innovation”	382	418
Eco-innovation	“Environmental innovation”	317	314
Eco-innovation	“Green innovation”	173	276
Eco-innovation	“Ecological innovation”	47	58
Eco-innovation	“Measuring innovation” AND “Environment”	12	8
Eco-innovation and product innovation	(“Eco-innovation” OR “Environmental innovation” OR “Green innovation”) AND (“Product innovation” OR “Product Design” OR (“Product innovation” AND “Recycling materials”)	173	145
Eco-innovation and process innovation	(“Eco-innovation” OR “Environmental innovation” OR “Green innovation”) AND (“Process innovation” OR “Process efficiency” OR (“Renewable energy” AND “Process improvement”)	66	46
Eco-innovation and organizational innovation	(“Eco-innovation” OR “Environmental innovation” OR “Green innovation”) AND (“Organizational innovation” OR “Organizational change”)	32	16
Eco-innovation and marketing innovation	(“Eco-innovation” OR “Environmental innovation” OR “Green innovation”) AND (“Marketing innovation” OR “Marketing practices”)	5	3

Once the literature sources were established, a search based on determining keywords combinations was carried out to select studies. Keywords were selected taking into consideration the main words related to this field and the words most used by researchers. According to Angelo et al. (2012), "environmental innovation" is the term most commonly used in review papers (65%), followed by "eco-innovation term" (22%) and "green innovation" (13%). Therefore, the keywords used for this stage are mainly combinations of the aforementioned terms, along with some eco-innovation implementations. Table 1 presents the keyword combinations used for the search mechanism and the corresponding results for each database. Keyword combinations are reported in rows while databases are reported in columns. The research timeframe covered the period from January 1990 to December 2017.

The key terms "environmental innovation", "eco-innovation" and "green innovation" embrace an extensive range of sub-topics in spite of being used in conjunction with the four types of EI and also with green practices like "design product", "renewable energy" or "recycling materials". Therefore, search strings were established with the aim of filtering the review and articles being searched. The following fields were selected: Agricultural and Biological Sciences, Environmental Science, Business Science, Economic Science, Ecological Science and Engineering Science. This defined a specific scope for the search and excluded papers whose focus was not relevant to the present study. From this search method, 2.491 papers were found and, as the word combinations were introduced into both databases, 1.969 duplications (79%) had to be removed. Then the title and abstract of each paper were read. Thus, 203 were potentially relevant to this review. After analyzing these complete papers, only those focusing on the EI implementation, i.e. on indicators that measure the implementation of eco-innovations in economic activity, became our set of sources.

The previous procedure led to an initial list of 53 pre-selected articles on eco-innovation implementation. After that, we conducted a cross-reference analysis in order to identify other relevant contributions. Consequently, 51 new references were added.

After analyzing the papers that represent the object of our analysis, the EIPI retrieved were clustered in four different types of EI (product, process, organizational and marketing EI) according with Marcon et al. (2017). This classification is described in more detail in the following sections.

3. Results

The selection process described in the previous section yielded a list of 104 publications. This literature review focused on four types of publications. Most of the publications have been classified as journal papers (85), followed by books or book chapters (15) and other related academic publications (4). Table 2 summarizes the range and frequency of the reviewed journals in the field of eco-innovation implementation. A notable 41% (35 articles) of the articles were published in the Journal of Cleaner Production, and approximately 7% (6 articles) were published in Research Policy. An additional 2% came from the Academy of Management, Journal of Sustainable Development, Journal of Business Ethics, Technovation, Business Strategy and the Environment, Ecological Economics, Packaging Technology and Science, International Journal of Production Economics, Research Technology Management, and Journal of Business Logistics; each respectively contributing 2 articles. Finally, 25 other articles were taken from 25 different journals.

Table 2. Number of articles published in different journals (1990-2017)

Journal name	Number of	Percentage
Journal of Cleaner Production	35	41%
Research Policy	6	7%
Academy of Management Journal	2	2%
Sustainable Development	2	2%
Journal of Business Ethics	2	2%
Technovation	2	2%
Business Strategy and the Environment	2	2%
Ecological Economics	2	2%
Packaging Technology and Science	2	2%
International Journal of Production Economics	2	2%
Research Technology Management	2	2%
Journal of Business Logistics	2	2%
Administrative Science Quarterly	1	1%
Environmental Innovation and Societal Transitions	1	1%
Management Service Quality	1	1%
Resources, Conservation and Recycling	1	1%
Policy Sciences	1	1%
Harvard Business Review	1	1%
International Journal of Operations and Production	1	1%
Journal of Marketing Channels	1	1%
Journal of Remanufacturing	1	1%
Interfaces	1	1%
California Management Review	1	1%
Futures	1	1%
Strategic Management Journal	1	1%
Dyna	1	1%
Clean Technologies and Environmental Policy	1	1%
Energy Economics	1	1%
Journal of Environmental Economics and Management	1	1%
SAM Advanced Management Journal	1	1%
Energies	1	1%
Environmental and Resource Economics	1	1%
Journal of Economic Literature	1	1%
The Leadership Quarterly	1	1%
Academy of Management Review	1	1%
Sustainability	1	1%
Management Decision	1	1%
Total	85	

An analysis was then conducted in order to determine the main areas of research, the years with the most studies published, and the countries on which most literature is focused (Dangelico, 2016; Caldera et al., 2017).

Over the past two decades, EI has been addressed from different perspectives with the main aim of understanding the motivation for its implementation and how it could be promoted. It should first be noted that studies on this subject have focused on the main factors that prompt firms to innovate in this field. These factors are called "drivers". Research on this topic presents and describes the various dimensions that characterize EI. In contrast, the most recent articles focus on the indicators which measure EI in different sectors and countries (Cheng and Shiu, 2012). Figure 1 shows how the number of publications on the environmental innovation field has significantly increased, up to four times since 2007. This result emphasizes the relatively novel interest on this field of research and the increasing attention that it is receiving. Specifically, in the year 2015 there is a high point in the number of publications due to an increase in studies about which factors motivate the introduction of green practices and about the analysis of eco-innovation impact at environmental and firm levels, particularly in the Journal of Cleaner Production and Innovation Management Policy and Practices. The figures 2 and 3 below display the countries and sectors that have caused this increase in publications.

Figure 1. Eco-innovation publications by year (1990-2017)

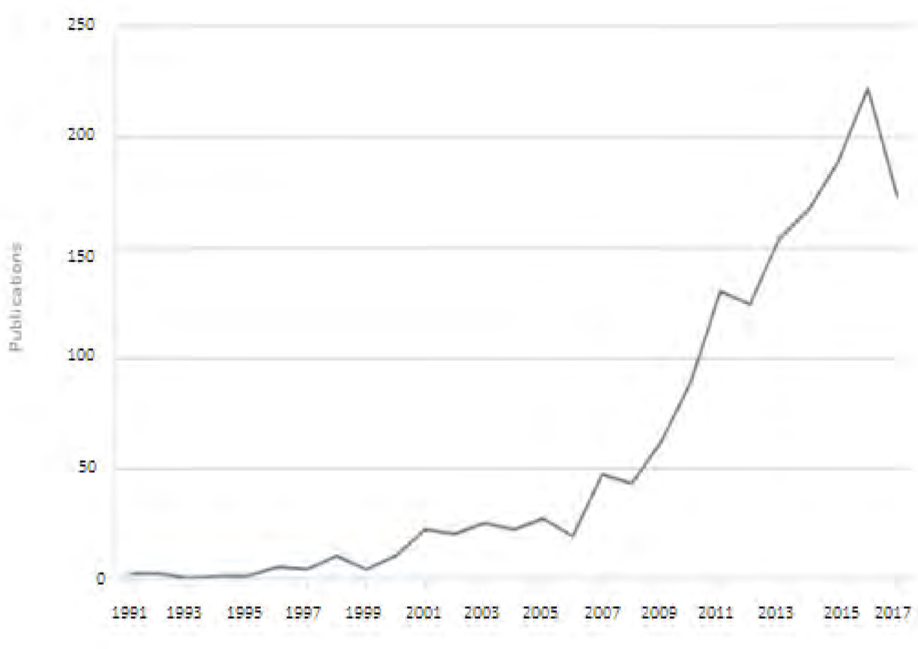
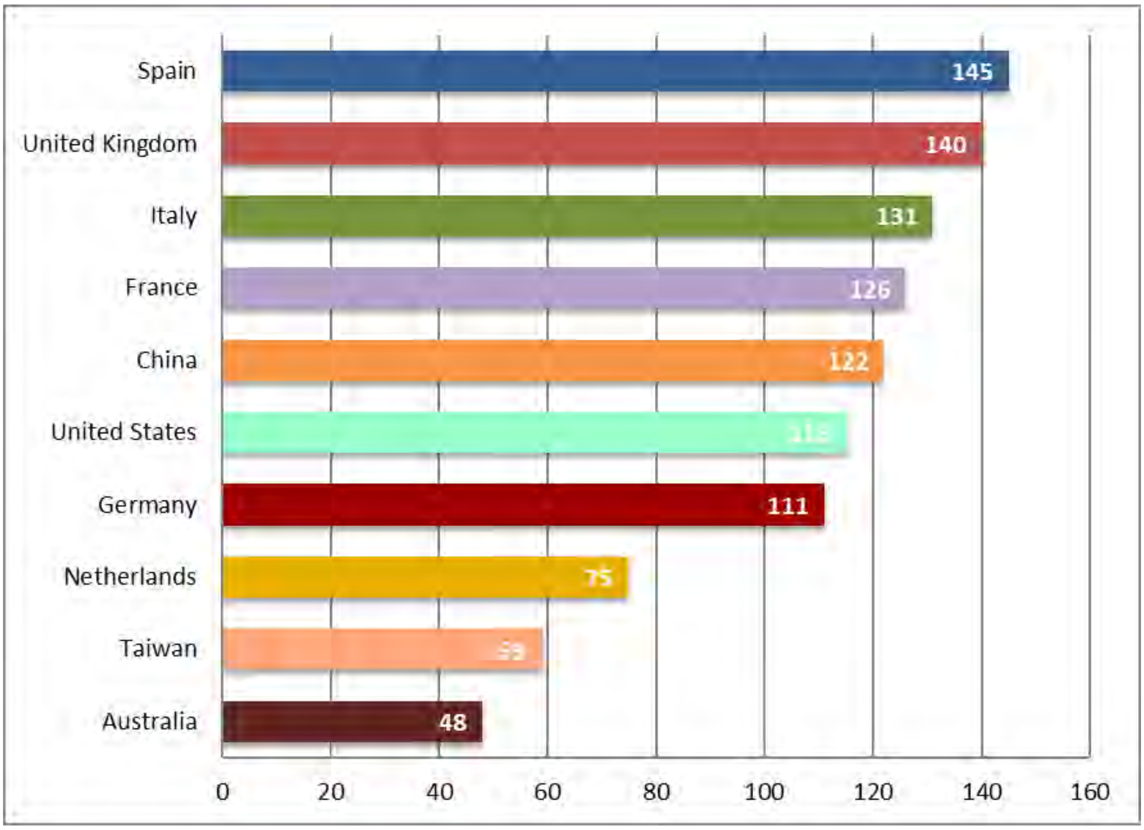


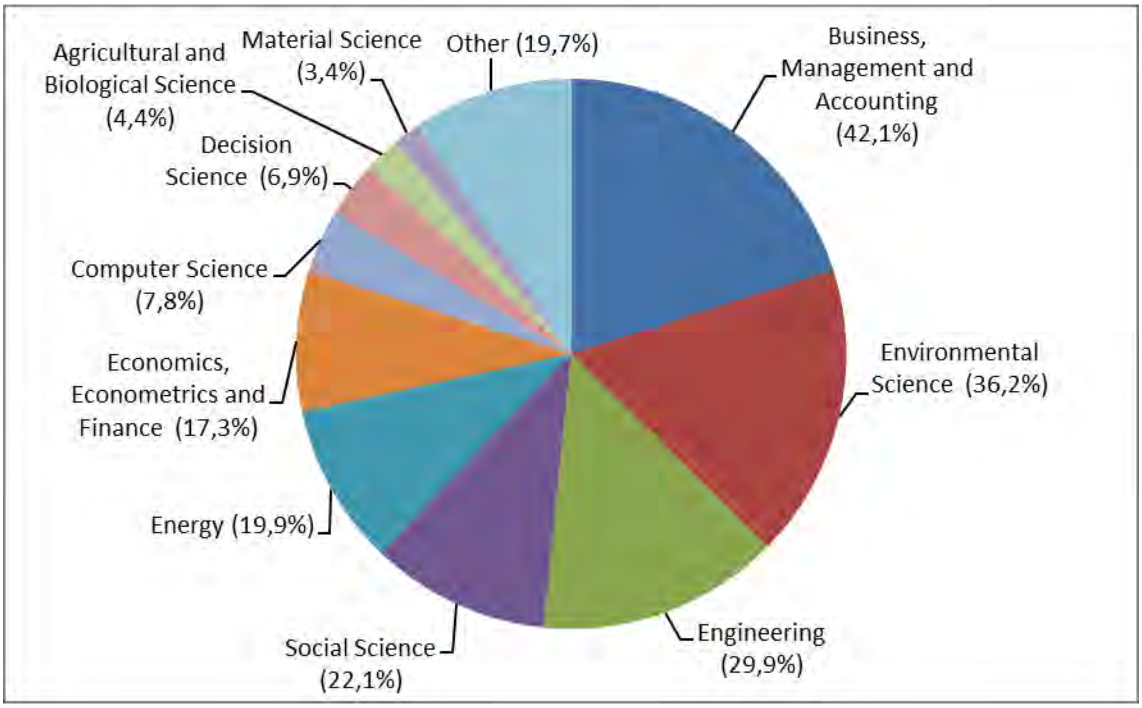
Figure 2 shows the geographic distribution and number of articles by countries, analyzing the literature published in this field since 2007, the year in which the number of publications about EI began to increase considerably. The graph shows that Spain is the country with the highest number of publications, followed by the United Kingdom, Italy, France and China.

Figure 2. Eco-innovation publications by country (2007-2017)



Moreover, Figure 3 displays the main subject areas of EI studies. The field with the most research is Business and Management (42.1%), followed by Engineering (29.9%) and Social Science (22.1%). This distribution of publications could indicate that the research findings were also likely applied to the industrial and energy sectors. In contrast, the green innovation field receives scant attention in Agricultural literature (4.4%), particularly when we consider how closely linked this sector is to the environment.

Figure 3. Eco-innovation publications by subject area (2007-2017)



Analyzing Figures 2 and 3, we can come to the follow conclusion. The countries with a greater number of publications on EI are those with a business network constituted by small and medium size firms. In this context, it is evident that they focus their EI studies on the Business and Management sector, making this sector the main subject area for EI papers. However, countries like Spain, Italy or France have a strong agricultural economic sector which is the engine of the economy in many of its regions. Thus, more studies about this sector would be necessary taking into account the considerable impact that the agriculture has on the environment and its close relationship with the use of natural resources.

4. Discussion: Overview of Research on Eco-innovation Performance Indicators

Key findings from the systematic literature review are detailed below. The findings emphasize 30 key EIPI. In this study they were clustered into four groups, as was shown in Table 3: (i) product innovation; (ii) process innovation; (iii) organization innovation; and (iv) marketing innovation. Thus, this Section is structured into four parts, one for each type of EI, as it has been mentioned in previous sections. To construct this classification, we followed the review by Marcon et al. (2017, p. 84). According to this work, product innovations (i) “can take the form of major or minor changes in the material used, in the technical specification and in the characteristics of the product or service"; process innovations (ii) "are intended to reduce costs, increase quality and provision of the products or services and include improved techniques in auxiliary support activities"; organizational innovations (iii) "refer to new or significantly improved routines, business models, methods and actions that change firms' practices, relations and decisions"; and marketing innovations (iv) "can occur through changes in product design, product placement, communication, new methods of product delivery, promotion or pricing strategies. Moreover, significant changes in product packaging are also considered important marketing innovations".

Table 3 presents a set of key EIPI retrieved from the analysis of the papers selected in Section 2. The articles were included in at least one category, and some articles are included in more than one. For example, Rodríguez and Wiengarten (2017) was considered to correspond to three different types of eco-innovation (EI), i.e. product, process and organizational, and, accordingly, this reference appears linked to these three types in the classification.

Table 3. Eco-innovation key performance indicators analyzed by the literature.

Eco-innovation Types	Eco-innovation performance indicators	References
Product Eco-innovation (1)	Use new cleaner material or new input with lower environmental impact (1.1)	Theyel (2000) Eder (2003) BID (2007) Crabbé et al. (2013) Doran and Ryan (2016) Sierra-Pérez et al. (2016) Castellacci and Lie (2017) Rodríguez and Wiengarten (2017)
	Use of recycled materials (1.2)	Van Hemel and Cramer (2002) Cheng and Shiu (2012) Dalhamar (2015) Marcon et al. (2017)
	Reduce/optimize use of raw materials (1.3)	Eder (2003) Hellström (2007) Pigosso et al. (2010) Crabbé et al. (2013)
	Reduce number of product components (1.4)	Hellström (2007) Cheng and Shiu (2012) Doran and Ryan (2016) Castellacci and Lie (2017) Rodríguez and Wiengarten (2017)
	Eliminate dirty components (1.5)	Eder (2003)

Table 3. Continued.

	Product with a longer life cycle (1.6)	Van Hemel and Cramer (2002) Hellström (2007) Asif et al. (2012) Ye and Zhang (2013) Bakker et al. (2014) Dalhamar (2015) Aziz et al. (2016)
	Product ability to be recycled (1.7)	Garrod and Chadwick (1996) Bakker et al. (2014) Dalhamar (2015) Castellacci and Lie (2017) Rodríguez and Wiengarten (2017)
Process Eco-innovation (2)	Reduce chemical waste (2.1)	Theyel (2000)
	Reduce use of water (2.2)	Alkaya and Demirer (2015) Azad and Ancev (2014) Piedra-Muñoz et al. (2018)
	Reduce use of energy (2.3)	Van Hemel and Cramer (2002) Cheng and Shiu (2012) Alkaya and Demirer (2015) Doran and Ryan (2016) Castellacci and Lie (2017) Rodríguez and Wiengarten (2017)
	Keep waste to a minimum (2.4)	Shrivastava (1996) Norberg-Bohm (1999) Cheng and Shiu (2012)
	Reuse of components (2.5)	Hellström (2007) Dalhammar (2015)
	Recycle waste, water or materials (2.6)	Van Hemel and Cramer (2002) Cheng and Shiu (2012) Doran and Ryan (2016) Castellacci and Lie (2017) Rodríguez and Wiegarten (2017)
	Environmental-friendly technologies (2.7)	Garrod and Chadwick (1996) Frondel et al. (2008) Guziana (2011)
	Renewable energy (2.8)	Johnstone et al (2010) Lacerda and Van den Bargh (2014) Nesta et al. (2014) Nicolli and Vona (2016)
	R&D (2.9)	Cohen and Levinthal (1990) Florida (1996) BID (2007) Kemp and Pearson (2008) Cainelli et al. (2015) Rodríguez and Wiengarten (2017)
	Acquisition of machinery and software (2.10)	BID (2007) Kesidou and Demirel (2012) Cainelli et al. (2015) Rodríguez and Wiengarten (2017)
	Acquisition of patents and licenses (2.11)	Griliches (1990) Lanjow and Mody (1996) Jolly and Phillpot (2004) Oltra et al. (2008) Johnstone et al. (2010) Kesidou and Demirel (2012) Cainelli et al. (2015) Rodríguez and Wiengarten (2017)

Table 3. Continued.

Organizational Eco-innovation (3)	Green human resources (3.1)	Amabile et al. (1996) Anderson (1998) Andriopoulos (2001) Halbesleben et al. (2002) Naffziger et al. (2003) O'Connor and Ayers (2005) BID (2007) Kemp and Pearson (2008) Montalvo (2003, 2008) Boons and Lüdeke-Freund (2013) Cheng and Chang (2013) Tseng et al. (2013) Hojnik and Ruzzier (2016a) Peng and Liu (2016) Rajala et al. (2016)
	Pollution prevention plans (3.2)	Frosch and Gallopoulos (1992) Tibbs (1992) Kemp and Pearson (2008)
	Environmental objectives (3.3)	Williams et al. (1993)
	Environmental audit (3.4)	Baram and Partan (1990) Garrod and Chadwick (1996) Hamner (2006) BID (2007) Kemp and Pearson (2008) Montalvo (2003, 2008) Eltayeb (2009) Zailani et al. (2012) Boons and Lüdeke-Freund (2013)
	Environmental advisory (3.5)	Del Brío and Junquera (2003) BID (2007) Scarpellini et al. (2012) De Jesús Pacheco et al. (2016)
	Invest in research (3.6)	Porter and Van der Linder (1995) Horbach (2008)
	Cooperation with stakeholders (3.7)	Cramer et al. (1991) Frosch and Gallopoulos (1992) Cramer and Schot (1993) Frosch (1994) Florida (1996) Anderson (1998) Becker and Dietz (2004) Hamner (2006) Chen (2008) Eltayeb (2009) De Marchi (2012) Matos and Silvestre (2013) Segarra-Oña and Peiró-Signes (2014) Ghisetti and Reinnings (2014) Ghisetti et al. (2015) Ghisetti and Pontoni (2015) Roscoe et al. (2015) Bossle et al. (2016) Rodríguez and Wiengarten (2017)
	New markets (3.8)	Blättel-Mink (1998) Niinimäki and Hassi (2011) Loorbach and Wijsman (2013)

Table 3. Continued.

	New systems (remanufacturing systems and transport systems) (3.9)	Stock (1992) Blättel-Mink (1998) Carter and Ellram (1998) Moore (2005) El Korchi and Millet (2011) Asif et al. (2012) Ye and Zang (2013) Bakker et al. (2014) Iritani et al. (2014)
Marketing Eco-innovation (4)	Returnable/Reusable Packaging (4.1)	Stock (1992) Hart (1995) Shrivastava (1995) Rosenau et al. (1996) Carter and Ellram (1998) Rogers and Tibben-Lemke (1998) Christmann (2000) Duhaime et al. (2001) Van Hemel and Cramer (2002) Twede and Clarke (2005) Zalani et al. (2012) Silva et al. (2013)
	Green Design Packaging (4.2)	Löfgren (2005) Martin et al. (2006) Henriksson et al. (2009) Langley et al. (2011) Cheng and Shiu (2012) Juul (2012) Zailani et al. (2012) Plumb et al. (2013) Wever and Vogtländer (2014) Lindh et al. (2016) Wilkström et al. (2016)
	Quality certifications (4.3)	Hamner (2006) Eltayeb (2009) Chiarvesio et al. (2015) Li and Hamblin (2016)

The set of key EIPI established in Table 3 highlights the performance indicators most cited by the EI literature to analyze and measure the EI in different sectors and countries, offering a state of art in this topic. It is discussed in the following section.

4.1. Product Eco-innovation

The materials used to make a product as well as the product characteristics themselves have an impact on the environment. Thus, numerous research studies on how to implement environmental innovations have focused on improving the type and quality of inputs and product sustainability in order to reach current environmental requirements and to decrease negative externalities. More specifically, this study of the literature found 7 EIPI based on EI products (1).

Related to the determinants of the product's characteristics and, in turn, its environmental impact, the literature enhances the inputs used to make a product as one of the major points to have in consideration to implant EI. In this sense, reducing the use of dirty inputs (1.5) or substituting them for cleaner or less polluting materials (1.1) contributes to decreasing waste and CO^2 emissions. The materials used to make a product comprise one of the EIPI that a great deal of research highlights as one of the factors necessary for creating products that are more environmental-friendly.

Some authors emphasize the importance of reducing or optimizing the use of raw materials (1.3) to obtain products (e.g., Eder, 2003; Hellström, 2007; Crabbé et al., 2013). The utilization of raw materials as an input in product manufacturing has a significant negative impact on the environment for two reasons. Firstly, its consumption ultimately increases (Agrawal and Ülkü, 2011). Secondly, the decarbonation of raw materials increases carbon dioxide (CO^2) emissions (Ishak et al., 2016). Thus, reducing the use of raw materials (1.3) by a sector or a company is a performance indicator that should be taken into consideration for measuring EI and sustainability level. In this line, Pigosso et al. (2010) support products whose raw materials are obtained from other products as a way to reduce contaminants. Eder (2003) also focuses attention on the necessity of substituting raw materials (1.3) for cleaner alternatives.

Using new cleaner materials or new inputs with lower environmental impact (1.1) is also used in EI literature as an indicator of a product's level of efficiency (e.g., Dora and Ryan, 2016; Castellacci and Lie, 2017; Rodríguez and Wiengarten, 2017). Theyel (2000) highlights the necessity of using cleaner or less polluting materials in a review based on the plastics and resins sector and the ink manufacturing sector in the US chemical industry; while Crabbé et al. (2013), in a study on Flemish production firms, emphasize the importance of innovating to obtain sustainable materials which contribute to making products more respectful of the environment. Also, BID (2007) recognizes the use of new sustainable materials (1.1) as an indicator of the innovation effort of a company. Other empirical market studies note the importance of using cleaner materials (1.1) to reduce the negative environmental impact of firms. According to Sierra-Pérez et al. (2016), introducing the use of cork to replace non-renewable materials in the construction sector decreases ecological impact. Eder's research (2003) highlights eliminating the use of dirty or polluting components (1.5) to make a product in order to obtain fewer contaminant products.

Other performance indicators related to the inputs used in manufacturing show the improvement in product efficiency. One of these indicators is the use of recycled inputs (1.2). According to Dalhamar (2015) and Marcon et al. (2017), the use of recycled materials (1.2) is an essential performance indicator of green innovation. In accordance with this concept, Van Hemel and Cramer (2002) and Cheng and Shiu (2012) emphasize that the use of recycled product components (1.2) is another tool for manufacturing more sustainably. Similarly, research conducted by Hellström (2007) highlights the reduction of the number of product components (1.4) as another successful indicator of product EI. Along this line, other authors introduce the indicator "reduce material per unit of output" (1.4) in the research to measure the level of efficiency of a product (e.g., Doran and Ryan 2016; Castellacci and Lie, 2017; Rodríguez and Wiengarten, 2017).

Analyzing the EI literature is demonstrated the product characteristics are strongly correlated with environmental impact. A product's durability (1.6) and ability to be reused (1.7) are the two most relevant characteristics studied by the EI literature as they are directly linked to product efficiency, reduced consumption of resources, and lower gas emissions. Hellström (2007), Bakker et al. (2014) and Aziz et al. (2016) present the long-life product (1.6) as an effective tool for obtaining a greater level of environment sustainability. Dalhammar (2015) discusses product durability (1.6) and the technical guarantees on life cycle as improvements, which can provide more environmental efficiency, while Van Hemel and Cramer (2002), in their study which analyzes the environmental performance of the US chemical industry, introduce an investigation to extend product lifetime (1.6) by providing a list of the main solutions for achieving sustainability. Moreover, Asif et al. (2012), Ye and Zang (2013) and Bakker et al. (2014) highlight remanufacturing as a strategy to extend product lifetime (1.6).

Additionally, Dalhammar (2015), Castellacci and Lie (2017) and Rodríguez and Wiengarten (2017) introduce the ability of a product to be recycled (1.7) after use as a key performance indicator for measuring EI level. This practice leads to the reduction of waste as it extends product life at the same time. Along this line, Garrod and Chadwick (1996) carried out a survey of companies located in the South of England to determine how firms had handled the increase of environmental pressures. Their analysis identified several firm performance indicators that were implemented, one which was the recycling of part of the used final product (1.7). Also, Bakker et al. (2014), in their study on household products, emphasize the recycling of products (1.7) as an essential tool in order to achieve greener practices.

4.2. Process Eco-innovation

The environmental impact of a company is not only due to what the company produces but also how the company manufactures its products. Groenewegen et al. (1996) have established the relationship between the manufacturing processes of a company and negative environmental impact. Thus, it is necessary to take into consideration improvements in manufacturing processes and include relevant EI indicators in order to efficiently measure levels of environmental innovation. This study of the literature has identified 11 EIPI based on improvements in manufacturing processes (2).

The total use of water or energy is a widely-used method in EI literature for analyzing process improvement. Alkaya and Demirer (2015), in a review of the Turkish chemical industry, use the indicators "reduce water consumption" (2.2) and "reduce energy consumption" (2.3) to study the sustainability of the sector's production processes and whether companies attempt to fulfill green requirements. In the same way, irrigated agriculture is one of the sectors where the use of water has been most analyzed. Many studies measure the effects of eco-innovations aimed at optimizing water usage on farmers' environmental impact (Azad and Ancev, 2014; Piedra-Muñoz et al., 2017, 2018). Other works which follow this line include: Van Hemel and Cramer (2002), who analyze a group of 77 small and medium sized companies (SMEs); Cheng and Shiu (2012), who measure EI from the perspective of implementation; Doran and Ryan (2016), who base their review on the Irish Community Innovation Survey; Catellacci and Lie (2017), who focus their study on manufacturing firms in Korea; and Rodríguez and Weingarten (2017), who study several German industries and highlight energy reduction (2.3) in the manufacturing process as a performance indicator to measure environmental efficiency.

The level of waste (2.4) in a process is also analyzed as a cause of pollution. Thus, Shrivastava (1996), Norberg-Bohm (1999) and Cheng and Shiu (2012) emphasize the importance of introducing new technologies with the aim of reducing waste to a minimum. Theyel (2000) expands on this reasoning by proposing the idea of reducing chemical waste (2.1) in production processes as much as possible. According to the Van Hemel and Cramer (2002) study, which focused on the US chemical industry, firms that innovate in terms of reducing chemical waste (2.1) are leaders in adopting environmental practices.

Materials-saving is another key performance indicator for measuring EI and the efficiency level of a process. This indicator can be viewed from two perspectives. On the one hand, the reuse of components or materials (2.5) attracts attention as a positive way of being greener in the manufacturing process (Hellström, 2007; Dalhammar, 2015). On the other hand, the recycling of waste, water, materials or inputs (2.6) is another means of reducing negative environmental impact. Thus, some authors introduce the indicator "recycled waste, water and materials" (2.6) in their studies to measure environmental innovativeness (e.g., Doran and Ryan, 2016; Castellacci and Lie, 2017; Rodríguez and Wiegarten, 2017). Furthermore, according to Van Hemel and Cramer (2002) the eco-indicator "recycling of materials" (2.6) is the most successful among firms to improve their environmental performance.

The level of investment carried out by a company is a relevant performance indicator of its effort to be greener. In this context, some authors analyze company investment in patents (2.11) as a means of achieving environmental innovations to improve energy consumption and material efficiency (Kesidou and Demirel, 2012; Cainelli et al., 2015; Rodríguez and Wiengarten, 2017). In a study on renewable technology, Johnstone et al. (2010) identify the number of patents (2.11) as a measurement indicator of EI. Additionally, Griliches (1990), Lanjow and Mody (1996), and Jolly and Phillipot (2004) show that patents are a good indicator for measuring innovation activity level. Furthermore, the European Commission contemplates the "eco-patents" as an indicator of the level of innovative activity in the environmental field and as a way for studying eco-innovations (Oltra et al., 2008).

Nevertheless, not all company research efforts and investments are always patented. Thus, in addition to the number of patents, other practices exist that this indicator does not take into consideration (Oltra et al., 2008; Artz et al., 2010). For this reason, although the number of patents is strongly correlated with research and development (R&D) spending, it is necessary to include the indicator "number of patents" along with others such as acquisition of machinery and software (2.10) or R&D investments (2.9) to achieve a more accurate view of the innovative reality of a firm. R&D activity (2.9) is treated by some authors as a key performance indicator in the EI process. In fact, it has been shown that firms which implement R&D activities (2.9) are more likely to be environmentally innovative than firms that are not R&D active since the former have a higher absorptive capacity (Cohen and Levinthal, 1990; Cainelli et al., 2015). According to Florida (1996), firms that are R&D active (2.9) improve their productivity and reduce negative environmental impact. Thus, some authors (e.g., BID, 2007; Kemp and Pearson, 2008; Rodríguez and Weingarten, 2017) introduce the indicator R&D (2.9) to measure EI and subdivide it into internal or external R&D.

In addition, other authors (e.g., Kesidou and Demirel, 2012; Cainelli et al., 2015; Rodríguez and Wiengarten, 2017) focus their studies on the acquisition of machinery (2.10) as a key factor for the purpose of more efficient use of energy and materials. BID (2007) also illustrates the importance of incorporating new capital assets, i.e., hardware and software (2.10), in order to implement ecological innovations in a company.

The use of renewable energy (2.8) and environmental-friendly technologies (2.7) are two more relevant EIPI emphasized by the literature in this field as ways of achieving more efficient manufacturing processes, making them crucial for addressing global environmental aims. Frondel et al. (2008) highlight the environmental benefit of introducing *end-of-pipe* technologies (2.7) in manufacturing processes, whereas Guziana (2011) concludes that clean technologies (2.7) are more proactively innovative than the former. Along this line, Garrod and Chadwick (1996), in their survey of environmental strategies carried out by companies located in the South of England, determined that investment in clean technology (2.7) is a tool that can be implemented to fulfill ecological requirements. Moreover, other articles address the importance of introducing renewable energies (2.8) in company processes in order to improve quality of life for current and future generations and to meet public environmental objectives (e.g., Lacerda and Van den Bergh, 2014; Nesta et al., 2014; Nicolli and Vona, 2016).

4.3. Organizational Eco-innovation

Chen (2008) illustrates the importance of the relationship between green intellectual capital and the competitive advantage of firms. Chen’s study which focused on the

Taiwanese information and electronics industry, emphasizes the positive correlation between these two indicators. According to its findings, there are three types of green intellectual advantage: green human capital, green structural capital, and green relational capital. Furthermore, the study identified 9 EIPI related to organizational eco-innovation (3). Said indicators are introduced below.

Green human capital (3.1) refers to the collective knowledge, skills, creativity, experience and capabilities of employees. In this sense, based on a study of the In-Bond industry in the northern region of Mexico, Montalvo (2003) highlights the influence of managerial characteristics (3.1) on EI and the environmental-economic risks of developing cleaner technologies and manufacturing processes. Other studies (e.g., Montalvo, 2008; Boons and Lüdeke-Freund, 2013; Chen and Chang, 2013) support this idea arguing that senior staff (3.1) can encourage employees to be more creative, innovative and respectful with the environment. According to Andriopoulos (2001) and Halbesleben et al. (2003), leaders (3.1) with appropriate green perspectives play a key role in facilitating organizational creativity as well as the implementation of environmental innovations. Amabile et al. (1996) highlight creativity (3.1) as a starting point for innovation. Furthermore, Rajala et al. (2016), in a study of the US-based carpet manufacturer Interface, illustrate the role of the managerial agency (3.1) in driving environmentally sustainable practices in a company in order to unite firm culture and firm orientation with a green business model. The relationship between employing managers who are more in tune with environmentally conscious practices and greener business models based on better ecological performance and higher investments in environmental initiatives has also been highlighted by other researchers, e.g., Anderson (1998), O'Connor and Ayers (2005), and Hojnik and Ruzzier (2016a). In this line, Naffziger et al. (2003) and Tseng et al. (2013) establish the relationship between the presence in a company of a manager with a higher level of environmental (3.1) concern and the time and money invested in environmental initiatives. Moreover, Peng and Liu (2016), in a study which explores the determinants of EI, include the indicator "managerial environmental awareness" (3.1) in order to measure green innovation. In addition, BID (2007) and Kemp and Pearson (2008) accentuate the importance of green human resources (3.1) as an indicator which shows the innovative effort of a firm.

Green structural capital includes organizational capabilities, organizational commitments, organizational culture and philosophies, patents, copyrights, etc. Some of these have been analyzed in the previous section as processes of EI. Nevertheless, organizational cultures and philosophies can also be considered an organizational EI. According to Battisti (2008), it is not only important for firms to generate innovations; innovations must be adopted and used by firms, incorporated into their routines and their company philosophy. Thus, environmentally-oriented culture is another green performance indicator that should be taken into account by the literature for measuring EI. In a review carried out by Williams et al. (1993), this indicator, i.e. environmentally-oriented culture, is measured using the number of environmental objectives (3.3) included in production plans and operations. The reviews of Frosh and Gallopoulos (1992), Tibbs (1992) and Kemp and Pearson (2008) also highlight the inclusion of environmental plans (3.2) in production processes.

From the point of view of several researchers (e.g., Baram and Partan, 1990; Hamner, 2006; Zailani et al. 2012), conducting external environmental audits (3.4) is another good performance indicator for measuring the level of company commitment to environmental requirements. In their study based on a firm survey, Garrod and Chadwick (1996) also introduce environmental audits (3.4) as a growing indicator used to achieve EI. Ecological audits (3.4) provide firms with knowledge as to whether their green innovation is being effective and, depending on the result, firms can implement new ecological practices to reduce their environmental impact. Thus, Kemp and Pearson (2008) enhance auditing systems as a key organizational innovation for the environment. In addition, consulting services (3.5), which ensure compliance with environmental standards, constitute another tool that has the potential to increase the EI level of a company (e.g., del Brio and Junquera, 2003; Scarpellini et al., 2012; de Jesus Pacheco et al., 2016). According to this, BID (2007) enhances the outsource consulting and technical assistance (3.5) as green innovative strategies.

Investment in research (3.6) is another key point that firms should introduce in their corporate culture. Although controlling pollution can be effective, it is not always the most efficient way to satisfy environmental requirements. Therefore, restructuring a firm’s approach toward environmental management, from pollution control to pollution prevention, may be the most ecologically-driven method (Gottlieb et al., 1995). Accordingly, investing in research becomes an effective tool for achieving this goal (Porter and Van der Linder, 1995; Horbach, 2008).

Green relational capital is defined as the relationships of the company with customers, suppliers, network members, and partners regarding environmental management and EI. Accordingly, cooperation with stakeholders (3.7) enhances the creation of competitive advantage and simultaneously helps to achieve environmental objectives (e.g., Matos and Silvestre, 2013; Roscoe et al., 2015; Rodríguez and Wiengarten, 2017). According to Cramer et al. (1991), Cramer and Schot (1993) and Frosch (1994), restructuring firm relationships with pressure groups (3.7) is an important factor for obtaining information about the environment and providing assistance to suppliers and customers. Furthermore, forming partnerships with these groups (3.7) affords greater possibilities to seek out solutions to environmental problems (Frosch and Gallopoulos, 1992) and to renew firm business models to make them greener and more sustainable (Anderson, 1998). Florida (1996) and Chen (2008) also highlight the close positive relationship between firm-supplier ties (3.7) and the creation of new environmental improvement opportunities. Cooperation with suppliers, universities and public research institutions (3.7) has three significant benefits. First, it provides the firm with knowledge (e.g., Ghisetti and Reinning, 2014; Ghisetti and Pontoni, 2015; Bossle et al., 2016). Second, it allows a firm to obtain information with the aim of improving products and processes (De Marchi, 2012; Segarra-Oña and Peiró-Signes, 2014). Third, it makes it possible for the firm to develop technological capabilities necessary to generate innovation (Becker and Dietz, 2004; Ghisetti et al., 2015).

One well-known cooperation method (3.7) is to create supplier questionnaires. These surveys provide firms with information about their level of environmental commitment and the quality of their environmental characteristics, activities and practices. In addition, firms obtain an idea of what kind of image their activities produce in the eyes of stakeholders (Eltayeb, 2009; Hamner, 2006). This practice allows firms to correct non efficient activities and implement new, greener ones.

The development of new market niches (3.8) is considered by some researchers to be another useful tool for the purpose of implementing green innovations (e.g., Blättel-Mink, 1998; Niinimäki and Hassi, 2011; Loorbach and Wiisman, 2013) and introducing new systems (3.9) (Blättel-Mink, 1998). According to El Korchi and Millet (2011), introducing remanufacturing systems or reverse logistic channels (3.9) allows firms to reduce environmental impact by reducing waste and extending product life cycle. Asif et al. (2012) and Ye and Zang (2013) believe multiple life cycle products (MLPs) (3.9) constitute an important strategy for developing sustainable products and that remanufacturing is the best tool for achieving this goal. Additional research supporting remanufacturing systems (3.9) has also been published in a number of other relevant works (e.g. Stock and Lambert, 2001; Moore, 2005; Bakker et al., 2014). Finally, implementation of new transport systems (3.9) based on new routes, short distances, and the replacement of diesel fuel is another means of applying green innovation (Iritani et al., 2014) and achieving less pollution through the reduction of CO^2 emissions.

4.4. Marketing Eco-innovation

Marketing innovation activities are relevant performance indicators for implementing and measuring EI, as stated by BID (2007). However, marketing green innovation has received less attention than other types of EI in environmental literature, which by no means makes it any less important. This review has identified 3 EIPI based on marketing (4). Recently, certain research has focused on identifying the environmental marketing indicators that can measure the level of EI implementation in order to reduce the negative environmental impacts of companies; achieve greater efficiency; and find new ways to carry out ecological innovation in the four dimensions: product, process, organizational and marketing.

Some environmental policies have focused on packaging, for example, the Directive 94/62/EC in the European Union, the response to the large amount of waste disposable packaging generates and its negative environmental impact (González-Torre et al., 2004). Thus, the use of returnable packaging (4.1), which can be recycled and reused, contributes to EI by increasing product efficiency while reducing waste and resource consumption. Some examples of relevant publications on the environmental benefits of using returnable packaging (4.1) include Rogers and Tibben-Lembke (1998), Duhaime et al. (2001) and Twede and Clarke (2005). In this line, Stock (1992), Carter and Ellram (1998) and Silva et al. (2013) focus their studies on the reduction of waste and the improvement in resource efficiency resulting from the use of returnable packaging. Furthermore, Zailani et al. (2012) emphasize the need for design innovation in reusable packaging in order to enhance sustainability. Similarly, more authors (e.g., Hart, 1995; Shrivastava, 1995; Christmann, 2000) highlight the importance of packaging design (4.2) that can be reused in order to improve the sustainable performance of firms. Other studies agree with this environmental innovation indicator (e.g., Rosenau et al., 1996; Van Hemel and Cramer, 2002). In the literature the importance of packaging design (4.2) to influence consumer interaction with products is demostrated (Löfgren, 2005). Jelsma (2006) illustrates, for example, that product attributes can determine consumer behavior. Some authors (e.g., Zailani et al., 2012; Wever and Vogtländer, 2014; Wilkström et al., 2016) question the importance of including 'sustainable' packaging design as a means to fulfill ecological requirements, discussing whether it encourages customers to reduce food waste and recycle packaging. In order to measure of the extent to which sustainable packaging has been implemented, a great deal of researchers have debated the attributes packaging must possess in order to be green, such as: easy to empty (Langley et al., 2011; Juul, 2012); easy to clean (Langley et al., 2011); easy to separate into different fractions (Henriksson et al., 2009) easy to fold (Martin et al., 2006); provides information about how to sort (Henriksson et al., 2009; Langley, et al., 2011); contributes by extending time between packaging date and expiration date (Plumb et al., 2013; Lindh et al., 2016); and contains the desired quantity (Lindh et al., 2016). According to Cheng and Shiu (2012), simplifying packaging is also a necessary way to obtain sustainable packaging.

Although the main focus in the literature about EI marketing type is on packaging, customer buying decisions are not only influenced by traditional criteria like cost, quality, and delivery but also by green firm image and sustainable firm activities. This is due to the increase in market awareness of environmental problems. In this context, quality certifications (4.3) are the best way to show markets whether a firm is fulfilling environmental requirements. Product certification according to international standards, such as ISO 14001 or Globalgap, is an increasingly necessary requisite for companies wishing to gain entry to numerous markets. This issue has been addressed by various authors, such as Hamner (2006), Eltayeb (2009) and Chiarvesio et al. (2015). Additionally, Li and Hamblin (2016), in a study based on pharmaceutical manufacturing companies in Tianjin (China), introduced the indicator "ISO 14001" to analyze the impact that some factors (CO_2, packaging, waste…) have on cleaner production. In this context, standards certifications related to environmental management can be a good EI performance indicator to measure the efforts to accomplish the environmental requirements.

5. Conclusions and Future Research

EI implementation has received little attention in comparison with the wide range of studies published on EI concepts, consequences and drivers (Kemp, 2009). Thus, the present study looks to fill the existing gap, analyzing the literature on key EIPI, and synthesizes the most current research on this topic, adding value in the following ways. On the one hand, it offers an overview of which performance indicators are the most cited in the EI literature. In this line, this review contributes to develop a body of knowledge to analyze and measure the level of EI implementation that can potentially guide recommendations for future economic, social and environmental policies in order to reach current environmental objectives (Carrillo-Hermosilla et al., 2010; Boons and Lüdeke-Freund, 2013). This is particularly interesting because EI policies play a key role in the EI implementation as Rennings (2000), Del Río et al. (2010) and Wagner and Llerena (2013) mention. On the other hand, a set of EIPI was developed to show the most important performance indicators that must be included in the four types of EI (product, process, organizational and marketing), which can also be used as a guide to obtain an efficient environmental innovation measurement. Furthermore, this can be useful to create compound indicators for measuring level of environmental innovation and, subsequently, comparing said levels between countries, sectors or companies.

It is clear that the environmental impact of firms' daily activities such as CO_2 emissions, non-efficient use of resources, and high waste levels of water and energy, increases concern regarding their ecological performance. Thus, the implementation of EI is critically important due to the ever-increasing demand for a cleaner environment. In this context, research works in business, environmental and economic literature are focused on trying to measure and analyze EI implementation levels in order to discover how environmental actors can reduce their negative environmental impacts, fulfill green requirements and be more efficient to ensure the well-being of current and future generations. The careful study of literature focused on measuring and analyzing EI implementation in different countries and sectors has generated the following conclusions. It is observed that a large portion of the literature on measuring EI are focused on product, process and organizational EI type. Thus, the 36% of the 30 key performance indicators identified corresponding to process EI, 30% to organizational EI and 23% to product EI. In this sense, marketing EI type has received little attention by the literature in spite of its increasingly known environmental impact. Moreover, the vast majority of literature on EI measurement is focused on the Business, Management and Engineering sector; thus, more studies should be carried out in sectors like agriculture due to its close relationship with the use of natural resources and environmental externalities. Our study also identified some weakness on existing studies on EI measurement. Most research has focused on exploring one or two types of EI (product, process, organizational or marketing EI), but not all four types in specific areas. This fact does not afford an efficient, comprehensive study on EI and, instead, offers a very limited vision of the level of EI in firms, sectors or countries. The most complete studies on this subject have been carried out by Doran and Ryan (2016), Castellacci and Lie (2017) and Rodríguez and Wiengarten (2017). However, they only investigate EI implementation in product and process type, so their conclusions do not accurately reflect the reality of the firm, and they can only provide a limited idea of the level of ecological innovation implementation. Another notable weakness in existing research on EI implementation is related to the performance indicators that are included. Choosing a complete combination of indicators in each EI type is not an easy task, and evidence suggests that the majority of studies include indicators that are chosen in rudimentary ways, with little attention given to which indicators add more environmental value in each sector and firm. Although some methods are better than others, no single method or indicator is ideal. Different methods should be applied for analyzing eco-innovation, as Kemp (2009, p.103) mentioned: "to see the whole elephant, instead of just a part". Consequently, it would be particularly interesting for future research to conduct studies in which all types of EI, as well as the most relevant green indicators in each type, are included. Future research that applies new questionnaires in different sectors can help to discover new ways of marketing. The inclusion of new indicators would help to fill existing gaps related to those EIPI that have already been identified. This is particularly useful when seeking to obtain an accurate measurement of EI level.

A number of limitations of this study can be cited. Firstly, it follows a strictly theoretical research method based on previous research. Future works could be aimed at studying actual case studies to identify what companies are actually doing. Secondly, another shortcoming is the search frame, as the database choice for the paper search could be expanded. Thirdly, one more limitation is related to the criteria initially used for the paper selection. Expanding criteria could lead to other EIPI not covered by this study.

Thus, all these points are also opportunities for future research.

Finally, the results have corroborated that environmental innovation should be analyzed as a whole in order to have a sound method for measuring EI level including the four dimensions of EI (product, process, organizational and marketing) and a complete indicator combination in each type. Looking to the future, this research has provided much information with implications for industry, governments and academia to understand which EI indicators can be implemented by environmental stakeholders to reduce their negative environmental impact and become greener. This study also supplies a set of EI implementation indicators to aid practitioners and policy-makers in assessing the balance between company activities and sustainability. These are relevant opportunities to advance the academic perspective towards the constitution of a body of knowledge on this research topic.

CHAPTER 3

REVEALING RESEARCH TRENDS IN AGRI-FOOD ECOLOGICAL INNOVATIONS

REVEALING RESEARCH TRENDS IN AGRI-FOOD ECOLOGICAL INNOVATIONS

Abstract

Eco-innovation (EI) in the agri-food sector is considered a key element in the path toward achieving the conservation of ecosystems and human wellbeing. Therefore, the aim of this study is to contribute to the understanding of the current status of agri-food EI studies, providing an international overview of literature for identifying the research trends and popular issues in this field. In this sense, bibliometric analysis based on the Scopus database was used to examine articles related to the topic, published between 1976 and 2020. A total of 201 papers were evaluated, showing that there has been a significant increase in research interest in the agri-food EI field since 2005. Moreover, the most influential articles are categorised by their main contributions in the EI themes. The results indicate that the most frequent keywords are ‘Sustainability’, ‘Sustainable development’ and ‘Eco-innovation’. This study also reveals a trend toward empathising with ‘Agroecology’, ‘Biodiversity’ and ‘Environmental economics’ in current agri-food EI research. In future works, more multi-case studies and multidimensional EI performance research in the agri-food sector will be necessary to create a body of knowledge on this subject.

Keywords: eco-innovation, agri-food sector, sustainability, ecosystems, bibliometric analysis.

1. Introduction

Humans have extensively and intensely intervened in natural ecosystems due to the need to obtain basic goods in a context marked by population increase, scarcity of resources and global warming. There is a consensus that food production will have to increase 70% by 2050 (FAO, 2009; Öborn et al., 2011; Dobermann and Nelson, 2013), the same year in which the world population is going to surpass 9,000 million (OECD, 2012).

In this context, ecological innovation or eco-innovation (EI) is positioned as a link between business performance and sustainable development. EI was defined by Kemp and Pearson (2007, p.7) as ‘’the production, assimilation or exploitation of a product, production process, service or management or business method that is novel to the organisation and which results, throughout its life cycle, in a reduction of environmental risk, pollution and other negative impacts of resources use compared to relevant alternatives’’. Similarly, Oltra and Saint Jean (2009, p.1) considered it to be “innovations that consist of new or modified processes, practices, systems and products which benefit the environment and so contribute to environmental sustainability”. Albeit different concepts are also found in several other works, such as Carrillo-Hermosilla et al. (2010) or Tamayo-Obergozo et al. (2017), all EI definitions include an environmental component and reflect its two main effects: fewer adverse impacts on the environment and more efficient use of resources (Hojnik and Ruzzier, 2016b).

The complexity of this issue is especially important in the agricultural sector. On the one hand, this sector is closely linked with resource conservation, such as water preservation, pest control and biodiversity maintenance (Bianchi et al., 2006; Power, 2010; Hayati et al., 2011). On the other hand, the agricultural processes and characteristics contribute directly to human wellbeing and social development as they fulfil the most basic needs of human beings, namely food. Moreover, in recent years, there has been a trend towards the ecological perspective of agriculture and, consequently, there has been rapid EI research growth in the agri-food sector.

Numerous studies have been carried out to analyse the EI phenomenon in the agri-food sector from different perspectives. Some explore the main factors influencing companies to implement green practices (Blasi et al., 2015; Lioutas and Charatsari, 2017). Others have focused on investigating those practices that enhance agricultural sustainability (García-Granero et al., 2018, 2020). According to Drejeris and Miceikienè (2018) and Martos-Pedrero et al. (2019), an employee’s green values are essential in sustainable development. In the cases of Shih et al. (2018) and Rabadán et al. (2019), they defend the positive effect that relationships with suppliers and cooperation with stakeholders have on a sustainable agricultural transition. Other investigations argue the need for specialisation in new environmental-friendly products and development of new processes to build EI in this sector (Godoy-Durán et al., 2017; Shih et al., 2018).

Additionally, some explore the environmental impacts and outcomes of agricultural eco-innovative practices (Galdeano-Gómez, 2010; Rodriguez-Rodríguez et al., 2012).

The increase in agri-food EI research allows investigation into how the EI concept is applied. Bibliometric analysis employs the quantitative of the literature and makes it possible to give shape, structure and direction to the research domain as it develops and advances (Liu and Liu, 2015; Wei et al., 2017; Wu and Wang, 2018). Recently, some studies have applied the bibliometric methodology in the EI field (Franceschini et al., 2016; Vaz et al., 2017; Yin et al., 2018; Taddeo et al., 2019). Nevertheless, to the best of our knowledge, there are still no papers published that systematically review the current research status of EI in the agri-food sector. This work contributes to fill this research gap, applying bibliometric techniques to provide an international overview of this area and explore the way in which scholarly research on agri-food EI is being conducted. Therefore, the goals of this study are: (i) to identify the latest research status and trends, including the quantity of articles, their geographical and periodical distributions, most productive journals, countries and authors, h-index and citations; (ii) to recognise the most influential articles and categorise them by their main contributions in the EI issues; (iii) to identify academic collaborations and key research topics; (iv) finally, based on the above-mentioned analysis, to provide recommendations regarding future agri-food EI research.

The present study is organised as follows: Section 2 provides the data sources and research methods. Section 3 presents the findings of the bibliometric analysis. Section 4 discusses the main characteristics of these studies. Finally, Section 5 presents the main conclusions and suggestions for future work.

2. Materials and Methods

In other to develop the objectives of this investigation, the literature is reviewed in two ways. On the one hand, a bibliometric analysis is applied to identify the main trends. On the other hand, the most cited publications are studied in depth in order to extract the main contributions.

The bibliometric technique was introduced by Garfield (1955). It consists of applying statistical methods to establish qualitative and quantitative changes within a given scientific research topic to detect the profile of publications on the topic and to highlight trends within the discipline (De Bakker et al., 2005; Daim et al., 2006; Bouyssou and Marchant, 2011).

Furthermore, like other bibliometric analyses, the Scopus database was selected to obtain the sample of studies to be analysed (Storopoli et al., 2019; Sudolska et al., 2019; Taddeo et al., 2019;). All the most frequently used terms related to ecological innovation and the agri-food sector were used as the search parameters. Their selection was based on previous literature on the same subject (Hellstrom, 2007; FAO, 2012; IICA, 2014; Barth, 2017; García-Granero et al., 2018). As shown in Figure 1, "eco-innovation*", "ecological innovation*", "environmental innovation*", "green innovation*", "sustainable innovation*", "eco-friendly innovation*", "environmentally friendly innovation*", agri*, agro*, food*, farm*, crop*, vegetab*, fruit* were used as search parameters in the search fields of title, keywords, and abstract. The search was carried out without any chronological restriction, obtaining publications from 1976 to 2020. Given that results of a study are frequently published as conference papers, book chapters and articles, in order to avoid duplications, only articles were included in the sample (Yin et al., 2018). The search was carried out in March 2020 and the final sample analysed was composed of 201 articles.

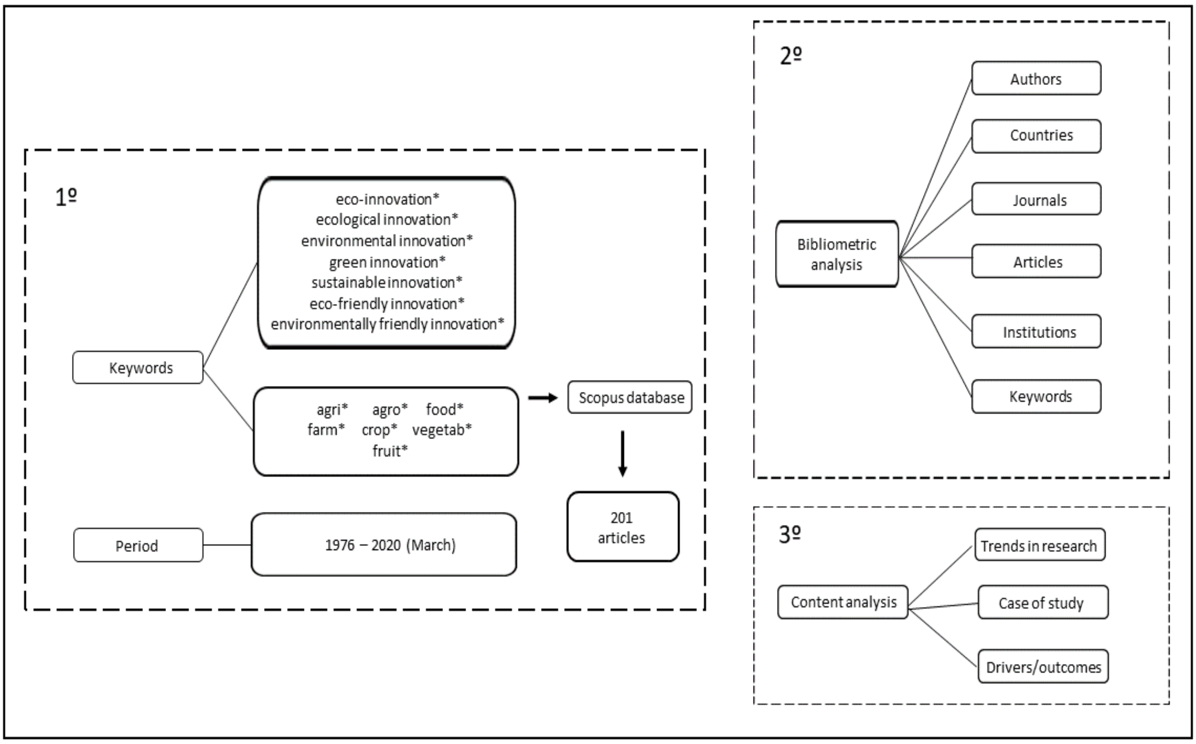
The bibliometric variables analysed by the EI studies in the agri-food sector are the following:

- The number of publications per year and by subject categories.
- The number of citations per year.
- The most relevant journals.
- The most cited papers published and their main contributions.
- The most productive authors, institutions and countries.
- Author co-citations network.
- Countries network.
- The most frequent topic words and their evolution.

After selecting the sample and the indicators to be evaluated, three software tools were used to process the data: Excel, SciMAT and VOSviewer. These software programmes are commonly employed for this type of study (Rodrigues Vaz et al., 2017;

de-Miguel-Molina et al., 2018). Finally, a keyword analysis was conducted to extract the main research trends.

Figure 1. Bibliographic portfolio.



3. Results

This section presents the main results, examining the research works published between 1976 and 2020. This time period begins in said year as the study entitled *Environmental practices: new strategies needed* by Van Es and Pampel (1976) was the first document published on the topic that is in the Scopus database.

3.1. Evolution of Publications and Citations

Figure 2 shows the accumulation of the number of studies published on EI in the agri-food sector since 1976 and reveals two stages in the publication trend. The first stage corresponds to the period between 1976 and 2005, when the volume of studies was less than 3 studies per year. During the second stage, from 2006 to 2015, research grew moderately. Finally, the third stage covers the period between 2016 and March 2020, when the number of publications increased considerably. The annual volume of this period is between 20 and 36, with the record number 36 corresponding to 2015.

Figure 2. Total publications on agri-food EI between 1976 and 2020 (March)

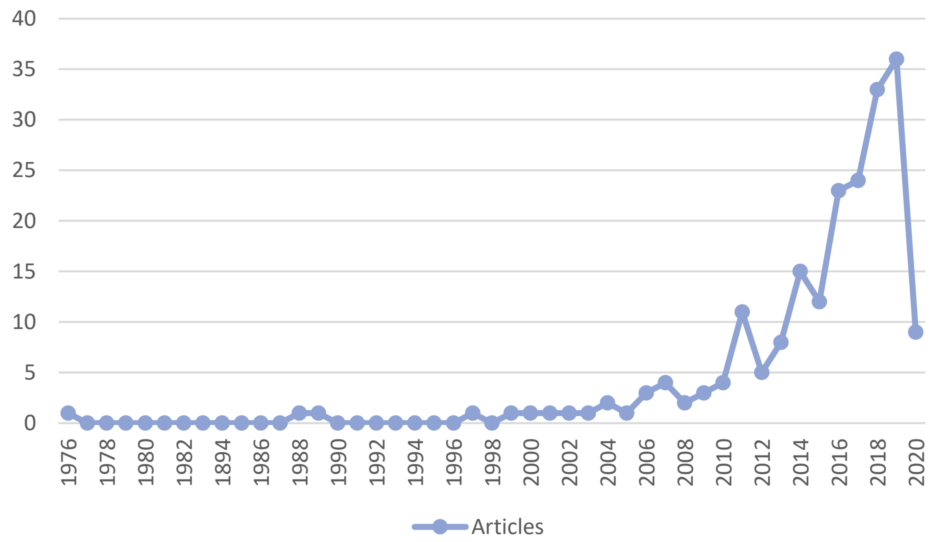
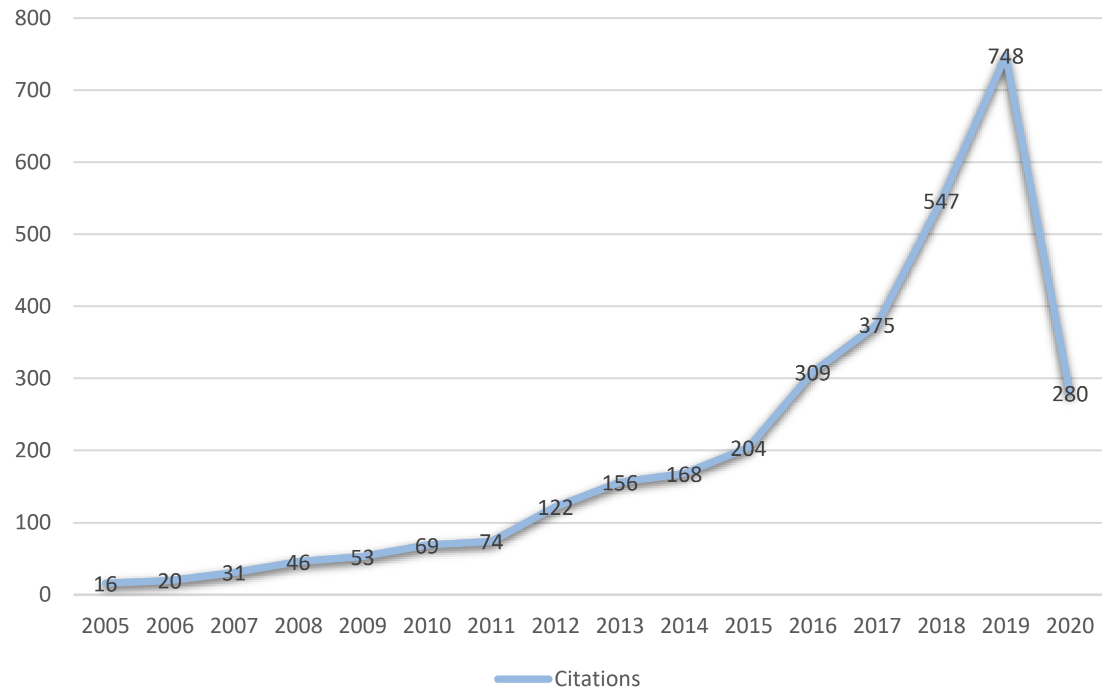


Figure 3 presents the annual number of citations of EI studies in the agri-food sector during the period of research growth (2005-2020). The results show an upward trend over the past year, reaching a record of 748 citations in 2019.

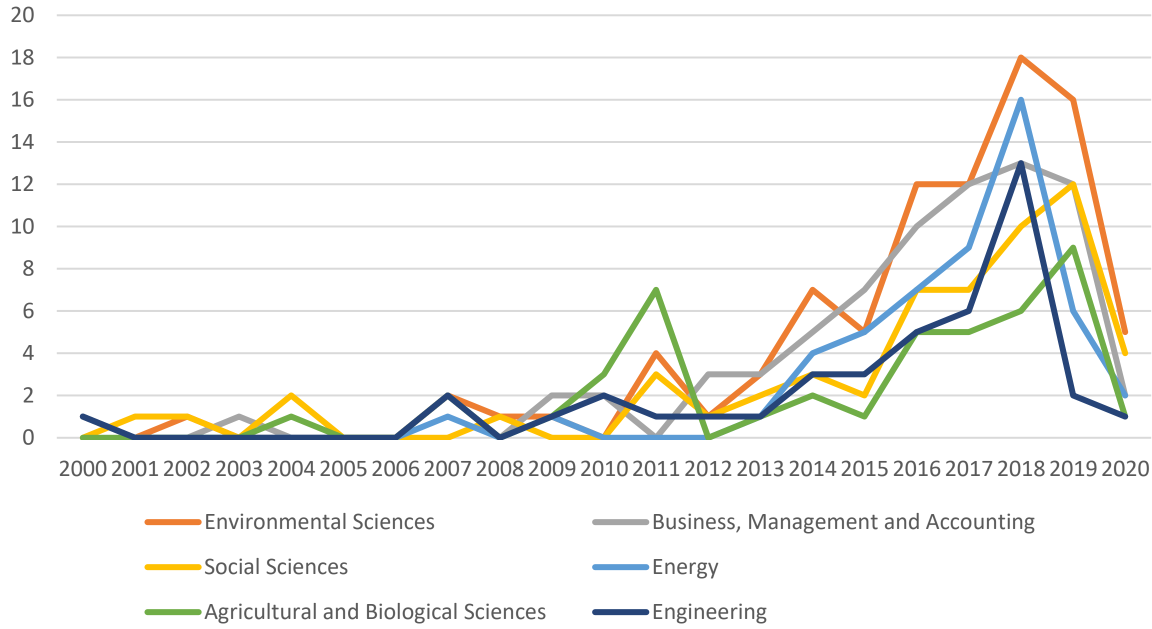
Figure 3. Total citations on agri-food EI between 2005 and 2020 (March)



3.2. Evolution of EI Research in the Agri-food Sector by Subject Area

The Scopus database classifies studies based on subject areas. This enables analysing the different disciplines involved in EI research in the agri-food sector. Figure 4 shows the evolution of the number of studies based on this classification. It should be taken into consideration that the same study can be classified into more than one category simultaneously. The *Environmental Sciences* category accumulates the highest number of studies with 20.3%. This is followed by *Business, Management and Accounting* with 16.9%, social science with 13.3%, *Energy* with 12%, *Agricultural and Biological Sciences* with 9.9%, and *Engineering* with 9.7%. Less than 5% of studies in the sample are classified in the remaining categories. *Environmental Sciences* is the category with the largest growth and it dominates research on EI in the agri-food sector by far, although the rest of the categories have also increased their number of publications throughout the whole period. This increase highlights the special interest that EI in the agri-food sector is attracting in several environmental, business and economic fields. The reason for this is that, in these sectors, environmental economics is essential to successfully achieving economic goals (e.g. productivity, employment and efficiency) in a way that promotes the conservation of natural ecosystems.

Figure 4. Comparative trend of subject categories related to agri-food EI research.



3.3. Most Relevant Journals on EI Research in Agri-food Sector

Table 1 shows the 10 top journals that published most of the articles on EI in the agri-food sector in the period. This group of journals accumulates more than 30% of the total number of publications in the sample, constituting the central core of journals that promote EI research in this sector.

The journal with the highest number of publications is *Journal of Cleaner Production*, with a total of 28. Moreover, this journal also features the highest h-index and the highest number of citations, with 1089. Its average number of citations per article is also the highest (38.89), as well as its Scimago Journal Rank (SJR) factor (1.62). *Sustainability* holds the second position according to the number of articles with 13, and it is third in citations with 71. In contrast, *British Food Journal* occupies the third position in number of publications with 5 and the second position related to number of citations with 75. *International Journal of Environmental Research and Public Health*, and *Business Strategy and the Environment* are the most recent newcomers to the subject as their first articles on the subject were published in 2019.

Table 1. Main characteristics of the top 10 productive journals in agri-food EI research.

Journal	Articles	SJR	h-index**	Country	Citations	Average Citations*	First Article	Last Article
Journal of Cleaner Production	28	1.62(Q1)	17	Netherlands	1089	38.89	2000	2020
Sustainability	13	0.55(Q2)	6	Switzerland	71	5.46	2014	2019
British Food Journal	5	0.49(Q2)	4	United Kigdom	75	15	2010	2019
Technological Forecasting and Social Change	4	1.42(Q1)	3	Netherlands	61	15.25	2016	2019
International Journal of Environmental Research and Public Health	3	0.82(Q2)	0	Switzerland	0	0	2019	2020
Journal on Chain and Network Science	3	0.47(Q2)	2	Netherlands	14	4.67	2013	2015
Sustainable Development	3	0.99(Q1)	2	United States	38	12.67	2015	2019
Agricultural and Food Economics	2	0.47(Q2)	1	United Kigdom	4	2	2015	2019
Agricultural Systems	2	1.36(Q1)	2	United Kigdom	30	15	2010	2018
Business Strategy and the Environment	2	2,17(Q1)	0	United States	0	0	2019	2020

*Total number of citations divided by the total number of articles; **Only sample documents.

3.4. Most Cited Publications

This section presents the 20 most cited articles found in the Scopus database (Table 2), based on the premise that heavily cited articles are likely to have a greater influence on the research field (Pilkington and Meredith, 2009; Liu et al., 2019). The most cited article, with almost 330 citations, is *Environmental supply chain dynamics,* carried out by Hall (2000). It investigates the circumstances under which environmental supply chain dynamics (ESCD) emerge based on British and Japanese food retail sectors. The results reveal that ESCD occur if there is a channel leader with sufficient power over their suppliers and technical competencies and environmental pressures also exist. In second place, *Conversion to organic farming: A typical example of the diffusion of an innovation?* by Padel (2001) has been cited 279 times. This investigation reviews several studies on organic farmers and identifies some similarities between organic farmers and early adopters of other innovations. A study by Nill and Kemp (2009) appears in third place with 218 citations. In this work the authors analyse three evolutionary policy approaches (i.e., strategic niche management, transition management and time strategies) to determine how they should be applied to sustainable development in the policy context.

The majority of the studies on the list are from the last 20 years, while *DIY culture and extended milieux: LETS, veggie boxes and festivals* by Purdue et al. (1997) is the only study from the 1990s.

Table 2. The 20 most cited studies on agri-food EI.

Rank	Citations	Title	Year	Author	Journal
1	329	Environmental supply chain dynamics	2000	Hall, J.	Journal of Cleaner Production
2	279	Conversion to organic farming: A typical example of the diffusion of an innovation?	2001	Padel, S.	Sociologia Ruralis
3	218	Evolutionary approaches for sustainable innovation policies: From niche to paradigm?	2009	Nill, J., Kemp, R.	Research Policy
4	168	Transforming innovation for sustainability	2012	Leach, M., Rockström, J., Raskin, P., Scoones, I., Stirling, A.C., Smith, A., Thompson, J., Olsson, P.	Ecology and Society
5	136	Drivers of green and non-green innovation: Empirical evidence in Low-Tech SMEs	2013	Cuerva, M.C., Triguero-Cano, Á., Córcoles, D.	Journal of Cleaner Production
6	117	Environmental impacts of food consumption in Europe	2016	Notarnicola, B., Tassielli, G., Renzulli, P.A., Castellani, V., Sala, S.	Journal of Cleaner Production
7	95	Industrialization as a key element of sustainable product-service solutions	2007	Evans, S., Partidário, P.J., Lambert, J.	International Journal of Production Research
8	89	Up, down, round and round: Connecting regimes and practices in innovation for sustainability	2013	Hargreaves, T., Longhurst, N., Seyfang, G.	Environment and Planning A
9	76	Production and supply of high-quality food protein for human consumption: Sustainability, challenges, and innovations	2014	Wu, G., Fanzo, J., Miller, D.D., Pingali, P., Post, M., Steiner, J.L., Thalacker-Mercer, A.E.	Annals of the New York Academy of Sciences
10	74	Chinese consumers' adoption of a 'green' innovation - The case of organic food	2012	Thøersen, J., Zhou, Y.	Journal of Marketing Management
11	68	In quest of reducing the environmental impacts of food production and consumption	2017	Sala, S., Anton, A., McLaren, S.J., Notarnicola, B., Saouter, E., Sonesson, U.	Journal of Cleaner Production

Table 2. Continued.

Rank	Citations	Title	Year	Author	Journal
12	63	DIY culture and extended milieux: LETS, veggie boxes and festivals	1997	Purdue, D., Dürrschmidt, J., Jowers, P., O'Doherty, R.	Sociological Review
13	59	When did plants become important to leaf-nosed bats? Diversification of feeding habits in the family Phyllostomidae	2011	Rojas, D., Vale, A., Ferrero, V., Navarro, L.	Molecular Ecology
14	44	Development of a tool for rapidly assessing the implementation difficulty and emissions benefits of innovations	2012	Bocken, N.M.P., Allwood, J.M., Willey, A.R., King, J.M.H.	Technovation
15	43	Reinventing R&D in an Open Innovation Ecosystem	2011	Traitler, H., Watzke, H.J., Saguy, I.S.	Journal of Food Science
16	39	Process eco-innovation: Assessing meso-level eco-efficiency in industrial water-service systems	2016	Levidow, L., Lindgaard-Jørgensen, P., Nilsson, Å., Skenhall, S.A., Assimacopoulos, D.	Journal of Cleaner Production
17	39	The willingness to adopt agro-ecological innovations: Application of choice modelling to Caribbean banana planters	2011	Blazy, J.-M., Carpentier, A., Thomas, A.	Ecological Economics
18	39	Skyfarming an ecological innovation to enhance global food security	2011	Germer, J., Sauerborn, J., Asch, F., de Boer, J., Schreiber, J., Weber, G., Müller, J.	Journal fur Verbraucherschutz und Lebensmittelsicherheit
19	39	Bats' conquest of a formidable foraging niche: The myriads of nocturnally migrating songbirds	2007	Popa-Lisseanu, A.G., Delgado-Huertas, A., Forero, M.G., Rodríguez, A., Arlettaz, R., Ibáñez, C.	PLoS ONE
20	37	Eco-innovation and retailers in milk, beef and bread chains: Enriching environmental supply chain management with insights from innovation studies	2015	Mylan, J., Geels, F.W., Gee, S., McMeekin, A., Foster, C.	Journal of Cleaner Production

3.5. Green Innovation Variables in the Agri-food Sector

This section presents an analysis of the most cited EI articles in the agri-food sector shown in Table 2. These works have been examined and classified into different categories proposed by Díaz-García et al. (2015) and Albort-Morant et al. (2017), in order to provide the main trends on the research topic. Thus, the papers have been clustered according to the following five categories:

- Drivers: interested in the antecedents of EI.
- Policy: aimed at policy evaluations and transitions.

- Process: centred on the process of the development of these types of innovations.
- Performance: focused on the results and outcomes of EI.
- Context: focused on presenting the case occurring in the context of study, such as a specific country or region.

According to this distribution, "drivers" and "process" are the most recurrent categories, as shown in Table 3. The variables that act as EI drivers in these studies include market pressures, environmentally sustainable goals, differentiation, stakeholder networks, and health and environmental awareness. Four studies are focused on a specific case of study. This may be because investigating the determinants and characteristics of a specific area can contribute to the conceptualisation and development of EI. Finally, only one article is clustered in the "performance" category.

Table 3. Contributions of the most cited research on agri-food EI.

Title	Trends in research	Case of study	Drivers	Outcomes
Environmental supply chain dynamics	Drivers	British and Japanese supermarket industry	Consumer, costumer and environmental pressures, Shareholders, employees, green voters, corporate citizenship, and improving technologies.	
Conversion to organic farming: A typical example of the diffusion of an innovation?	Process	Organic farming in South West of England		
Evolutionary approaches for sustainable innovation policies: From niche to paradigm?	Policy	OECD agricultural sector		
Transforming innovation for sustainability	Drivers/process	Dryland agriculture in East Africa	Sustainable develop goals	
Drivers of green and non-green innovation: Empirical evidence in Low-Tech SMEs	Drivers	Spanish food and beverage low-tech SMEs	Voluntary certifications, Quality Management Systems and differentiation.	

Table 3. Continued.

Title	Trends in research	Case of study	Drivers	Outcomes
Environmental impacts of food consumption in Europe	Context	European food sector		
Industrialization as a key element of sustainable product- service solutions	Drivers	European food production systems	Cooperation with stakeholders	
Up, down, round and round: Connecting regimes and practices in innovation for sustainability	Process	Eostre organics in UK		
Production and supply of high-quality food protein for human consumption: Sustainability, challenges, and innovations	Process	OECD food sector		
Chinese consumers' adoption of a 'green' innovation - The case of organic food	Drivers	Chinese organic food sector	Beliefs in healthiness, taste and environmental friendliness	
In quest of reducing the environmental impacts of food production and consumption	Process	OECD food sector		
DIY culture and extended milieux: LETS, veggie boxes and festivals	Drivers	UK organic farming sector	Networks	
When did plants become important to leaf-nosed bats? Diversification of feeding habits in the family Phyllostomidae	Context	South America phyllostomidae plant sector		

Table 3. Continued.

Title	Trends in research	Case of study	Drivers	Outcomes
Development of a tool for rapidly assessing the implementation difficulty and emissions benefits of innovations	Performance	OECD agricultural sector		Improvement in gas emissions
Reinventing R&D in an Open Innovation Ecosystem	Drivers/process	OECD agricultural sector	Stakeholders networks	
Process eco-innovation: Assessing meso-level eco-efficiency in industrial water-service systems	Drivers/process	Arla food sector in EU	Environmental policy, future higher costs, and resource scarcity	
The willingness to adopt agro-ecological innovations: Application of choice modelling to Caribbean banana planters	Context	French West Indies agriculture sectors		
Skyfarming an ecological innovation to enhance global food security	Context	European skyfarming sector		
Bats' conquest of a formidable foraging niche: The myriads of nocturnally migrating songbirds	Context	European nyctalus lasiopterus bat sector		
Eco-innovation and retailers in milk, beef and bread chains: Enriching environmental supply chain management with insights from innovation studies	Drivers/process	Food and beverage sectors in UK	Environmental policy and internal considerations	

3.6. Most Productive Authors in Agri-food EI Research

The top 10 most productive authors in EI research in the agri-food sector contribute with 28 articles, which have been cited 712 times, and they are listed in Table 4.

In terms of the number of published articles, the most prolific author is S. Sala from the *European Commission Joint Research Centre* with 4 articles; followed by J.M. Blazy, V. Blok, V. Catellani, S. Evans, O. Omta, and F. J. Saéz-Martínez, with 3 articles each. With regards to the number of citations, S. Sala occupied the first position with 239, followed by V. Castellani with 170. The rest of the authors have received less than 90 citations.

All the authors are from European countries, namely the United Kingdom, Belgium, France, The Netherlands, Spain, Greece and Italy. This fact highlights the importance that Europe gives to sustainable development and ecosystem conservation.

Table 4. The top 10 productive authors in agri-food EI research.

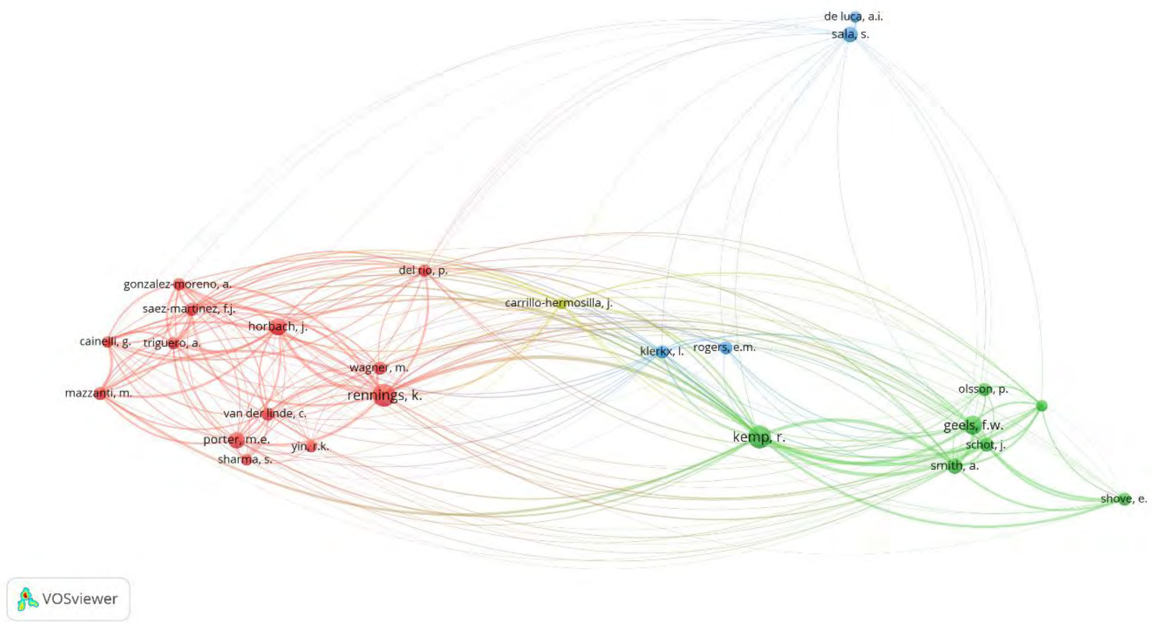
Author	Institution	Country	Articles	Citations*	Average citations**	h-index
Sala, S.	European Commission Joint Research Centre	Belgium	4	239	59.75	29
Blazy, J.M.	INRA Agrosystèmes Tropicaux	France	3	82	27.33	10
Blok, V.	Wageningen University and Research Centre	Netherlands	3	40	13.33	20
Castellani, V.	European Commission Joint Research Centre	Belgium	3	170	56.67	14
Evans, S.	Cambridge Institute for Sustainability Leadership	United Kingdom	3	56	18.67	23
Omta, O.	Wageningen University and Research Centre	Netherlands	3	38	12.67	24
Sáez-Martínez, F.J.	Universidad de Castilla-La Mancha	Spain	3	4	1.33	12
Arozamena, E.R.	Universidad de Cantabria	Spain	2	32	16	3
Assimacopoulos, D.	National Technical University of Athens	Greece	2	42	21	17
Blasi, E.	Università degli Studi della Tuscia Viterbo,	Italy	2	9	4.5	7

* Only sample documents; **Total number of citations divided by the total number of articles.

3.7. Author Co-citations Network.

Figure 5 displays the author co-citation networks. Three main co-citation networks can be observed. The red network is led by K. Reinnings and includes other authors such as J. Horbach, M.E. Porter, M. Wagner, P. del Rio, and A. Triguero. The green network includes the following researchers: R. Kemp, P. Olsson, F.W. Geels, J. Schot, A. Smith, and E. Shove. Finally, the blue network is comprised of A.I. de Luca, S. Sala, E.M. Rogers and L. Klerkx.

Figure 5. Author co-citations network.



3.8. Most Productive Institutions in EI Research in the Agri-food Sector.

With regard to affiliation institutions, there are 10 universities and research centres that contribute with more than 40 articles of the sample, which have received 1078 citations. The h-index for the top 10 institutions is between 7 and 2 (Table 5), of which the *Wageningen University and Research Centre* is the institution with the highest score.

Additionally, the *Wageningen University and Research Centre* is ranked number one in the number of articles published, specifically, 15. It is followed by the *University of Castilla-La Mancha, INRAE Occitanie-Toulouse, Università degli Studi di Torino* and *European Commission Joint Research Centre*, each with 5 articles. In contrast, the *European Commission Joint Research Centre* is the institution with the greatest impact, as it has received more than 400 citations, which is a testament to the quality of its research work. The second position is occupied by *Wageningen University and Research Centre* with 118 citations.

Nine of the ten most productive institutions in the field come from Europe, namely Spain, France, Italy, Belgium, Greece, Germany and the Netherlands. Only one institution is from a non-European country, *Universidade Federal do Rio Grande do Sul,* which is from Brazil.

Table 5. The top 10 productive institutions in agri-food EI research.

Institution	Country	Articles	Citations	h-index
Wageningen University and Research Centre	Netherlands	15	118	7
Universidad de Castilla-La Mancha	Spain	5	156	2
INRAE Occitanie-Toulouse	France	5	75	3
Università degli Studi di Torino	Italy	5	63	4
European Commission Joint Research Centre	Belgium	5	458	6
National Technical University of Athens	Greece	4	50	3
CNRS Centre National de la Recherche Scientifique	France	4	78	4
Alma Mater Studiorum Università di Bologna	Italy	4	43	2
Universidade Federal do Rio Grande do Sul	Brazil	3	25	3
Universität Bonn	Germany	3	12	2

3.9. Most Active Countries in Agri-food EI Research.

Table 6 shows the countries that published the most articles in the research field. Italy holds the first position with 33 papers. It is followed by the United Kingdom with 31, Spain with 26 and the Netherlands with 23. In relation to the total number of citations, the United Kingdom is the leader with 937, followed by Spain with 772 and Italy with 434. With respect to the average number of citations obtained per article, the most outstanding countries are Sweden with 37.8, the United Kingdom with 30.23, Spain with 29.69 and the United States with 20.61. Furthermore, the United Kingdom published the oldest article of the ranking in 2001.

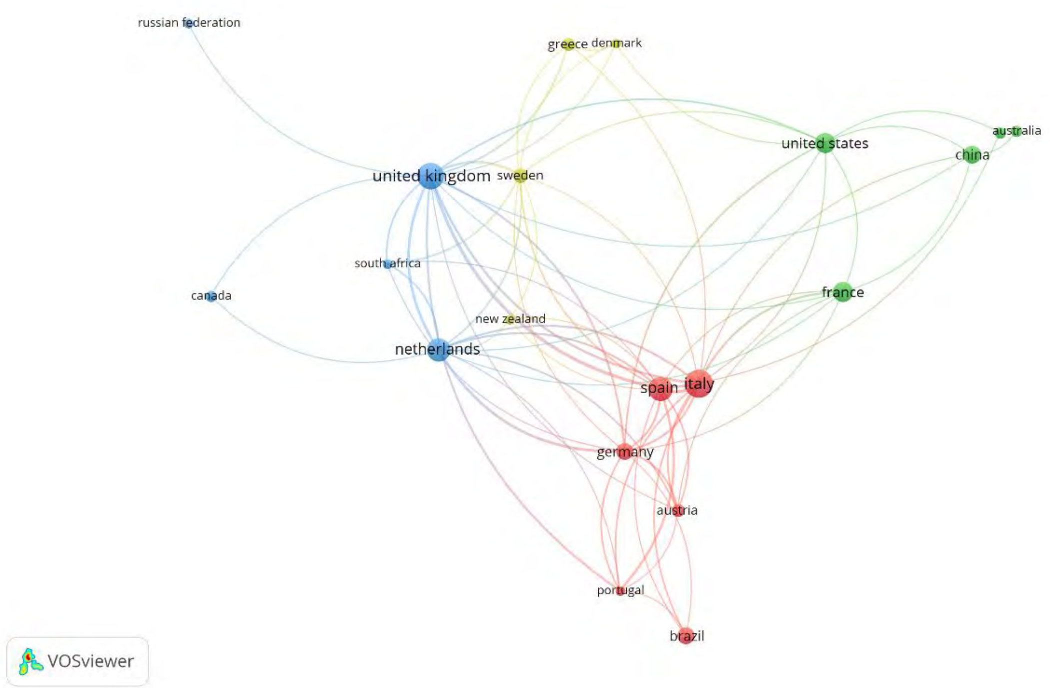
Table 6. Main characteristics of the most relevant countries in agri-food EI research.

Country	Articles	Citations	Average Citations*	h-index**	First Article	Last Article
Italy	33	434	13.15	10	2011	2019
United Kingdom	31	937	30.23	13	2001	2020
Spain	26	772	29.69	12	2007	2020
Netherlands	23	457	19.87	9	2003	2020
France	18	143	7.94	7	2002	2019
United States	18	371	20.61	6	1976	2019
China	14	109	7.79	5	2004	2020
Germany	13	102	7.85	6	2011	2020
Brazil	12	71	5.92	5	2011	2019
Sweden	9	341	37.89	6	2012	2020

*Total number of citations divided by the total number of articles; **Only sample documents.

The results of the analysis of the collaboration network established between different countries are shown in Figure 6. On the final map, the size of the circle varies depending on the number of articles for each country; the lines represent the link established between countries, where the thickness depends on the number of collaborations, and the different colours identify the main collaboration groups. Four relevant clusters can be distinguished. The green cluster is led by France and the United States in terms of number of articles. This cluster includes Australia and China as their partners. The red cluster is led by Spain, Italy and Germany. This cluster includes Austria, Portugal and Brazil as partners. The blue cluster is led by the United Kingdom and the Netherlands. It has South Africa, Canada and Russian Federation networks. The yellow cluster includes ties with Greece, Demark, Sweden and New Zealand.

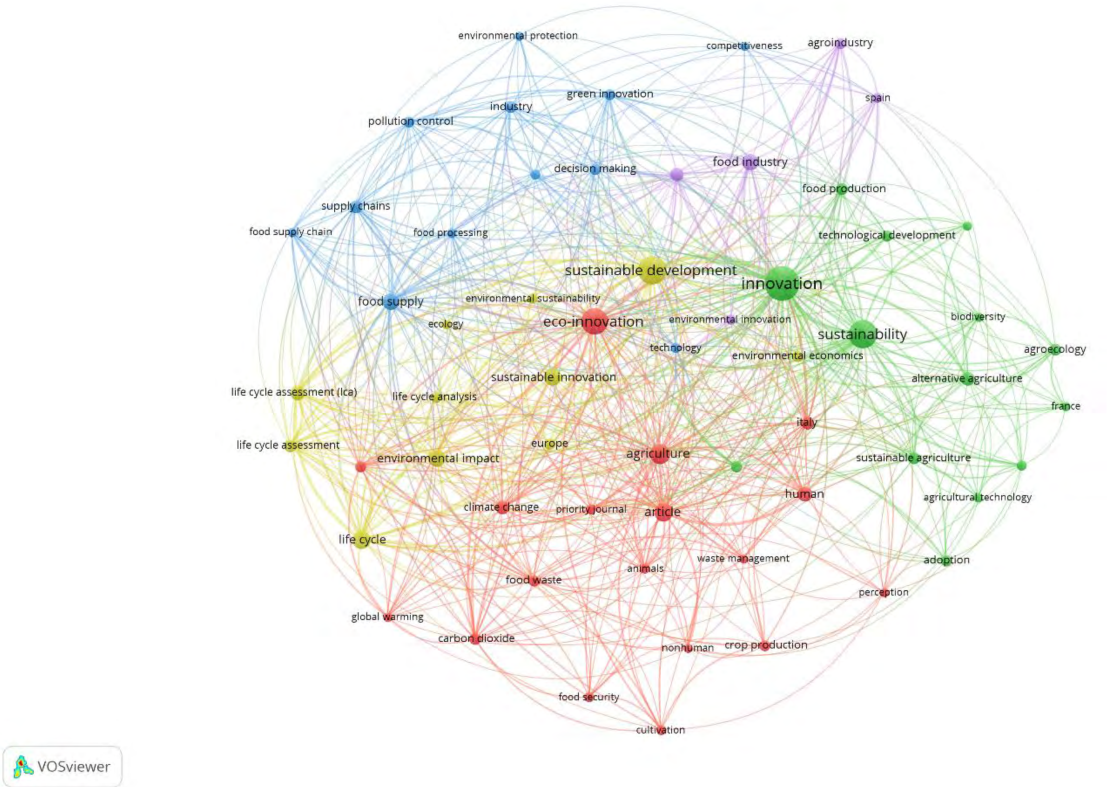
Figure 6. Main relationships between countries in agri-food EI research.



3.10. Most Frequent Topic Words.

Keywords analysis can identify the research themes of a research field (Hou et al., 2015). In this study there is a total of 1702 keywords, but most of them appear only once. Thus, the top 60 keywords were selected with a frequency ≥ 5 for the purpose of analysis. Figure 7 includes these most frequent topics addressed within this field. Thus, some rather large nodes can be observed, representing the main terms or topics: innovation, sustainability, sustainable development and EI.

Figure 7. Most frequent topic words.



Innovation is the most widely used term, as it is the key concept upon which researchers in the field of EI begin their work. The next most highlighted keywords nodes are sustainability, food production, sustainable agriculture, agroecology and alternatives agriculture. This is due to the increasing importance given to the development of new environmental-friendly production methods to achieve the transition towards sustainability. Similarly, sustainable development and environmental economics comprise another important cluster that features terms closely linked to the preservation of the ecological system. This cluster also includes the topics of sustainable innovation, environmental impact, environmental sustainability and ecology.

A number of other terms are also becoming more common and, as such, deserve special mention, such as those comprising the relationship between Spain, environmental innovation, food production and agroindustry. Additionally, some important keywords can be found in the link between pollution control, decision making, green innovation and food supply.

Nonetheless, EI research on the agri-food sector has been carried out since 1976, so it is quite possible that the keywords highlighted have changed over time. Consequently, two periods have been analysed (1976-2005 and 2006-2020) to identify the evolution of the main keywords applied in agri-food EI research. Figure 8 shows the three main categories of keywords that capture the attention of EI studies in the first period. The red category includes keywords related to methodological models (e.g. modis, algorithm and data processing). The green category is led by sustainability, agricultural and management; while blue is composed of environmental disasters, economic development, population growth and environmental innovation strategy. In contrast, Figure 9 shows the substantial growth of the keywords used in research during the second period of study, among which six important keyword categories can be highlighted: sustainable development, innovation, eco-innovation, food industry, food supply chain and life cycle assessment. This evolution enhances a trend toward increasing awareness about EI practices as solutions for environmental problems and the sustainable development of ecosystems.

Figure 8. Most frequent topic words in the period 1976-2005.

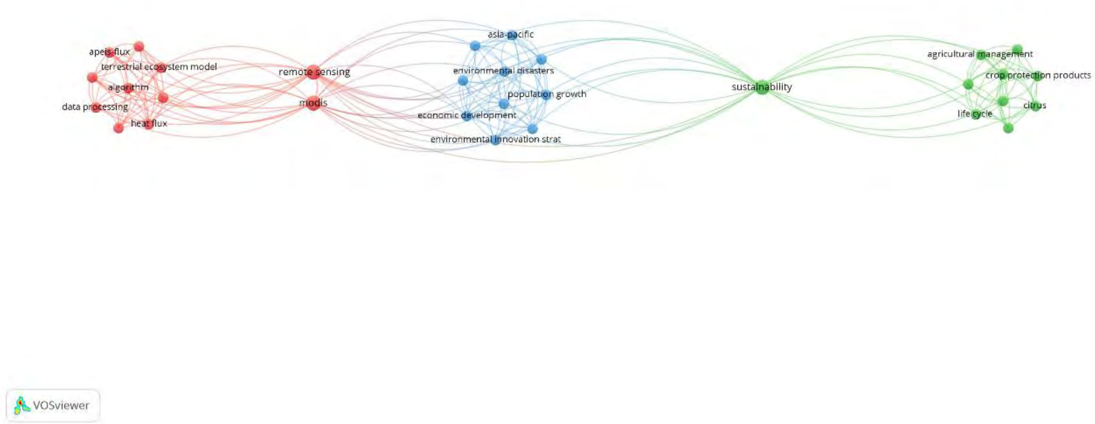
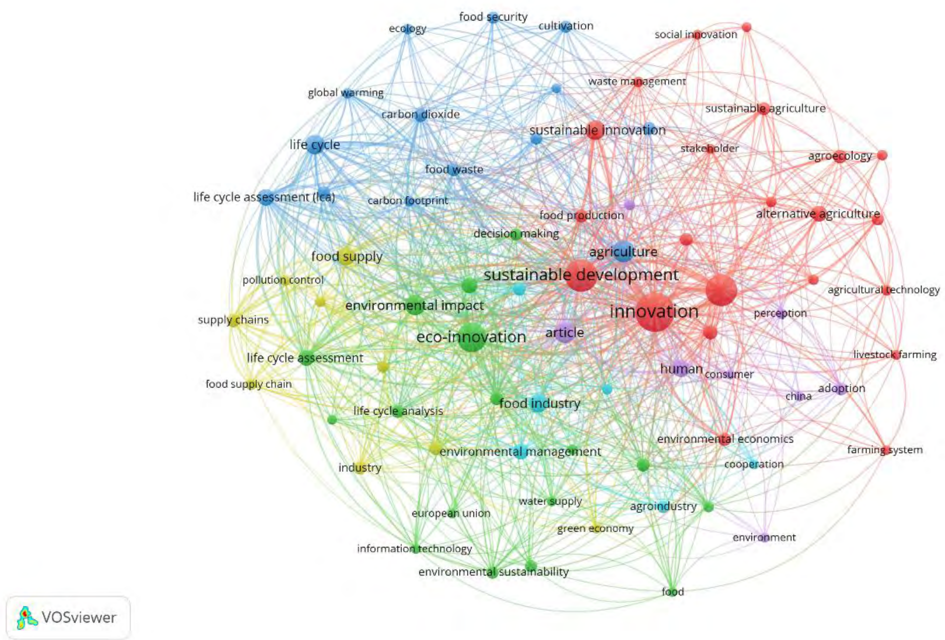


Figure 9. Most frequent topic words in the period 2006-2020.



Additionally, a keywords analysis was carried out to detect the preferences in the research conducted by the top 10 productive countries included in Table 6. As a result, a group of terms that comprised a general line of research was identified (see Table 7). Most of the studies are focused on European countries, the United States, China or Brazil. This finding demonstrates the importance that empirical analysis gives to the environmental impact that developed and emerging countries have. The countries with the highest level of concern for environmental externalities and climate change are Italy, the United Kingdom, the United States, Germany and Sweden. In contrast, Spain, France and Brazil are interested in the development of alternative agriculture, such as agro-ecology or ecological production. France and Spain are two of the largest European producers of agricultural products, which together with the current environmental problems, makes it necessary to develop new environmental-friendly production methods. Therefore, for these two countries, ecology production is a priority subject in agri-food EI that can contribute positively.

In the case of Germany, the combined use of the terms food security, human and sustainability can be highlighted. Food security is one of the most recent topics linked to human health and the use of less pollutant inputs in the food production process (e.g. fertilizers and pesticides). What is more, the terms environmental economics and economic aspects stand out due to the current necessity to govern economic activity in a way that promotes human wellbeing and ecological sustainability.

Table 7. Main keywords for the most active countries in agri-food EI research.

Country	Keywords
Italy	Sustainability, innovation, Italy, eco-innovation, sustainable development, life cycle, agriculture, article, climate change, environmental impact.
United Kingdom	Innovation, sustainability, sustainable development, eco-innovation, sustainable innovation, biodiversity, environmental economics, environmental impact, Europe, greenhouse gases.
Spain	Eco-innovation, sustainable development, innovation, Spain, life cycle, article, food industry, sustainability, agroindustry, ecology.
Netherlands	Innovation, sustainability, agriculture, Europe, food industry, sustainable development, technological innovations, animals, article, contestation.
France	Innovation, agroecology, France, agro-ecology, alternative agriculture, Caribbean Islands, collective action, environmental impact, Guadeloupe, Leeward Islands
United States	Agriculture, innovation, article, sustainability, human, sustainable innovation, United States, biodiversity, climate change, cooperation.
China	Innovation, agriculture, sustainability, sustainable development, China, environmental impact, environmental management, environmental regulation, green innovation, MODIS.
Germany	Innovation, climate change, crop production, Europe, article, environmental impact, food security, human, sustainability, adaptation.
Brazil	Eco-innovation, Brazil, sustainability, innovation, pollution control, sustainable development, sustainable innovation, adoption, alternative agriculture, benefits.
Sweden	Eco-innovation, article, innovation, sustainability, sustainable development, agriculture, biodiversity, climate change, economic aspect, food supply.

4. Discussion

This investigation provides a review of the EI literature in the agri-food sector and summarises the available research and findings published to date in order to offer a guide to researchers interested in the environmental innovation field. Throughout the analysis process, some considerations have emerged:

- *Drivers*. There is a great deal of interest in what drives agri-food firms to be more environmental-friendly. Almost half of the most cited articles focus on the identification of the antecedent factors that motivate actors to implement EI. Most research agree that one of the most important drivers is the relationship with stakeholders (e.g. customers, consumer, competitors). This finding is in line with another research, such as De Marchi (2012) and Latupeirissa and Adhariani (2020). Furthermore, environmental regulation, environmental culture and relationship learning also have a positive influence on EI implementation decisions (Albert-

Morant et al., 2017). In this line, Triguero et al. (2013) and Rabadán et al. (2019) highlight the collaboration with external agents, environmental policy influences and demand side factors as the main determinants of EI activities.

- *Policies and regulation*. The influence that policies and regulations have on EI is a key issue in the development of a framework in the field and it has drawn increasing attention over the years. In accordance with the findings, Hojnik and Ruzzier (2016b) emphasise the role that regulation plays in the adoption and diffusion of different types of EI and constitute one of the most common triggering factors. Moreover, Jin and Shi (2020) underline the positive direct impact that environmental regulation has on driving agri-food EI. Nevertheless, most of the policy approaches are static in a dynamic context. Thus, an evolutionary policy approach has been established by some researchers based on the belief that the externalities associated with environmental innovations combine with the forces that contribute to impeding the change towards sustainable development (Nill and Kemp, 2009). When adopting this approach, environmental policy instruments should internalise both environmental and knowledge externalities (Hemmelskamp, 1999), as well as take an evolutionary perspective (Nelson and Winter, 1982; Cowan and Hultén, 1996; Cowan and Kline, 1996).

- *EI process*. The analysis of the EI development process has centred much of the literature and demonstrates the multidimensionality of research perspectives. One of the articles in this category with major impact analyses life cycle assessment (Sala et al., 2017). This concept has been investigated to evaluate the impact of whole product life cycle on the environment (Piccinno et al., 2016; Secchi et al., 2016). In line with the result of Yin et al. (2018), life cycle assessment is drawing attention for being a more appropriate solution to achieve environmental goals than traditional theory. What is more, the ecosystem added value of implementing agroecology and organic farm practices is considered to be an interesting future research path to achieve the transition toward sustainability in the agri-food sector and global food security (Germer et al., 2011; Lampkin et al., 2017).

- *Performance*. The evaluation of EI environmental output and externalities is another relevant area to examine. The positive impact that EI practices implementation has on environment performance has been demonstrated (Galdeano-Gómez et al., 2008; Cai and Li, 2018; Ulvenblad et al., 2018; Fondevila et al., 2019). Several authors emphasise the reduction of gas emissions as one of the major environmental contributions of carrying out green practices (Bocken et al., 2012; Weina et al., 2016). However, there are also many other positive effects of implementing EI. Thus, in accordance with Peterson (2019), green innovation is positioned as a key strategy to achieve natural resource conservation.

- *Context*. A trend in the analysis of EI in a specific agri-food context can be detected. Therefore, several studies focus on a particular context of research in order to discover theories that contribute to building a theoretical foundation (Galdeano-Gómez, 2013; Ulvenblad et al., 2018; García-Granero et al., 2020). Specifically, most authors focus analysis on European agricultural sectors. For instance, Rodríguez-Rodríguez et al. (2012) and Galdeano-Gómez et al. (2017) investigate sustainability in the Spanish agri-food industry; meanwhile, Galliano et al. (2019) study the environmental evidence of the French rural area. Moreover, Drejeris and Miceikienè (2018) analyse sustainable innovativeness in Lithuania.

- *Multidimensionality*. It can be observed that the above-mentioned investigations focus their explorations on one specific background, obtaining conclusions that are limited to its unique circumstances and conditions. In this sense, more research which analyses and compares different situations is necessary to discover more general implications that can be applied to different sectors and countries. For example, Hall (2000) explores the various drivers that motivate companies to be more environmental-friendly in the Japanese food retail industry as well as in the UK supermarket and aerospace sectors. In the same line, Mylan et al. (2015) examine the driving factors and the development of green practices in the UK milk, beef and bread supermarket chain. Notwithstanding, the foregoing research only contemplates the economic, coordination and cooperation factors of EI, yet it is essential to explore the different product, process, organisational and marketing dimensions of EI in order to progress toward an efficient and multidimensional EI measurement (García-Granero et al., 2018).

- *Keywords trends*. The EI issue in the agri-food sector has grown strongly in recent decades. This is reflected by the increase in citations, which reached a total of 748 in the last year, displaying the great impact that this topic has in EI literature. The main reason might be the increased awareness about the environmental problems that society must face, such as global warming, deforestation, population increase, biodiversity loss and limited resources, which is made evident by the keywords' analysis. At present, innovation, sustainability, sustainable development, eco-innovation and agriculture are the most popular topics. Agriculture is a key concept in the transition towards sustainability development due to its particular characteristics (e.g. intensive use of natural resources, use of hazardous inputs such as fertilizers and insecticides and the consumption of large amounts of energy). Nonetheless, the analysis of the main keywords' evolution reveals considerable differences between the research topics of interest. There has been increasing awareness about the need to conduct economic activity applying the principles of environmental economics. Thus, other recent topics that focus on current ecological problems and more eco-friendly practices have emerged in the last several years, such as climate change, food waste, food security, biodiversity, agroecology, sustainable agriculture, ecology and alternative agriculture. Therefore, these terms highlight the efforts that European researchers have made to find solutions to environmental problems caused by current agricultural production methods.

5. Conclusions and Future Research

This study presents a bibliometric analysis of the literature on eco-innovation (EI) in the agri-food sector, according to the publications available in the Scopus database. Thus, it provides a general overview of literature for identifying the research trends and popular issues in this field. In brief, this analysis offers a guide to those interested in environmental innovation in the agricultural fields, providing information with regard to the past, the present, and the future of this topic by compiling a body of knowledge.

The analysis of the evolution of the publications and citations on EI in the agri-food sector allows us to appreciate the development of research in the field, which has experienced substantial growth since 2016; especially in the economic, business and environmental fields. As for origin, European countries, institutions and authors are the most influential in the development of the field. They have published most of the articles with the highest impact. The *Wageningen University and Research Centre* has published the most articles on the agri-food EI field, while the *European Commission Joint Research Centre* is the institution with the highest number of citations. With regard to the most active countries in the research field, there are four (i.e., Italy, United Kingdom, Spain and Netherlands) that have published more than half of the articles on agri-food EI research. With respect to the most prolific authors, S. Sala, J.M. Blazy, V. Blok, V. Castellani, S. Evans, O. Omta, and F. J. Sáez-Martínez are those with the largest number of publications and citations.

According to the research themes analysis, popular items related to sustainable development have been identified: EI, agri-food green practices, environmental problems, ecosystems conservation and environmental economics. Despite the considerable improvement of agricultural EI research, most of the articles with the highest impact are focused on the motivating factors that influence the decision to be 'greener', as well as on the analysis of the EI process limiting the multidimensionality of EI development. However, the outcomes of EI implementation and its link with the EI process is a key push factor of environmental innovation. For instance, more investigations on process/performance trends can positively contribute to understanding the complex EI phenomenon. Only one of the most cited articles contemplates the outcomes of implementing EI, investigating merely the benefit that green practices implementation has in the reduction of gas emissions. Thus, the articles with the highest impact ignore other positive externalities of EI implementation such as ecosystem conservation, water quality improvement and resource productivity increase. Furthermore, only a few studies investigate more than one case of study, and all of them only provide a limited number of EI variables. It is noteworthy to include a list of variables that represent the multidimensional aspect of EI in order to obtain conclusions that can be applied to the environmental and economic reality. In this context, it would be necessary to widen the literature path toward the relationship between the multidimensional characteristic of EI process and its performance, as well as more multi-case study research in order to develop a solid theoretical framework in the field.

This study features some limitations. Firstly, this research is based on a sample of documents published in Scopus. There are more studies on EI in the agri-food sector published in non-indexed journals that are not accessible using the Scopus database.

Secondly, the results depict the current situation, which may change over time, especially for the publications from the past two years whose number of citations will still grow considerably. Finally, it should be noted that this study has been developed within a specific field: eco-innovation in the agri-food sector. Therefore, researchers should be cautious about generalising these conclusions.

For future research, scholars might consider conducting a bibliometric analysis using other databases, such as Web of Science or Google Scholar, which would contribute to validate the findings of this study and gather more information. In addition, this study could be complemented by a deeper analysis of the content of the studies themselves, as well as an analysis that reflects the current topics in the area and their evolution over time.

CHAPTER 4

MULTIDIMENSIONAL ASSESSMENT OF ECO-INNOVATION IMPLEMENTATION: EVIDENCE FROM SPANISH AGRI-FOOD SECTOR

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MULTIDIMENSIONAL ASSESSMENT OF ECO-INNOVATION IMPLEMENTATION: EVIDENCE FROM SPANISH AGRI-FOOD SECTOR

Abstract

Understanding eco-innovation is an essential endeavor to achieve global sustainable development. In this sense, further research on implementation is needed to expand knowledge beyond current boundaries. The aim of this paper is to contribute to this debate by conducting an original multidimensional analysis using Spanish agri-food sector data. The empirical methodology applies a combination of descriptive statistics, cluster analysis and the chi-squared test. Two groups of well-differentiated eco-innovative firms are identified, those with high and low eco-innovation implementation levels. Quality certifications, environmental consulting and cooperation with stakeholders are the variables that contribute most to distinguishing these two groups. The results also reveal that operating income volume, number of employees and commercialization volume are key factors to become more eco-innovative. In this sense, larger businesses are found to have a higher level of eco-innovation implementation than small and medium size enterprises. The main contributions of this work are fourfold. Firstly, it presents a comprehensive framework of eco-innovation implementation in its four dimensions (product, process, organizational and marketing). Secondly, it fills existing gaps in the literature by analyzing 'green' organizational and marketing eco-practices. Thirdly, it expands the sectorial scope of eco-innovation research primarily focused on high-tech sectors. Finally, this study makes it possible to design certain policies for public and private decision makers.

Keywords: eco-innovation, implementation, multidimensional, agriculture, cluster analysis.

1. Introduction

Eco-innovation (EI) is defined as the introduction of new products or significantly increasing product/service's value, improving processes, and creating organizational changes and new marketing solutions which can minimize the use of natural resources (including material, energy, water and soil), as well as reduce the release of dangerous substances throughout a product life cycle (Miedzinski et al., 2013). This concept plays a crucial role in the transition towards more sustainability development economies (Bocken et al., 2012). Furthermore, when dealing with damage caused to the environment, EI is especially important in contexts where it is necessary to introduce new, cleaner production techniques and provide more efficient products and changes in business models (OECD, 2012; Rajala et al., 2016). Therefore, identifying the main EI practices implemented by different sectors can help public and private decision makers to understand what instruments need to be developed for the purpose of promoting EI.

In recent years, a number of works on EI practices have been conducted. Although the Inter-American Development Bank recognizes that organizational and marketing EI practices are key points for developing more sustainable economies (BID, 2007), most of the research conducted has focused only on product and process EI dimensions (Doran and Ryan, 2016; Castellacci and Lie, 2017; Rodríguez and Wiengarten, 2017). In these cases, the conclusions obtained do not accurately contemplate all eco-practices and can only provide a limited overview of the EI reality that exists within different sectors. Therefore, there are very few studies which provide a comprehensive framework for the analysis of EI in its main environmental dimensions (product, process, organizational and marketing), and they only contemplate a certain type of firm (e.g. small and medium size or multinationals) in non-European markets (Marcon et al., 2017; Astuti et al., 2018). Furthermore, the vast majority of EI studies are focused on the industrial sector (Hollenstein, 1996; Crabbé et al., 2013). For this reason, it is necessary to expand the sectorial scope of this topic to develop more efficient green practices, regulations and policies. As Gente and Pattanaro (2019) highlight, further research on EI implementation is needed to expand knowledge beyond current boundaries and achieve global sustainable development goals. In this sense, despite the fact that they have received very limited attention, two sectors of great environmental importance are agriculture and exports (García et al., 2018; Labella et al., 2017). In the case of the exports sector, exporting firms face a highly complex environment as they are more exposed to global competition (Lages et al., 2009; Hortinha et al., 2011). Some researchers have highlighted that it is precisely for this reason that these companies are more likely to introduce environmental innovations (Cassiman and Golovko, 2011; Shearmur et al., 2015), especially those directly related to a sector with significant environmental impact such as agriculture. For this reason, among others, agricultural innovation is vitally important for the successful development of the food production sector as well as for preserving the environment (Spielman and Birner, 2008; OECD, 2013).

This paper contributes to filling these gaps in the literature by developing a comprehensive framework for evaluating EI implementation multidimensionally. Therefore, it elaborates a frame of reference, which makes it possible to analyze the EI practices implemented in the Spanish wholesale sector of fresh fruits and vegetables and, in turn, identify the characteristics, variables and green dimensions that contribute to differentiate the most eco-innovative companies.

For this purpose, a combination of descriptive analysis, cluster analysis and the chi-squared test were utilized (Nunes et al., 2014). The statistical analysis reveals the existence of two groups of eco-innovative firms with distinct levels of EI. The differences between the two groups are highly dependent on operating income level, number of employees and volume of commercialization.

2. Theoretical Framework

Different EI frameworks have been suggested in the literature for analyzing the level of EI implementation. Kemp and Pearson (2007) recommend the environmental technology, organizational, product/service and green systems dimensions of innovation. Whereas, Carrillo-Hermosilla et al. (2010) and Kiefer et al. (2017) propose using the design, user, product-service, and governance dimensions of Eis. Moreover, Rodriguez-Rodriguez et al. (2012) and Galdeano-Gómez et al. (2017) point out the importance of EIs to achieve synergies between socio-economic and environmental dimensions in the agri-food sector. Furthermore, with the aim to standardize critical aspects of EI studies, the Eco-Innovation Observatory (EIO) (2020) considers EI the “introduction of any new or significantly improved product, process, organizational change or marketing solution that reduces the use of natural resources and decreases the release of harmful substances across the whole life-cycle.” Following this guideline, some recent studies (Marcon et al.,2017; Astuti et al., 2018; García-Granero et al., 2018) propose four different main dimensions of EIs: product, process, organizational and marketing.

The present article builds upon the framework proposed by Marcon et al. (2017) and García-Granero et al. (2018) for analyzing EI implementation in an agri-food sector, because they provide a comprehensive overview of the main dimensions and subdimensions, accounting for the numerous individual characteristics of EI. In general, these four types of EI are complementary in many cases, so that the EI can be visualized with a holistic approach. Considering the close relationship with the environment that the agri-food activity has and the characteristics of companies (low-tech firms), the analysis of diverse dimensions can be important in order to offer a better view of EI implementation in this sector.

2.1 Eco-Innovation Dimensions

Product eco-innovations can be defined as the introduction of environmentally-friendly new products or significant improvements of product characteristics, such as advances in technical components and materials (Pujari, 2006). The theoretical framework on product EI is based on a vast line of research focused on the improvement of the type and quality of inputs used as well as on the sustainability of products with the aim of successfully complying with the current environmental regulations. Four main practices are used in this approach. Some authors highlight the need to reduce the use of raw inputs in order to obtain less polluting products (Eder, 2003; Hellström, 2007; Crabbé et al., 2013). The use of cleaner materials or new inputs with lower environmental impact (BID, 2007; Doran and Ryan, 2016; Castellacci and Lie, 2017; Rodriguez and Wiengarten, 2017) is also proposed as a performance indicator. Marcon et al. (2017) and Van Hemel and Cramer (2002) analyze the use of recycled inputs. Besides, the product's ability to be reused (Castellacci and Lie, 2017; Rodriguez and Wiengarten. 2017) is a practice examined to reduce the level of energy and materials consumed at the same time it decreases CO2 emissions and levels of waste (Garrod and Chadwick, 1996).

According to Negny et al. (2012), process EI modifies the organization's operational processes and systems, decreases unit costs of production, produces new or significantly improved eco-products and reduces environmental impact. A wide range of EI literature investigates those practices in the process dimension that firms implement with the aim of reducing their negative environmental impact. Most of these investigations introduce water and energy consumption (Cheng and Shiu, 2012; Doran and Ryan, 2016) as EI indicators. For example, Alkaya and Demirer (2015) apply them in a review of the Turkish chemical industry, Catellacci and Lie (2017) utilize them to analyze the manufacturing sector in Korea, and Rodríguez andWeingarten (2017) in a study on the German industry sector. Other process EI indicators contemplated by researches, which ensure the efficient use of natural resources while optimizing the level of waste in the production and commercialization processes, are the reuse of components or materials (Hellström, 2007) and their recycling (Van Hemel and Cramer, 2002; Doran and Ryan, 2016; Rodriguez and Wiengarten, 2017). Moreover, the eco-indicator number of patents (Griliches, 1990; Lanjow and Mody, 1996; Jolly and Philpott, 2004; Johnstone et al., 2010) is introduced by some authors to measure EI. Although patents could be an output of company research efforts and investments, the latter are not always patented. For this reason, it is also necessary to include other indicators such as R&D expenditure (BID, 2007). Some authors emphasize the importance of analyzing the level of investment in R&D activities to gain a better understanding of EI (Cohen and Levinthal, 1990; Cainelli et al., 2015; Rodriguez and Wiengarten, 2017). The practical use of renewable energy and environmentally-friendly technologies is also a well-known eco-innovator and a large number of works address this topic. Frondel et al. (2008) highlight the environmental benefit of introducing end-of-pipe technologies in the manufacturing process. Garrod and Chadwick (1996) emphasize the importance of investing in clean technologies in a study on English companies. In the same vein, Guziana (2011) defends the innovative proactivity of clean technology.

Organizational EI can be explained as new or significant improvements in routines, methods and actions that improve firms' practices, relations and decisions with respect to the environment (Marcon et al., 2017). According to the findings of Chen (2008), there are three types of green intellectual advantages, which encompass these essential corporate routines and practices (García-Granero et al., 2018): human, structural and relational capital. Green human capital is attracting attention in the academic literature thanks to its impact on business decision-making. In this line, research such as Montalvo (2008) and Chen and Chang (2013) highlight the influence of green managerial characteristics in firm orientation towards an environmentally-friendly business model. Similarly, other authors uphold the role of senior sta in the green orientation business culture (Anderson, 1998; Andriopoulos, 2001; Halbesleben et al., 2003; O'Connor and Ayers, 2005). Furthermore, Banco

Interamericano de Desarrollo (BID, 2007) and Peng and Liu (2016) underline the importance of introducing the analysis of a firm's green human resources as an indicator which shows its innovative efforts. On the other hand, green structural capital includes organizational capabilities, organizational commitments, organizational culture and philosophies, patents, copyrights, etc. Environmentally-oriented culture is an eco-innovator that has been analyzed for more than two decades by an extensive body of research. According toWilliams et al. (1993), introducing environmental objectives into production plans and operations is a useful variable for analyzing EI level, while for authors such as Frosh and Gallopoulos (1992) and Tibbs (1992), the implementation of external environmental audits is a good indicator of a company's intention of learning how to be more eco-innovative (Hammer, 2006; Eltayeb, 2009; Zailani et al., 2012). The hiring of environmental consulting services is another variable analyzedby the literature in this EI dimension (Del Brio and Junquera, 2003; Scarpellini et al., 2012; De Jesús Pacheco et al., 2016). In regard to green relational capital, the majority of the studies are focused on firm relationships with pressure groups (Cramer et al., 1991; Cramer and Schot, 1993; Frosch, 1994) as a key factor to create new environmental improvement opportunities (Florida, 1996; Chen, 2008).

Marketing EI includes the implementation of new green marketing methods and refers to changes in product presentation, sales placement, communication, new methods of delivery, promotion or pricing strategies. Moreover, significant green changes in packaging are also considered important marketing EIs (Marcon et al., 2017). These innovation activities are relevant indicators for implementing and measuring EI as BID (2007) emphasizes. However, marketing EI has received less attention than the other dimensions in environmental literature when analyzing the level of EI in a firm, sector or country (García-Granero et al., 2018). The use of returnable packaging is the main practice studied by researchers (Stock, 1992; Carter and Ellram, 1998; Rogers and Tibben-Lembke, 1998), along with the use of recyclable packaging (Christmann, 1995; Hart, 1995; Shrivastava, 1995; Van Hemel and Cramer, 2002). These green packaging design practices contribute towards reducing waste levels and the efficient use of resources (Duhaime et al., 2001; Twede and Clarke, 2005). What is more, biodegradable packaging is positioned as a key tool in several sectors to satisfy the environmental requirements of markets precisely because it is made of non-pollutant materials (Ivankovic et al., 2017).

2.2 Eco-Innovation in the Agri-Food Sector

Innovation is positioned as a key factor in the discussion about the relation between agriculture and sustainability (IPES-Food, 2016; Global Harvest Initiative, 2017; FAO, 2019; FAO, 2020). In fact, agricultural innovation is considered vital for the sustainability transition and achieving food security (El Bilali, 2018; IICA, 2020; UNCTAD, 2020). Thus, in recent years, some researches are focused on analyzing the EI phenom in this sector (Barth et al., 2017; García et al., 2018).

The increase in food crises, which place population health at risk, demands the implementation of new production practices that encourage the improvement of food safety levels. For this purpose, biological control and traceability implementation are two specific practices commonly carried out in the agri-food sector (Codex Alimentarius Commission, 2019). Barth et al. (2017) point out the increment in product value that adds the traceability implementation. Galdeano-Gómez et al. (2017) introduce the variable minimizing the use of fertilizers and phytosanitary product to measure the sustainability in the Spanish agricultural production. As a result, environmental sustainability is closely linked to biological control, as the latter is analogous to a high level of pest control (Sönmez and Mamay, 2018).

Furthermore, the increase in population awareness about the environmental and health problems involved in the production and consumption of pollutant goods calls into question the need to use environmental certifications in order to achieve standards for safety and quality (Barth et al., 2017). Certifications can be defined as a voluntary inspection process that audits and provides written assurance that a process, product or service meets a specific set of standards (Segarra-Oña et al., 2011). These standards prove the safety of the product customers consume (Hammer, 2006; Eltayeb, 2009; Chiarvesio et al., 2015). In fact, there are several works that recommend the use of environmental certifications as an instrument for measuring EI (Remoe, 2005; Kemp and Pearson, 2007; Speirs et al., 2008; Godoy-Durán et al., 2017). Thus, private standards certifications, such as GLOBALG.A.P. (worldwide standard for Good Agricultural Practices) or GRASP (GLOBALG.A.P. Risk Assessment on Social Practices), are utilized in the European food sector as marketing tools to maintain consumer trust regarding the high quality of products, as well as to make considerations for animal welfare and environmental protection (Uscebrka et al., 2009; Hernández-Runio et al., 2018). Recently, some studies introduced quality certifications in the EI analysis (Godoy-Durán et al., 2017).

Other investigations highlight the importance of developing cooperation with stakeholders in the EI process (Rabadán et al., 2019; Shih et al., 2018). Meanwhile, studies such us Drejeris and Miceikienè (2018), Ulvenblad et al. (2018) and Barth et al. (2017) enhance the important value that a green organizational business model has in the transition towards sustainability. In this context, environmental attitudes, perceptions and intentions are included in the analysis of EI, and the staff environmental orientation is also a point of interest of investigations (Barth et al., 2017; Drejeris and Miceikienè, 2018).

3. Materials and Methods

The research methodology was composed of the following main phases: a literature review, a survey questionnaire as a data collection tool, and, finally, a statistical data analysis including descriptive analysis, cluster analysis, and the chi-squared test. The three phases are detailed in the following section.

3.1 Definition of Variables

A literature review based on Scopus and Web of Science (WoS) databases was conducted in order to identify contributions in the context of EI, not only to determine the variables, indicators and practices implemented, but also to identify what methodologies are applied to analyze EI.

García-Granero et al. (2018) summarize the state of this field of research and highlight the main practices that have been taken into consideration by the literature to investigate how different sectors implement EI. This review determined which practices have a significant effect on the agri-food sector. Thus, the most relevant indicators and variables that should be measured are selected in order to analyze EI implementation in this sector (Table 1).

Table 1. Indicators and variables of eco-innovations included in the analysis.

Eco-innovation Dimension	Eco-innovation Indicator	Description of the variable		
		Name	Survey question	Measurement scale
Product EI	Ecological/integrated production	Ep	What percentage of the total production is dedicated to ecological/integrated production?	Percentage
Process EI	Biological control	Bc	Has your firm implemented biological control?	Dichotomous scale
	Recycled/reused materials	Rm	What percentage of the total use of plastics, pallets and packaging is recycled or reused?	Percentage
Organizational EI	Environmentally-oriented culture	Ct *	What is the importance of your company's environmental impact? What is the importance of adopting environmental plans and objectives in the company? What is the importance of achieving the environmental plans and objectives adopted? What is the importance of staff working with respect for the environment? What is the importance of investing in environmental initiatives? What is the importance of implementing EIs?	Likert scale (1–5)
	Quality staff	Qs	Percentage of employees working in the quality department?	Percentage
	Analysis laboratory	Lb	Does your firm have an internal analysis laboratory?	Dichotomous scale
	Environmental audit	Aud	Does your firm perform environmental audits?	Dichotomous scale

Table 1. Continued.

Eco-innovation Dimension	Eco-innovation Indicator	Description of the variable		
		Name	**Survey question**	**Measurement scale**
	Environmental consulting	Ax	Does your firm request environmental consulting from any expert?	Dichotomous scale
	Stakeholder cooperation	Cp	Does your firm cooperate with universities or R&D centers?	Dichotomous scale
Marketing EI	Quality certification	Certf	Number of quality certifications?	Natural numbers
		Ggp	Percentage of hectares certified with GLOBALG.A.P. certification?	Percentage
		Gsp	Percentage of hectares certified with GRASP certification?	Percentage
	Green design packaging	Rpkg	Use of recycled packaging?	Percentage
		Bpkg	Use of biodegradable packaging?	Dichotomous scale

* This variable is given by the average from the six survey questions. Source: own elaboration.

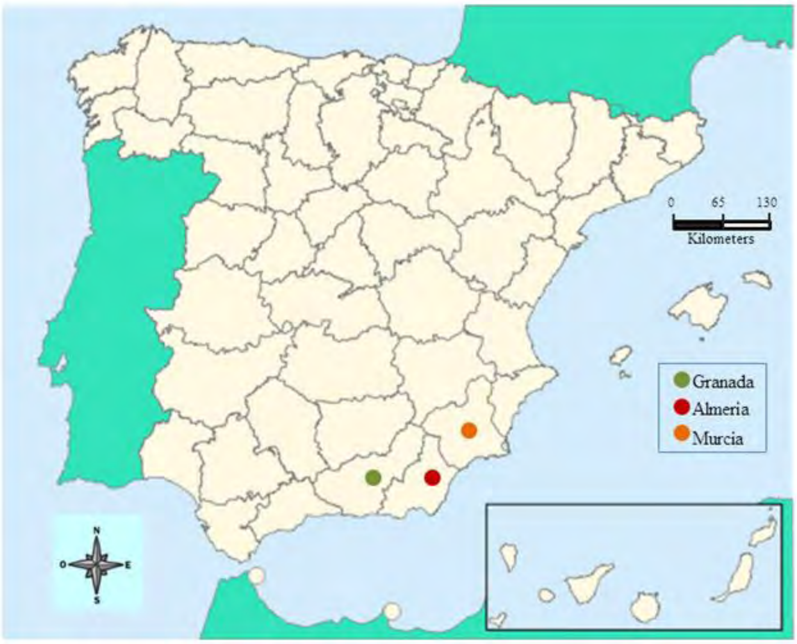
There is a common criterion throughout the EI literature for evaluating the level of product and process EI regardless of the sector under analysis (Dora and Ryan, 2016; Castellacci and Lie, 2017; Rodríguez and Wiengarten, 2017). In the case of product EI, a great deal of the literature of the literature introduces variables that consider the improvement of the environmental characteristics of a product, either through the use of less pollutant or reusable inputs (Van Hemel and Cramer, 2002; Crabbé et al., 2013). As for process EI, most works analyze those variables related to the reuse, recycling or introduction of techniques that support the improvement of product quality (Cheng and Shiu, 2012; Rodríguez and Wiengarten, 2017). However, with regard to organizational EI, while the vast majority of the EI studies in the last twenty years have focused on staff environmental culture and cooperation with stakeholders (Frosh and Gallopoulous, 1992;

Amabile et al., 1996; Anderson, 1998), other more recent studies have introduced practices such as environmental audits, environmental consulting or the implementation of environmental plans in daily business activity (BID, 2007; Kemp and Pearson, 2007; Zailani et al., 2012). Similarly, while twenty years ago the EI literature did not contemplate marketing EI activities, subsequent studies highlight the introduction of green packaging and quality certifications as variables for measuring EI (Hamner, 2006; Eltayeb, 2009; Cheng and Shiu, 2012).

3.2.Sample and Data Gathering

This study focuses on the Spanish wholesale sector of fresh fruits and vegetables, specifically in the southeast region (provinces of Almeria, Granada and Murcia) due to the increase of production in this area and the adaptation process of ecological practices required in consumer markets in recent decades (Galdeano-Gómez et al., 2017). In this case, agricultural activity has a strong impact on the environment because it involves intensive use of resources, requires intensive transport and generates a considerable amount of waste (Tolón-Becerra et al., 2013). These negative externalities have implied a constant adoption of innovations and eco-efficiency methods of production and commercialization in the sector´s firms (Godoy-Durán et al., 2017). Moreover, Spain is the first exporter of fresh fruits and vegetables in the European Union and one of the three largest world exporters, together with the US and China (Pérez-Mesa et al., 2019). In terms of figures, Spanish exportation of these products reached 13.8 million tons in 2017, earning nearly 15 billion EUR (Spanish Agriculture Ministry, 2019). In this context, the Spanish provinces of Almeria, Granada and Murcia contribute to these figures by more than 50 percent (Hernández-Rubio et al., 2018; Piedra-Muñoz et al., 2017). Figure 1 shows the location of this Spanish region.

Figure 1. Location map of the region of Almeria, Granada and Murcia in Spain.



To achieve the objectives proposed in this research, the data were obtained through surveys designed for this purpose. Questionnaires were aimed at staff who were closely involved in the EI aspects of the firms. All firms were contacted by telephone and all the individuals identified were then invited to participate in the survey via telephone or email. The survey was carried out in January and February 2019, coinciding with the production and commercialization season 2017-2018 (from September to July).

According to the Iberian Balance Sheet Analysis System (*Sistema de Análisis de Balances Ibéricos* in Spanish, SABI), 302 firms commercialized fruit and vegetables in the provinces of Almería, Murcia and Granada in 2017. The sample was randomly selected without replacement. The final number of valid surveys was 79. This represents a response rate of 22.32%, which is highly satisfactory. According to Menon et al. (1996), the average top management survey response rate is in the range of 15-20 percent.

The descriptive analysis of the questionnaire responses from the sample of fresh fruits and vegetables commercialization companies is shown in Table 2.

Table 2. Profile of the final sample (frequencies for descriptive variables)

Variable	Description	Frequency (*N* = 79)
Age (years)	<15	31
	15–30	34
	31–45	9
	>45	5
Number of employees	<50	25
	50–250	31
	>250	23
Legal form	Limited liability companies (SL in Spanish)	50
	Anonymous society (SA in Spanish)	6
	Agrarian transformation company (SAT in Spanish)	12
	Cooperatives	11
Operating income (million EUR)	<10	28
	10–43	32
	>43	19
Commercialization volume (million kg)	<10	27
	10–50	36
	51–100	8
	>100	8
Percentage of commercialization volume in vegetables (%)	<50	14
	≥50	65
Percentage of commercialization volume allocated to European market (%)	<50	6
	≥50	73

This table indicates that limited liability companies dominate the sector (63.29%), followed by agrarian transformation companies (15.19%) and cooperatives (13.92%). The majority of the firms are between 15 and 30 years of age (43.04%). The figures also reveal that 39.24% of the firms have between 50 and 250 employees and 40.5% have operating incomes between 10 and 43 million euros. Thus, these characteristics indicate that the sector is mainly represented by medium size companies. Furthermore, the survey also shows that 45.57% have a commercialization volume between 10 and 50 million kilos and 82.28% commercialize more than half of this volume in vegetables, meaning the sector is dominated by the fresh vegetables commercialization firms. In addition, 92.4% of the companies are European market oriented, as more than the half of their commercialized volume is allocated to this market.

3.3.Estimation Methods

Three statistical techniques were used: descriptive analysis, cluster analysis, and the chi-squared test. Descriptive analysis provided a better understanding of the profile of companies in the sector. Cluster analysis is a multivariate statistical technique which is able to separate the sample into groups, achieving maximum homogeneity in each group and the clearly differentiating between the groups. There are two main types of cluster analysis: non-hierarchical cluster and k-means cluster (Hair et al., 1999).

Firstly, the non-hierarchical cluster analysis (Ward's method) was used in this investigation to identify the number of groups that maximizes heterogeneity between them (Kobrich et al., 2003). The results, presented in a dendrogram (see Appendix A, Figure A1), indicate that two is the optimal number of clusters in the sample: Group 1 (the lowest eco-innovator firms) and Group 2 (the highest eco-innovator firms).

Once the optimal number of groups was obtained, k-means cluster was applied, choosing the Euclidean distance as the distance measurement (Hair et al., 2006). K-means cluster allocates every data point to the nearest cluster while keeping the centroids, previously calculated for each group, as small as possible. Next, a one-way ANOVA was carried out with the aim of testing the statistical differences between the clusters (Kuswardhani et al., 2014; Nunes et al., 2014).

Finally, the chi-squared tests checked the relationship between the compositions of Groups 1 and 2 and the following profile variables: age of the company, operating income, number of employees, commercialization volume and percentage of commercialization volume in vegetables. The choice to use the chi-squared test was based on the relevance of knowing the main socio-economic factors that can affect firms' decisions to implement EIs (Nunes et al., 2014; Khan et al., 2018).

4. Results

The main results of applying descriptive statistics, cluster analysis and the chi-squared test are presented below.

4.1.Descriptive Statistics

Table 3 presents a brief description of the EI variables measured in the study in order to provide a profile of the firm eco-innovative level. Additionally, the correlation coefficients of variables are detailed in Appendix A (Table A1).

Table 3. Summary statistics for the EI variables in the sample.

Variable	Variable name	Mean	Std. Dev.	Min.	Max.
Product EI					
Ep	Ecological/integrated production	0.21	0.33	0	1
Process EI					
Bc	Biological control	0.80	0.40	0	1
Rm	Recycled/reused materials	0.47	0.37	0	1
Organizational EI					
Ct	Environmentally-oriented culture	3.73	0.86	0	5
Qs	Quality staff	0.053	0.37	0	0.33
Lb	Analysis laboratory	0.15	0.36	0	1
Aud	Environmental audit	0.44	0.50	0	1
Ax	Environmental consulting	0.46	0.50	0	1
Cp	Stakeholder cooperation	0.42	0.49	0	1
Marketing EI					
Certf	Quality certifications	4.44	2.57	0	11
Ggp	GLOBALG.A.P. certification	0.64	0.36	0	1
Gsp	GRASP certification	0.52	0.41	0	1
Rpkg	Recycled packaging	0.44	0.38	0	1
Bpkg	Biodegradable packaging	0.27	0.44	0	1

The data show that the average percentage of employees in charge of controlling and managing the quality of the products as well as the production processes is below 5.5%. This figure is rather small in relation to the maximum percentage of staff in these areas, which reaches 33% in some firms. Nevertheless, the mean level of green organizational culture displays a high value (3.73), which is reflected in the high implementation of certain eco-innovative practices, such as biological control, environmental consulting or production certified with GLOBALG.A.P.

These preliminary data also reveal the sector's weakness in the implementation of some green practices, for example, recycling, the use of biodegradable packaging or the implementation of internal biological control laboratories. These practices display a medium value below 0.5, which means a great deal must still be done to achieve greater environmental efficiency.

4.2. Cluster Analysis. Typology of Firms with Regards to Eco-innovation Implementation

An exploratory factor analysis was conducted because the data collected are reported using a single informant from each company and from the same questionnaire in the same period (Cheng et al., 2014). Previously, variables were normalized with the aim of comparing different measuring instruments. The results reveal that the first factor captures only 28% of the variance, which demonstrates a low threat of common method bias. Next, a non-hierarchical cluster analysis (Ward's method) was applied, prior to the k-means cluster analysis, in order to find the number of groups that maximizes the differences between them, as mentioned in Section 3. The results obtained in the dendrogram (Appendix A, Figure A1) were analyzed and two clusters appear as the best solution. In order to confirm the number of clusters selected, the Calinski test was performed. The two-group solution with a Calinski–Harabasz pseudo-*F* value of 87.44 is largest, indicating that the two-group solution is the most distinct compared with the three-group (72.85), four-group (55.60) and five-group (48.03) solutions. Thus, two different groups were identified: Group 1, consisting of firms with a lower level of EI implementation; and Group 2, made up of firms with a higher level of EI implementation.

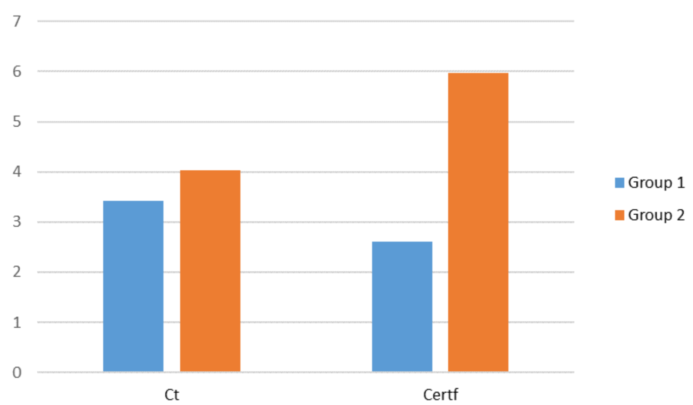
Table 4 also shows the analysis of the variance of the cluster analysis (one-way ANOVA analysis). All the variables, except "the use of biodegradable packaging", differ statistically between groups with a level of likelihood of 5% (p-value < 0.05). The results also reveal that the variables "number of quality certifications", "percentage of GLOBALG.A.P certified hectares" and "percentage of GRASP certified hectares", are those that contribute most to the differentiation between groups; followed by the variables "biological control", "environmental consulting" and "cooperation with stakeholders".

Figure 2 presents the mean value of Groups 1 and 2 for the different quantitative variables measured on a numerical scale shown previously in Table 1. In contrast, Figure 3 displays the mean value of Groups 1 and 2 for the different qualitative variables and those quantitative variables measured on a percentage scale.

Table 4. Characteristics of identified clusters and test statistics of one-way ANOVA.

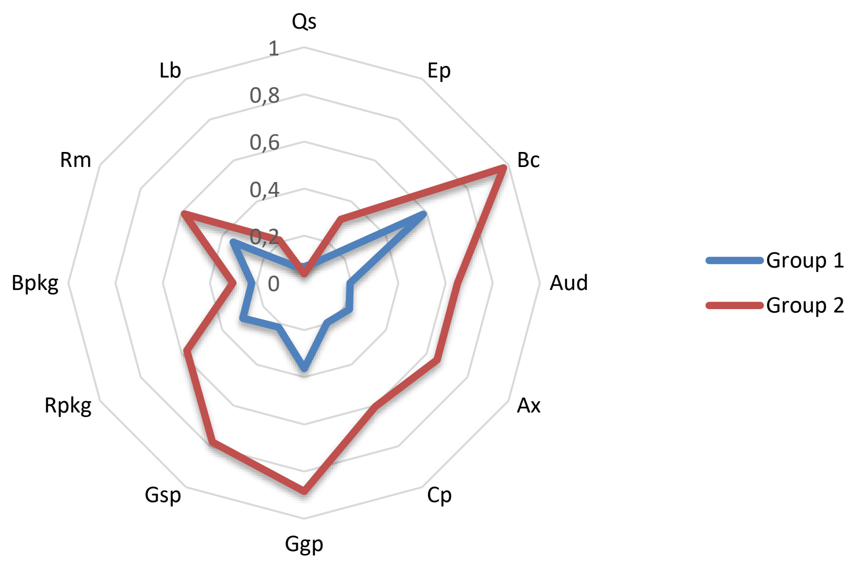
		Eco-innovative firm clusters					
		Group 1 *N = 37*		**Group 2** *N = 42*			
		Low		**High**			
Variable	**Variable name**	**Mean**	**Std. Dev.**	**Mean**	**Std. Dev.**	***F***	***p*-value**
Product EI							
Ep	Ecological/integrated production	0.10	0.24	0.31	0.37	9.57	.003
Process EI							
Bc	Biological control	0.58	0.50	0.98	0.15	22.29	0.000
Rm	Recycled/reused materials	0.35	0.33	0.59	0.37	10.80	0.002
Organizational EI							
Ct	Environmentally-oriented culture	3.42	0.87	4.03	0.65	13.65	0.000
Qs	Quality staff	0.07	0.08	0.04	0.05	3.46	0.067
Lb	Analysis laboratory	0.08	0.27	0.30	0.41	2.74	0.002
Aud	Environmental audit	0.19	0.42	0.65	0.49	17.33	0.000
Ax	Environmental consulting	0.22	0.44	0.65	0.49	14.70	0.000
Cp	Stakeholders cooperation	0.19	0.40	0.60	0.50	17.96	0.000
Marketing EI							
Certf	Quality certifications	2.61	1.91	5.98	1.85	69.63	0.000
Ggp	GLOBALG.A.P. certification	0.36	0.35	0.88	0.16	71.56	0.000
Gsp	GRASP certification	0.22	0.30	0.78	0.28	82.28	0.000
Rpkg	Recycled packaging	0.30	0.37	0.57	0.36	10.79	0.002
Bpkg	Biodegradable packaging	0.22	0.41	0.30	0.47	0.87	0.355

Figure 2. Average scores for Groups 1 and 2 in eco-innovations quantitative variables measured in number scale.



Notes: Ct = Environmentally-oriented culture; Certf = Quality certifications.

Figure 3. Average scores for Groups 1 and 2 in eco-innovations quantitative variables measured in percentage scale and qualitative variables.



Notes: Ep = Ecological/integrated production; Bc = Biological control; Rm = Recycled/reused materials; Ct = Environmentally-oriented culture; Qs = Quality staff; Lb = Analysis laboratory; Aud = Environmental audit; Ax = Environmental consulting; Cp = Stakeholders cooperation; Certf = Quality certifications; Ggp = GLOBALG.A.P. certification; Gsp = GRASP certification; Rpkg = Recycled packaging; Bpkg = Biodegradable packaging.

Group 2 is comprised of firms with higher environmental culture. This orientation leads them to introduce environmental plans and aims into their daily activities. Also, the senior staff place the utmost importance on all company operations being environmentally respectful and fulfilling the environmental goals established. Thus, these firms conduct environmental audits and cooperate with environmental experts, universities and R&D groups in order to discover new ways to reduce their negative environmental impact. Moreover, these firms comply with a large number of certifications in order to meet the quality standards requested by consumers and markets. Furthermore, some firms in Group 2 have introduced internal laboratories with the aim of conducting random pesticide and insecticide controls to ensure levels of these inputs are kept to the minimum. Finally, their use of recyclable and biodegradable packaging is higher.

As for Group 1 companies, in the survey they also responded as having a high-level of environmentally-oriented culture and display a slightly higher percentage of employees in the quality department than Group 2. Nevertheless, the results reveal low values of EI implementation in practices such as the number of quality certifications and the volume of ecological production commercialized. In addition, their cooperation with stakeholders as well as their use of recyclable packaging and their recycled material volume is still far from Group 2 implementation levels.

4.3. Chi-squared Tests

In order to understand how and why the two groups are different, a chi-squared analysis was used to determine which characteristics in the two clusters differ (Khan et al., 2018). The chi-squared test examines the relationship between the composition of groups and the following profile variables: age of the company, percentage of the commercialization volume in vegetables, operating incomes, number of employees and commercialization volume. With an error of less than 5%, the analysis reveals that the age of the company and the percentage of the commercialization volume in vegetables are not factors that contribute to differentiating the level of EI between groups, as shown in Tables 5 and 6.

Table 5. Observed and expected frequencies for age of the company in Groups 1 and 2.

Age of the company (years)			Less than 15	Between 15–30	Between 30–45	More than 45	Total
Group	1	Observed	17	17	2	1	37
		Expected	14.5	15.9	4.2	2.3	37
	2	Observed	14	17	7	4	42
		Expected	16.5	18.1	4.8	2.7	42

Pearson chi-squared: 4.570; $df = 3$; $p = 0.206$.

Table 6. Observed and expected frequencies for percentage of the commercialization volume in vegetables in Groups 1 and 2.

Percentage of the commercialization volume in vegetables (%)			Less than 50	More than 50	Total
Group	1	Observed	8	29	37
		Expected	6.6	30.4	37
	2	Observed	6	36	42
		Expected	7.4	34.6	42

Pearson chi-squared: 0.726; $df = 1$; $p = 0.394$.

Table 7 presents the observed and expected frequencies for the operating income in Groups 1 and 2. The observed number of firms in Group 1 with operating incomes under 43 million euros is higher than the expected frequency, while the observed number of firms in Group 2 with operating incomes above 43 million euros is higher than the expected number. Thus, those firms whose operating incomes are above 43 million euros are influenced by factors that drive them to be more eco-innovative.

Table 7. Observed and expected frequencies for operating income in Groups 1 and 2.

Operating income (thousands of euros)			Less than 10,000	Between 10,000–43,000	More than 43,000	Total
Group	1	Observed	21	16	0	37
		Expected	13.1	15	8.9	37
	2	Observed	7	16	19	42
		Expected	14.9	17	10.1	42

Pearson chi-squared: 25.787; *df* = 2; *p* = 0.000.

Table 8 and 9 present the observed and expected frequencies for the number of employees and the millions of kilos commercialized in Groups 1 and 2, respectively. The observed number of firms in Group 2 with more than 250 employees and a volume of commercialization over 50 million kilos is higher than the expected number. Therefore, firms with more than 250 employees and a volume of commercialization over 50 million kilos are influenced by factors that drive them to be more eco-innovative.

Table 8. Observed and expected frequencies for number of company employees in Groups 1 and 2.

Employees (number)			Fewer than 50	Between 50-250	More than 250	Total
Group	1	Observed	18	19	0	37
		Expected	11.7	14.5	10.8	37
	2	Observed	7	12	23	42
		Expected	13.3	16.5	12.2	42

Pearson chi-squared: 29.221; *df* = 2; *p* = 0.000.

Table 9. Observed and expected frequencies for commercialization volume in Groups 1 and 2.

Commercialization volume (millions of kilos)			Fewer than 10	Between 10–50	Between 50–100	More than 100	Total
Group	1	Observed	16	20	0	1	37
		Expected	12.2	16.9	3.7	4.2	37
	2	Observed	10	16	8	8	42
		Expected	13.8	19.1	4.3	4.8	42

Pearson chi-squared: 15.017; $df = 3$; $p = 0.002$.

5. Discussion

The statistical results highlight some weaknesses in EI implementation in the Spanish agri-food sector. On one hand, the sector does not place enough importance to the implementation of certain eco-innovative practices (e.g. waste level, water/energy consumption or R&D investments). Consequently, it also ignores other EI practices which are very important to achieve cleaner production and environmental sustainability in the sector.

On the other hand, about product EI, despite the fact that ecological and integrated production has increased in recent years, it continues to be lower than that of traditional production. As the cluster analysis demonstrates, the level of ecological or integrated production does not reach 50% of the total production. Regarding process EI, although all the sector companies implement traceability control due to its being legally required, biological control is not implemented by the whole sector, despite being a key factor in quality control of goods and ecosystems. These results demonstrate the need to implement eco-support policies along with more mandatory environmental policies, with the aim of urging companies to introduce eco-innovative practices in their daily activities. Environmental regulations are positioned as key drivers of EI initiatives (Van Hemel and Cramer, 2002) and have special influence on Spanish firms (Jové-Llopis and Segarra-Blasco, 2018).

Concerning organizational EI, Group 2, which is comprised of the most eco-innovative firms, has a greater propensity to establish relationships with environmental experts and stakeholders in order to improve its environmental impact. As the descriptive analysis highlights, this group of companies not only regularly performs environmental audits and requests environmental consulting, but it also has a higher number of staff allocated to control the quality of goods and the production process. This description confirms the conclusion reached by González-Moreno et al. (2019) regarding the need to create intense relationships with stakeholders in order to develop a fluent EI process in the food sector. Also, these findings are in line with other works that underscore the importance of relationships with pressure groups in the development of EI (Chan and Lau, 2005; Becheikh et al., 2006; De Jesús Pacheco et al., 2016; Kiefer et al., 2017).

Regarding marketing EI, 'green' packaging design is another point to address. The use of recycled or biodegradable materials is positioned as an environmental solution, but despite increased usage in recent years, its implementation is still low (Ivankovic et al., 2017). As the cluster analysis reveals, the use of recycling packaging is located far below 40% in Group 1 and the use of biodegradable packaging in both groups barely reaches 30%. Thus, in accordance with the recommendation of Ahmed and Alam (2012), promoting the use of 'green' packaging is an important environmental and marketing tool. In environmental terms, it contributes significantly to reduce waste levels and CO2 emissions; while in terms of marketing, it contributes to market growth. Futhermore, as Verghese and Lewis (2007) defend, cooperation in packaging systems ensures reductions in costs and increases in environmental efficiency. With regard to environmental certifications, they are a tool that is increasingly implemented by the sector and the indicators related to them contribute most to differentiating the EI level between groups, as the ANOVA analysis reveals. According to the findings of Segarra-Oña et al. (2011), these certifications are indicative of incremental innovations.

The results also reveal that most of the sector companies are small and medium size companies (75.9%); however, those companies with an income volume above 43 million euros are more likely to implement eco-innovative practices. This is in line with Becheikh et al. (2006), who point out that the innovation activity is more probable in large-sized firms. As Arranz et al. (2019) states, the lack of EI development in firms can be caused by the perception of high costs, the need for financing and the lack of environmental knowledge. In this line, implementing policies that promote financial incentives as well as non-financial, such as seeking environmental partners, is a key factor to achieve cleaner production (Kulczycka and Lelek, 2014; Arranz et al., 2019; Gónzalez-Moreno et al., 2019). In accordance with the findings of Ghisetti and Pontoni (2015), regulatory stringency has positive, significant effects on EI, and policy-makers need to introduce regulatory-standards in order to further promote sustainable transition. This is of great interest especially in the agri-food sector, highly linked to the use of natural resources and the food value chain. According to the SDGs, promoting EI the in agri-food sector contributes to encouraging companies to implement greener production methods with less amount of waste, use natural resources in an efficient way and obtain products more respectful to the public health, in accordance with the quality requirements (Rodríguez-Rodríguez et al., 2012; Langendahl et al., 2016; Marcon et al., 2017).

6. Conclusions

This study conducts a multidimensional analysis of EI implementation. For that purpose, the study complies sets of variables for the four main dimensions of EI (product, process, organizational and marketing) utilizing data from a survey carried out *ad hoc* on the agricultural sector in the southeast of Spain. Thus, seeking to undertake much more than a mere, conventional analysis of EI implementation and to expand the sectorial focus of study, the empirical analysis examined several types of EI practices implemented in an agri-food sector: Spanish wholesalers of fruits and vegetables.

The statistical analysis reveals that, despite having a group of more eco-innovative companies, the efforts made to reduce negative environmental externalities are mostly limited to large companies as they have more economic resources. In fact, the vast majority of the sector is composed of small and medium size companies, which show less propensity to eco-innovate, especially in those green practices with higher costs of implementation, such as the use of recyclable and biodegradable packaging or the implementation of internal analysis laboratories for a better control of pollutant inputs usage in the production of the goods. Moreover, although most of the companies are certified with quality certifications, not all of their production comes from farmers that are standard certified. In addition, regarding the group of less eco-innovative firms, the results highlight the need for an increase in their environmental awareness. For instance, although they respond in the survey as introducing environmental plans and aims in their daily activity, the insufficient degree of cooperation with environmental experts reveals that a great deal of work still remains to be done in order to achieve a sustainable production process. These results demonstrate the need to develop new financial and non-financial regulations that support innovation practices in the sector, especially for small and medium size companies, while also taking into consideration the importance of organizational and marketing eco-dimensions.

6.1. Implications for Theory and Practice

Overall, this investigation develops a comprehensive framework for a multidimensional analysis of EI implementation in its four dimensions, filling the gap in the literature, which has focused mainly on analyzing product and process, and only includes organizational and marketing EI to some extent. Also, as most of the analyses on this issue are focused on the industrial sector, this research offers a new framework on the state of EI implementation in a high impact environmental sector: the agri-food sector. Thus, this study makes it possible to broaden the focus of analysis and develops a method of EI analysis that more closely resembles reality.

In addition, the findings of this research infer some policy implications for both public and private decision makers. On one hand, it allows governments to know in which directions regulatory efforts should be focused. For example, they should promote more fiscal benefits and economic aid to encourage small and medium size companies to implement greener practices, especially related to organizational and marketing dimensions. Small- and medium-sized companies have to make more e orts to bear the high costs of implementing eco-practices, so facilitating R&D cooperation with universities and research centers would support the assumption of these costs. In addition, decision makers should encourage the access of these types of companies to public funds specially destined for the development of ecological practices. On the other hand, it provides companies with knowledge on green practices that can be implemented to become more environmentally efficient, and also helps them to understand the importance of implementing EI practices in all dimensions in order to achieve cleaner production and develop sustainable production processes.

6.2. *Limitations and Future Research*

Like all empirical research, this study features some limitations, which could serve as reference for future works. Firstly, some relevant EI variables could not be measured (e.g. level of waste or recycling of materials) because the firms simply do not keep logs on certain data. Therefore, firms should be encouraged to register this important information, which would allow future works could focus on expanding the variables that have an influence on EI implementation. Secondly, a posterior EI analysis could be conducted to compare results with those initially obtained to determine their evolution over time. Thirdly, the study focuses on the Spanish agri-food sector, so it would be particularly interesting if future research conducted a similar analysis of other national and international agri-food sectors in order to make comparisons. Finally, the multidimensional assessment framework of EI implementation proposed by this paper could be applied to other sectors.

CHAPTER 5

MEASURING ECO-INNOVATION DIMENSIONS: THE ROLE OF ENVIRONMENTAL CORPORATE CULTURE AND COMMERCIAL ORIENTATION

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MEASURING ECO-INNOVATION DIMENSIONS: THE ROLE OF ENVIRONMENTAL CORPORATE CULTURE AND COMMERCIAL ORIENTATION

Abstract

Eco-innovation (EI) is a complex process that involves product, process, organizational and marketing dimensions, each with its own determinants, characteristics and contributions to environmental business performance. Thus, analyzing EI activity is essential to obtaining a holistic view in order to achieve sustainable development. This study offers a multidimensional EI measurement and, what is more, evaluates its relationship with environmental corporate culture and commercial orientation drivers in a high environmental impact context, i.e., the agri-food sector. The proposed model was tested using the partial least-squares technique, which was applied to data collected from a sample of 93 companies located in southeast Spain. This study confirms the importance of several dimensions, namely marketing, organization and process, to corporate adoption of EI. Additionally, this research also reveals the positive relationship that both drivers, environmental corporate culture and commercial orientation, have with EI. The findings also suggest that theorists and practitioners must contemplate EI from the point of view of its four dimensions in order to achieve an efficient, more realistic analysis. Subsequently, this work carries some theoretical conclusions and implications for research and practice.

Keywords: eco-innovation, multidimensional, commercial orientation, environmental corporate culture, partial least square technique.

1. Introduction

Despite decades of academic and practitioner attention, interest in the analysis of the eco-innovation (EI) process continues to increase. In fact, growing awareness of climate change and environmental degradation makes it necessary for companies to implement

EI to respond to consumers' environmental demands and regulatory requirements. In this context, there is a growing belief that the agri-food sector is a key factor in the development of more sustainable economies, mainly because of its multidimensional performance (Gómez-Limón and Sánchez-Fernández, 2010). The complex relationship of this sector with the environment (e.g., resource conservation, socioeconomic factors, etc.) positions EI as a significant element for achieving economic and environmental benefits (Galdeano-Gómez et al., 2017). Implementing EI allows companies and sectors to be more sustainable and, at the same time, to increase their competitiveness and productivity (Adams et al., 2012; OECD, 2013).

EI is defined as "the production, assimilation or exploitation of a product, production process, service or management or business method that is novel to the organization (developing or adopting it) and which results, throughout its life cycle, in a reduction of environmental risk, pollution and other negative impacts of resources use (including energy use) compared to relevant alternatives" (Kemp and Pearson, 2007 p.7). This complex process has been addressed from different perspectives in recent decades. From the firm-level perspective, a growing body of literature on EI drivers has been developed and there are common conclusions about which are the stimuli that motivate firms to implement greener practices. Some research defends the positive impact that internal characteristics have on a company's decision to be 'greener', such as firm size, solvency rate, social structure or personal circumstances (Feder et al., 1985; Diederen et al., 2003; Gardebroek, 2006; Knickel et al., 2009). In contrast, other authors focus their investigations on the influence that external environment has on a firm's reason for implementing EI. Some of the external factors most commonly considered by EI literature are the regulatory and institutional frameworks, for instance setting new standards, and the demand-pull drivers, i.e., market conditions (Reinnings, 2000; Horbach, 2008; Kesidou and Demirel, 2012; de Marchi, 2012; Doran and Ryan, 2016). Technology-push factor, i.e., advances in science and R&D, is also a key determinant of EI (Cleff and Rennings, 1999; Horbach, 2008; Ghisetti and Pontoni, 2015). Other works outline a combination of these factors that affect firms' EI adoption (Carter and Williams, 1959; Kleinknecht and Verspagen, 1990; Ghisetti and Pontoni, 2015). In this line, recent EI literature brings to the forefront the effect that firm commercial orientation as well as environmental corporate culture have on the business decision to implement eco-innovative practices, especially in agri-food firms (Rkein and Andrew, 2012; Rodríguez-

Rodríguez et al., 2012; Ortiz-de-Mandojana et al., 2016; Tsai and Liao, 2017; Liao, 2018). Commercial orientation, as an organizational capability, significantly influences environmental business strategy and environmental corporate identity (Wang et al., 2018).

Regarding the EI implementation perspective, and despite its having generated considerable advances, there is no prior research that provides insights related to a complete and efficient EI measurement. Most studies in this field prove incomplete as they only consider EI implementation analysis from the product and process dimensions (Doran and Ryan, 2016; Castellacci and Lie, 2017; Rodríguez and Wiengarten, 2017). Very few studies contemplate the four EI dimensions, i.e., product, process, organization and marketing (Marcon et al., 2017; Astuti et al., 2018), and they only focus on the industrial sector and multinational companies. Furthermore, those works that are focused on the agri-food sector include a limited range of green indicators for assessing environmental performance (Rodríguez-Rodríguez et al., 2012; Galdeano-Gómez et al., 2017; El Bilali, 2018). In this sense, further investigations are necessary to develop a body of knowledge on this subject, especially due to the increased awareness of the importance that green marketing and organizational practices have on company environmental performance (BID, 2007; Marcon et al., 2017; García-Granero et al., 2018). Likewise, it is important to conduct research in the agri-industry due to a need for increased food production in a world combined with a need for better degrees of sustainability in the food value chain (Barth et al., 2017).

As some authors mention “you cannot manage what you do not measure” (Cooper and Edgett, 2008; Ehrenfeld, 2008). In this sense, this work aims to analyze EI implementation using a multidimensional approach. Therefore, the main objective is to develop a holistic EI implementation level model, regardless of firm size, and, more specifically, offer a multidimensional EI measurement including green product, process, organizational and marketing dimensions. In the same model, this study also tests the relationship between EI and firm features of environmental corporate culture and commercial orientation, within the agri-food sector. These go beyond the limitations established in other research, analyzing EI implementation in a context of study which differs from the industrial sector, while at the same time helping to understand this multifarious practice. In this way, we address the following research questions: 1) Is environmental corporate culture positively related to EI level? 2) Is commercial orientation positively related to EI level? 3) What is the relationship between EI level and its four dimensions (product, process, organization and marketing)? To answer these questions, a Partial Least Squares based-structural equation modeling method (PLS-SEM) was applied to the agri-food sector. In particular, we focus on the fruit and vegetable farming-marketing companies of southeast Spain, which operate in environments aimed at international markets and whose evolution has been notably marked by environmental issues (Galdeano-Gómez et al., 2013). These farming-marketing companies, acting as wholesalers in origin (i.e., located in the production areas), are characterized by an intensive horticulture and a commercial activity aimed at European countries. This agri-food system implies considerable amounts of waste and residues, intensive use of resources and water consumption (Rodríguez-Rodríguez, 2012). Therefore, these firms have an important role in overcoming externalities and moving towards a more environmentally-respectful production system (Galdeano-Gómez et al., 2017).

Consequently, this study makes two main contributions. First, this paper contributes to the stream of research providing a novel multidimensional EI measurement contemplating all types of companies, regardless of size. It offers a holistic view on which EI types provide greater opportunities to comply with environmental requirements. Secondly, this research also tests a more complex relationship between environmental corporate culture, commercial orientation and EI level in a sector closely linked to the environment: the agri-food sector. To our knowledge, there are no previous works that have studied all these aspects in the same empirical model; thus, a considerable research gap is herein addressed.

The present study is structured as follows. Section 2 presents the theoretical background, model and hypotheses. It also includes a brief conceptual delimitation of the different constructs (environmental corporate culture, commercial orientation and EI level) that shape the research model. Section 3 contains a description of the research methodology used to test the hypotheses posited. Subsequently, Section 4 provides a detailed description of the main results derived from the data analysis through Partial Least Squares (PLS) path-modeling. Finally, Section 5 presents the discussions, conclusions, implications and limitations of this study.

2. Background and Hypotheses

EI activity is a complex process that includes a vast diversity of innovations which can be classified into four dimensions: product, process, organization and marketing (BID, 2007; Marcon et al., 2017; García-Granero et al., 2018). These four types of EI coexist in all sectors; thus, developing a scale to measure them by identifying their key performance factors is crucial to achieving an accurate measurement level of EI implementation.

Although the phenomenon of EI has received increasing attention in recent decades, most of the literature approaches this topic in a variety of industrial sectors (García-Granero et al., 2018). For example, Van Hemel and Cramer (2002) and Alkaya and Demirer (2015) highlight EI implemented in the chemical industry; Crabbé et al. (2013) study EI in companies from building industry, chemical industry, furniture manufacturing, medical equipment, metal processing and plastic processing industry; while Theyel (2000) focuses on the plastic and resin sector. More studies about EI in the industry have been carried out with the aim of exploring and explaining the EI process itself (Dalhamar, 2015; Castellacci and Lie, 2017; Rodriguez and Wiengarten, 2017). However, in recent years, there has been a trend towards highlighting the importance that the agri-food sector has in the sustainability transition and the role EI has as a competitive advantage for the future of these companies (Barth et al., 2017; García et al., 2018). In fact, the attention paid by institutions and businesses to the environmental and social implications of this sector has encouraged companies to improve their environmental performance. Moreover, as far as quality is concerned, consumers are increasing their demand for environmentally-friendly production methods (Carpentier and Ervin, 2002; Galdeano-Gómez et al., 2013). Sustainable agricultural development can enhance the nutritional quality of food and thereby produce positive health effects (Benbrook et al., 2013). Several studies address these questions and agree on the capacity that the agri-food sector has for implementing EI and adapting to these green demands (Galdeano-Gómez et al., 2017; Labella et al., 2017). One line of EI research in the agri-food sector is focused on analyzing a series of motivating factors that lead companies to adopt more sustainable practices. Lioutas and Charatsari (2018) contemplate the adaption to social requirements, environmental concern, convenience, economic incentives and the internal need to pursue change, such as factors related to EI adoption decisions. Guerrero-Lara et al. (2019) investigate the influence of legislation, administrative support and social-economic values on the promotion of EI in the Spanish agri-food sector. In the same context of study, Rabadán et al. (2019) focus their investigation on the influence that market green demand, regulation, cooperation and economic objectives have on firm EI strategy. As for other aspects, a great deal of the EI literature in the agri-food sector addresses the development of a framework, which enables the conceptualization of EI practices. (Dangelico et al., 2019). Galdeano-Gómez et al. (2013) investigate the EI process and the synergies between the sustainability dimensions integrating technology and green practices oriented towards the efficient use of resources in ecological aspects. Rodríguez-Rodríguez et al. (2012) analyze the environmental performance contemplating technology, efficiency and environmental indicators related to environmental investment intensity or environmental audits. Other studies, such as Godoy-Durán et al. (2017) and Labella et al. (2017), use eco-indicators associated with product and process practices to analyze EI and measure sustainability. Furthermore, Langendahl et al. (2016) include commercial and organizational practices to conceptualize the sustainable innovation journey in the UK agri-food sector. Drejeris and Miceikienè (2018) and Shih et al. (2018) propose product and process green practices while also highlighting the important role that environmental oriented staff have in EI process in the Lithuanian and Asian agri-food sectors, respectively. What is more, Caffaro et al. (2019) analyze EI in the Italian agri-food sector by contemplating variables related to information and environmental attitude behavior. Nevertheless, despite the effort to offer an efficient measurement, these investigations only consider a sparse assortment of eco-indicators, not all EI dimensions. Thus, more empirical research is needed to discover a wide range of EI practices that are aimed at developing a solid theoretical foundation.

The proposed model was developed analyzing the extant literature on EI. Previous studies suggest that environmental corporate culture and commercial orientation have a significant impact on EI adoption (Newton and Harte, 1997; Rkein and Andrew, 2012; Liao, 2018; Wang et al., 2018). In addition, other researches defend the importance of taking into consideration the four EI dimensions to analyze the relationship between the different EI practices and the level of EI implementation (BID, 2007; Marcon et al., 2017; García-Granero et al., 2018). In this line, the sector's environmental performance is represented in six constructs: environmental corporate culture, commercial orientation, product EI, process EI, organizational EI and marketing EI. They are expected to support the efficient measurement of EI level. EI practices, environmental corporate culture, commercial orientation and EI level constructs are discussed in the following subsections.

2.1. Eco-innovation Level

EI is a concept that has been widely examined by the economic, business and environmental academic literature from the perspectives of concepts, drivers and consequences. Nevertheless, studies on its implementation are scant (Kemp, 2009). In recent years, researchers have addressed EI from the measurement perspective with the aim of achieving an efficient way to analyze this complex process and fill the gap existing in the literature.

Several EI studies emphasize the necessity to introduce four EI dimensions, namely product, process, organization and marketing, in a sector's environmental performance (OECD, 2005; BID, 2007; Horbach, 2008; OECD, 2012; Triguero et al., 2013; García-Granero et al., 2018). Product EI is related to the product innovation involving environmentally-friendly materials, environmentally-friendly packaging, recovery of products and recycling, and eco-labelling (Chen et al., 2006; Chen, 2008). Process EI refers to a firm's ability to improve existing processes and develop new ones that increase resource savings and prevent pollution (Chen et al., 2006; Chen, 2008). Organizational EI can be explained as either a new or significant improvement in routines, business models, methods and actions that change a firm's practices, relations and decisions, with the aim of reducing adverse environmental impacts (Marcon et al., 2017). Within environmental management systems (EMS), marketing EI involves the integration of environmental aspects into product placement, communication, new methods of product delivery, promotion or pricing strategies (Marcon et al., 2017). Based on these definitions, it is evident that strong interrelationships exist between the four EI dimensions. Firstly, process EI modifies the organization's operational processes systems while simultaneously producing new or significantly improved eco-products, thereby reducing environmental impacts (Negny et al., 2012). Furthermore, it has been demonstrated that organizational EI facilitates the implementation of process EI and product EI (Murphy and Gouldson, 2000). Secondly, the implementation of marketing EI requires the introduction of green products and processes in order to conform to the environmental standards of the markets (García-Granero et al., 2018). However, EI literature analyzes

EI activity by studying the EI dimensions separately, without taking into consideration how they are interconnected (Hallstedt et al., 2013; Lozano, 2013). Moreover, the majority of these studies fail to consider the impact that organizational and marketing dimensions have on environmental performance (del Río et al., 2010; Crabbé et al., 2013; Doran and Ryan, 2016; Ishak et al., 2016). In fact, the most complete investigations in this study area are mainly focused on three EI types (i.e., product EI, process EI and organizational EI), ignoring the relevance of EI marketing practices (Horbach, 2008; Rodríguez and Wiengarten, 2017). Thus, EI performance has never been properly examined, and only the studies carried out by Marcon et al. (2017) and Astuti et al. (2018) addressed all the green dimensions, though they only focused on the industrial sector and multinational companies.

2.2. Environmental Corporate Culture and the Eco-innovation Level Relationship

The effect of environmental corporate culture on environmental firm performance is a subject that is attracting the attention of recent literature on EI. Most studies have shown that organizational attitudes, governance and cultures may affect firm EI (Bleischwwitz et al., 2012; Bossle et al., 2016; Dangelico, 2016; Ortiz-de-Mandojana et al., 2016; Tsai and Liao, 2017). According to Ajzen (1991), it is true that EI might be affected as attitude would naturally influence decisions. A positive attitude in an organization towards a given environmental issue makes it more likely to implement EI behavior (Liao, 2018). For instance, companies may implement new manufacturing practices that prevent pollution, or they may adopt efficient environmental management systems (Eiadat et al., 2008; Wijethilake et al., 2016). Indeed, corporate environmental performance is regarded as a key driver of improving EI strategy (Porter and Kramer, 2006; Glavas and Mish, 2015; Wijethilake et al., 2016). For example, the number of environmental objectives included in production plans and operations or the inclusion of environmental plans in production processes are a good indicator about how environmentally-friendly a company is (Frosch and Gallopoulos, 1992; Tibbs, 1992; Williams et al., 1993; Kemp and Pearson, 2008). Furthermore, spreading green values within the organization could promote a firm's implementation of green business practices (Parr, 2009). In this sense, the role of managerial agency in a firm proves to be a key factor. Senior staff can encourage employees to be more innovative and respectful with the environment (Anderson, 1998; Andriopoulos, 2001; Halbesleben et al., 2003). Rajala et al. (2016) illustrate the role of the managerial agency in driving environmentally sustainable practices in a company and developing a green business model orientation. The importance of managers in environmental corporate culture has also been analyzed by other researchers (e.g. O'Connor and Ayers, 2005; Hojnik and Ruzzier, 2016a). Without question, there is a consensus in the EI literature on the positive effects that employing staff who are more in tune with environmentally-friendly practices and greener business models has on better ecological performance and higher level of environmentally oriented cultures (Anderson, 1998; O'Connor and Ayers, 2005; Hojnik and Ruzzier, 2016a).

According to Howard-Grenville and Bertels (2012), environmental corporate culture is what builds EI practices. Moreover, Newton and Harte (1997) emphasize the significant impact that environmental corporate culture has on environmental practices. Thus, these findings indicate that the link between environmental corporate culture and EI level is straightforward. However, in general, prior studies on EI only test this relationship in industrial and high-tech sectors (Peng and Liu, 2016; Magsi et al., 2018).

Based on the above findings, the following hypothesis is proposed:

Hypothesis 1 (H1): *Environmental corporate culture is positively related to firms' EI level in the agri-food sector.*

2.3. Commercial Orientation and the Eco-innovation Level Relationship

In a context marked by internalization and growing competition, companies seek ways of creating value for their customers by developing new practices that allow them to differentiate and capture market share for the main goal of surviving (Kumar and Reinartz, 2016; Crick, 2019). In this sense, firms' commercial orientation is a key tool for achieving this objective. Nevertheless, defining commercial orientation is not an easy task. The increasing reliance on market-based approaches defends this concept as a business philosophy surrounding the concept of creating value for customers in ways that competitors cannot imitate (Ellis, 2006; Jones and Shaw, 2018; Crick, 2019).

Behavioral and cultural theories suggest that commercial orientation is a practice focused on customers (Kohli and Jaworski, 1990; Narver and Slater, 1990; Rkein and Andrew, 2012). Most studies have shown that demand for corporate social responsibility has a significant effect on EI firm performance (Rehfeld et al., 2007; Kesidou and

Demirel, 2012; Doran and Ryan, 2016). This point of view defends that the essence of commercial orientation is customer value. Thus, commercial orientation is related to customer orientation (Deshpandé and Webster, 1993; Mugisha et al., 2005; Rkein and Andrew, 2012).

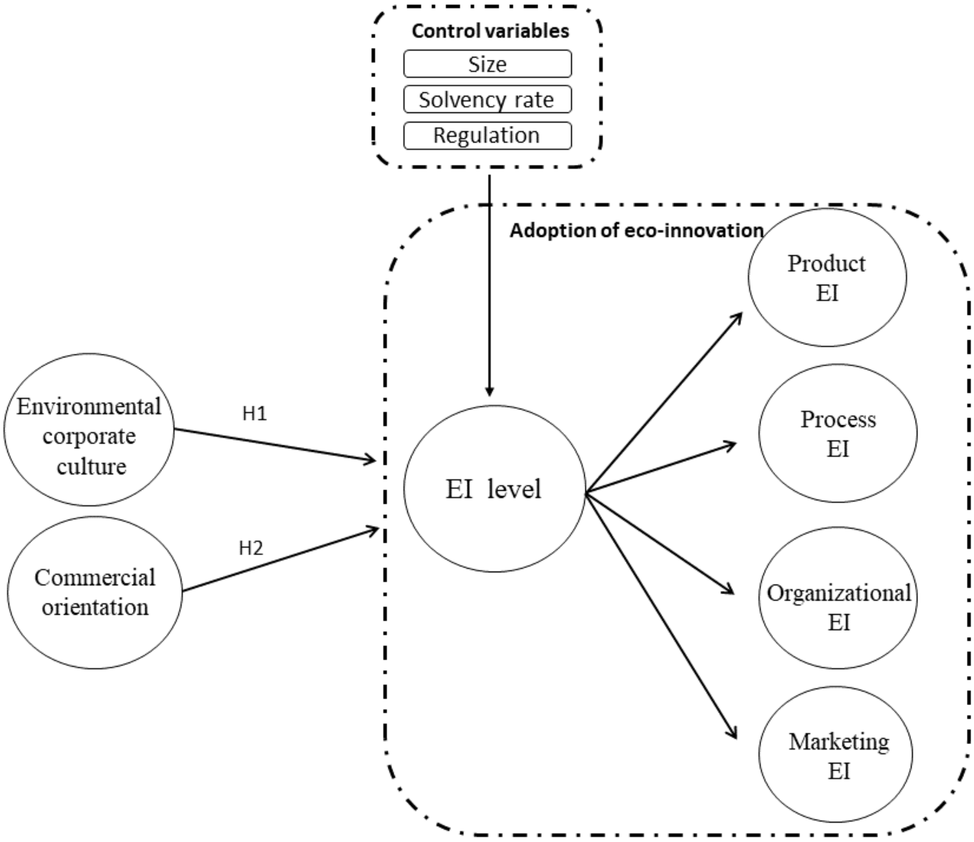
Furthermore, given the importance of the relationships between an organization and other stakeholders beyond customers, such as competitors (Hákansson, 1982; Dwyer et al., 1987; Anderson and Narus, 1990; Crosby et al., 1990), other research highlights the importance of competitor orientation as an additional commercial orientation dimension (Narver and Slater 1990; Deshpandé, 1999; Martin et al., 2015). In this line, some studies have found the acquisition of a competitive advantage and the motivation of growth in the market to be strong drivers of EI firm performance (Salomon and Shaver, 2005; Weerawardena and O'Cass, 2004). In this sense, as EI is conducive to firm differentiation, it can help firms to gain market opportunities as well as improve their organizational image (Im and Workman, 2004; Cheng and Shiu, 2012; Liao, 2016).

In short, competitor orientation and customer orientation, as two key commercial orientation dimensions, encourage firms to implement green practices (Rkein and Andrew, 2012; Liao, 2018; Martin et al., 2015). Thus, it is important to highlight the relationship between commercial orientation and sector environmental performance (Crick, 2019). Therefore, based on this discussion, the following hypothesis is formulated:

Hypothesis 2 (H2): *Commercial orientation is positively related to firms' EI level in the agri-food sector.*

Figure 1 presents the conceptual model for EI.

Figure 1. Conceptual model for eco-innovation (EI)



3. Research Method

The methodology used in this study is based on a survey to provide a multidimensional EI analysis at firm level. This section presents a discussion of the data collection process and the sample used for statistical analysis as well as the development of the EI measurement.

3.1 Sample and Data Collection

The agri-food sector located in the southeast Spanish region (Granada, Almeria and Murcia provinces) constitutes the reference for this empirical setting, which uses data for farming-marketing firms in the period 2017-2018. This sector constitutes a key economic activity, representing 24% of GDP (Gross Domestic Product) and 27% of employment (Galdeano-Gómez et al., 2013). Greenhouses are the principal feature of production in this area (Rodríguez-Rodríguez et al., 2012) and they require intensive use of resources and generate considerable amounts of waste and residues (e.g., packaging materials, fertilizers, plastics, etc.). On the other hand, the agri-food sector also contributes to the development of services (e.g., financing, consulting, R&D, etc.) and an associated auxiliary industry with a high environmental orientation (e.g., fertilizers, bees, seeds, etc), which accounts for approximately 32% of GDP in the area (Aznar-Sánchez et al., 2011; Galdeano-Gómez et al., 2017).

Furthermore, this sector clearly targets foreign markets and has a strong capacity for growth and adaptation to new demands. Over 60% of the production of these firms is exported, which accounts for over 35% of total Spanish agricultural exports and about 18% of all vegetables consumed in Europe (Cajamar, 2016). Thus, these firms must operate in a highly complex environment and deal with international competitors, regulations, standards and requirements, making EI implementation a highly relevant topic for this group (Antonietti and Marzucchi, 2014; Hojnik et al., 2018). Consequently, such firms have been evolving towards environmental adaptation with a more efficient use of resources and a reduction of environmental impact (Martos-Pedrero et al., 2019). This is particularly important in the agri-food context, where all supply chain members have a high environmental impact (Spielman and Birner, 2008; OECD, 2013). As a result, this agri-food model has drawn international attention, as several studies show (e.g., Galdeano-Gómez et al., 2013, 2017; Piedra-Muñoz et al., 2016; Godoy-Duran et al., 2017), and constitutes an adequate empirical frame of reference.

The data were collected using a questionnaire targeted at the environmental management of the companies. The survey was designed specifically for this purpose based on field studies and the relevant literature on EI (García-Granero et al., 2018). Next, the survey instrument was pre-tested on five firms' environmental quality managers, and the questions were selected and modified according to their comments and suggestions. Following these steps, the final questionnaire was structured in three main sections: (1) company economic and financial information, (2) perception of drivers influences, and (3) a series of items on process EI, product EI, organizational EI, and marketing EI.

According to the Iberian Balance Sheet Analysis System (*Sistema de Análisis de Balances Ibéricos* in Spanish, SABI), 302 firms commercialized fresh fruit and vegetables in the provinces of Almería, Murcia and Granada during that period. The sample was simple randomly selected without replacement. The final number of valid surveys was 93. This represents a satisfactory response rate of 30.8% (Menon et al., 1996).

The final sample companies are all internationalized and commercialize fresh fruit and vegetables production to the European Union. According to European legislation (European Commission, 2009), the sample includes 9 micro companies (fewer than 10 employees), 19 small companies (10-49 employees), 37 medium-size companies (50-249 employees), and 28 large companies (250 or more employees). With regard to EI, all companies implement product, process, organizational and marketing EI. 88 companies in the sample have some kind of environmental certification.

3.2 Measurement and Variables

Previous studies have identified and validated the scales which measure EI variables (e.g., Damanpour et al., 2009), although none of them were specifically developed for EI. Thus, based on EI research and literature (BID, 2007; Rodríguez and Wiengarten, 2017; García-Granero et al., 2018), the present study expressly develops new scales with multiple items for EI, following the suggestions of Churchill (1979).

Once an initial set of EI items was ready, a pilot-test was performed to ensure its reliability and validity. Performing a pilot-test is an important step in the scale development process because it can remove any invalid items (Anderson and Gerbing, 1991; Cheng et al., 2014). For this purpose, five environmental managers from five different marketing-producer companies were asked to review and comment on the items, their clarity, ambiguity, completeness, readability and structure. As a result, 24 multi-item scales were generated, including three constructs (environmental corporate culture, commercial orientation and EI level).

Table 1 describes the multi-scales of each one of these items and Table 2 shows the descriptive analysis of them.

Table 1. EI multi-scale items and variables measurements.

Variables and items	**Measurement scale**
Control Variables	
Solvency rate	Natural numbers
Size	Natural numbers
Regulation	Likert scale (1-5)
Commercial orientation	
Customer orientation	Likert scale (1-5)
Achieve competitive advantage	Likert scale (1-5)
Improve corporative image	Likert scale (1-5)
Growth in market	Likert scale (1-5)
Environmental corporate culture	
Degree of importance of implanting environmental plans and objectives	Likert scale (1-5)
Degree of importance of achieving environmental objectives	Likert scale (1-5)
Degree of importance of the company' staff being environmentally respectful	Likert scale (1-5)
Degree of importance of the company' environmental initiatives investment	Likert scale (1-5)
Degree of importance of the company' environmental impact	Likert scale (1-5)
Product EI	
Ecological/integrated production	Percentage
Biodegradable packaging	Dichotomous scale
Recycling packaging	Percentage
Process EI	
Packaging control system implemented	Dichotomous scale
Green technology investment	Thousand euros
Green patent number	Natural numbers
Material recycling	Percentage
Organizational EI	
Environmental advisory implemented	Dichotomous scale
Environmental audit implemented	Dichotomous scale
Cooperation with stakeholders	Dichotomous scale
Environmental quality staff	Natural numbers
Marketing EI	
Environmental quality standard certifications	Natural numbers
Environmental management system certifications	Dichotomous scale
GlobalGap certification	Percentage
GRASP certification	Percentage

Table 2. Descriptive analysis of the variables and items.

Variables and items	**Min.**	**Max.**	**Mean**	**Std. desv.**
Control variables				
Solvency rate	0.27	3.06	1.170.44	
Size	3	1200	220.9	
	295.2			
Regulation	1	5	3.46	1.22
Commercial orientation				
Customer orientation	1	5	4.22	0.92
Achieve competitive advantage	1	5	3.62	0.95
Improve corporative image	1	5	4.03	1.00
Growth in market	1	5	3.70	0.78
Environmental corporate culture				
Degree of importance of implementing environmental plans and objectives	1	5	3.85	0.99
Degree of importance of achieving environmental objectives	1	5	3.76	1.11
Degree of importance of the company' staff being environmentally respectful	1	5	3.96	0.93
Degree of importance of the company' environmental initiatives investment	1	5	3.67	1.06
Degree of importance of the company' environmental impact	1	5	3.72	1.02
Product EI				
Ecological/integrated production	0	1	0.22	0.34
Biodegradable packaging	0	1	0.22	0.42
Recycling packaging	0	1	0.47	0.37
Process EI				
Packaging control system implemented	0	1	0.68	0.47
Green technology investment	0	280	19.52	53.4
Green patent number	0	8	0.52	8
Material recycling	0	1	0.48	1.57
				0.39
Organizational EI				
Environmental advisory implemented	0	1	0.43	0.5
Environmental audit implemented	0	1	0.42	0.5
Cooperation with stakeholders	0	1	0.36	0.48
Environmental quality staff	0	28	4.78	5.58
Marketing EI				
Environmental quality standard certifications	0	11	4.36	2.4
Environmental management system certifications	0	1	0.81	0.39
GlobalGap certification	0	1	0.67	0.37
GRASP certification	0	1	0.49	0.42

The reflective or formative relationships of the items with respect to their corresponding latent variables were proposed following the suggestions of Jarvis et al. (2003) and Mackenzie et al. (2005). According to these authors, commercial orientation, product EI, process EI, organizational EI and marketing EI constructs have a formative character because they are determined by their items, and present indicators that are established exogenously and are not correlated among one another (Chin, 1998). In contrast, the environmental corporate culture construct presents a reflective relationship as the items cover different aspects of the concept included in the construct (Podsakoff et al., 2006). Finally, the relationships between environmental corporate culture and commercial orientation constructs with EI construct, respectively, are both formative; meanwhile, the relationship between EI level construct and its first order structure (four dimensions) is reflective.

3.2.1 Variables

The environmental corporate culture variable refers to green organizational capabilities, ecological organizational commitments and environmentally-friendly organizational philosophies. Adapted from previous studies (Williams et al., 1993; Montalvo, 2003, 2008; Scarpellini et al., 2012; de Jesus Pacheco et al., 2016), it includes five 5-point Likert scale items related to the introduction of environmental objectives and plans, environmental implementation practices and compliance with environmental initiatives. What is more, adapted from Rajala et al. (2016) and Hojnik and Ruzzier (2016a), it includes one item related to the ecological preference of workers and staff.

The commercial orientation variable represents business orientation towards the identification of customer needs. Respondents were asked to answer four questions about the motivating factors to be more customer oriented, such as customer demand, acquisition of competitive advantage, improvement in corporative image and the growth in market (Weeranwardema and O'Cass, 2004; Kesidou and Demirel, 2012; Rkein and Andrew, 2012; Doran and Ryan, 2016). 5-point Likert scale items were used, ranging from "strongly disagree" (1) to "strongly agree" (5).

The EI level construct relates to these green practices that companies implement in order to be more environmentally friendly. Drawing upon previous research (BID, 2007; OECD, 2005; Marcon et al., 2017; García-Granero et al., 2018), this variable presents a second order structure formed by product EI, process EI, marketing EI and organizational EI constructs. Product EI is determined by three items: ecological production; use of biodegradable packaging input; and recycled packaging input (FAO, 2012). Process EI is assessed by four items: package control system; green technology investment; green patents; and recycling (Florida, 1996; BID, 2007; Johnstone et al., 2010; Dalhammar, 2015; Rodríguez and Wiegarten, 2017). Organizational EI is measured by four items that include: implantation of external environmental advisory and audits; cooperation with stakeholders; and environmental quality staff (Frosch, 1994; Boons and Lüdeke-Freund, 2013; de Jesus Pacheco et al., 2016; Peng and Liu; 2016). Based on Uscebrka et al. (2009), Chiarvesio et al. (2015) and Hernádez-Rubio et al. (2018), marketing EI includes four items related to environmental certifications: environmental quality standards certifications (which includes most common certifications, such as Tesco Nature, Naturland and Integrated Production); environmental management system certifications (which includes other certifications, such as IFS Food, QS and ISO); volume of certified hectares with GlobalGap; and volume of certified hectares with GRASP.

3.2.2 Control Variables

This study controlled for possible confounding effects by including three relevant variables: firm size, solvency rate and environmental regulation (Klomp and de Haan, 2008; Amin and Chin, 2019; Zhao et al., 2019). Firm size was measured by total number of employees (Huang and Li, 2015). Solvency rate assesses the company's ability to meet its liabilities with its cash flow (Diederen et al., 2003). Finally, environmental regulation includes one 5-point Likert scale item to indicate the regulatory and normative pressures implemented by the Spanish Government in order to reduce negative environmental company impact (Bocken et al., 2011; De Marchi, 2012).

3.3. Statistical Analysis

A Partial Least Squares based-structural equation modelling method (PLS-SEM) is applied to test the research model and hypotheses proposed (Roldán and Sánchez-Franco, 2012). PLS-SEM method estimates complex cause-effect relationship models with latent variables or constructs. It is composed of two sub-models: the measurement model and the structural model. The first one represents the relationships between the observed data and the latent variables. The second takes into account the relationships between the latent variables. An iterative algorithm solves the structural equation model by estimating the latent variables using both sub-models in alternating steps. The measurement model estimates the latent variables as a weighted sum of its manifest variables. The structural model estimates the latent variables by means of linear regression between the latent variables estimated by the measurement model. This algorithm repeats itself until convergence is achieved (Hair et al., 2018). PLS-SEM is considered the most appropriate technique when structural models are complex, with formative and reflective indicators, as in this study (Hair et al., 2014). This method was preferred over covariance approaches since it is designed to predict relationships among variables in relatively small samples (although representative) with less sensitivity to normality assumption (Henseler et al., 2016). It was also applied because it accounts for measurement error and corrects for attenuation, thereby overcoming many of the problems associated with regression models (Jaccard and Wan, 1996). Moreover, due to the shape of the proposed model, PLS was chosen because it allows evaluation of a composite measurement model (Henseler et al, 2014; Sarstedt et al., 2016). As it is a structural model that includes a second order construct, a build-up approach was carried out (Aldás-Manzano, 2012).

As previous researchers have suggested that unusual patterns of scores can disproportionately influence the results (Tabachnick and Fidell, 2006), an outliers analysis was conducted with the aim of identifying and discarding them.

3.4. Common Method Variance (CMV)

CMV is addressed because the collected data were reported using a single informant from each of the companies and they were collected from the same questionnaire during the same period of time. Therefore, an exploratory factor analysis was conducted which included all the measurement scales proposed in the model using SPSS. Similar methodological approaches have used CMV to assess the potential existence of common method variance (Cheng et al., 2014; Hojnik et al., 2018).

The results reveal that no single factor accounts for most of the variance and that the first factor captures only 24.97% of the variance, which demonstrates a low threat of common method variance.

4. Statistical Results

4.1 Evaluation of Measurement Model

The evaluation of the measurement model is intended to assess the relationships between the indicators and the constructs. Due to the fact that the study uses both reflective and formative measurements, the measures of the variables were tested and validated in several ways. Two statistical tests were performed to evaluate the formative variables of the model in both steps of the build-up approach method: (i) multicollinearity analysis, and (ii) analysis of the weight-loading relationship of each indicator (Hair et al., 2014). The relative relevance of each formative indicator was supported by a comprehensive literature review, interviews with managers, and previous questionnaires pre-tests (as reported in Section 3.2). Based on the feedback and insights from the interviews with managers, the wording of some items was slightly modified to an acceptable level of significance.

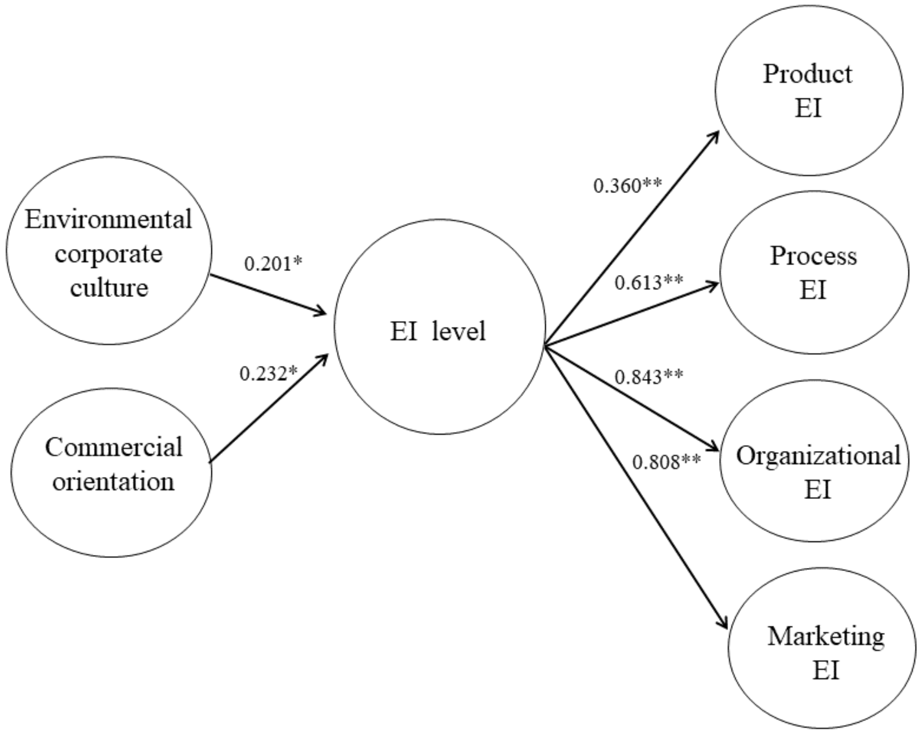
As for another aspect, the existence of collinearity in formative constructs can cause erroneous results. In this line, Hair et al., (2011) defines Variance Inflation Factor (VIF) values below 5.00 for each item to avoid multicollinearity problems. As shown in Table B1 (Appendix B), all VIF values are under this value in the proposed model. Therefore, the existence of multicollinearity problems can be rejected, which validates the formative constructs for the model composition.

Likewise, the convergent and discriminant validity was examined to evaluate the reflective variables. Composite reliability is an indicator of shared variance among the set of observed variables used as indicators of a latent construct (Fornell and Larcker, 1981; Cheng et al., 2014). As shown in Tables C1 and C2 (Appendix C), the composite reliabilities of all constructs exceed the usual 0.60 benchmark in both steps of the build-up approach method (Bagozzi and Yi, 1988). The results provide the necessary evidence that all reflective constructs exhibit convergent validity. Moreover, all factor loadings are greater than 0.50 and the p-values are significant at the 0.05 level; thus, the convergent validity is assured (Fornell and Larcker, 1981; Hojnik et al., 2018). Discriminant validity was tested by comparing the average variance extracted (AVE) with the variance if each factor was shared with the other factors of the model (Cheng et al., 2014). All the diagonal elements representing the square root of the AVE are greater than the highest shared variance (the off-diagonal correlations).

4.2 Evaluation of Structural Model

Once the measurement model was assessed by testing the multicollinearity and the weight-loading relationship of the measurement scales for the formative indicators as well as the convergent and discriminant validity for the reflective indicators, partial least squares structural equation modelling (PLS-SEM) was used to test the hypothesized relationships between the latent variables. The steps suggested by Aldás-Manzano (2012) were followed as the proposed model is a second order construct and it is necessary to apply the build-up approach method. With this approach, firstly, the structural model is estimated ignoring the second order construct in order to calculate the residual value of the first order dimensions. Secondly, these residual values are included as indicators of the second order construct to estimate the model proposed. The evaluation of the structural model aims to determine the relationships between the constructs. Thus, three statistics were used: (i) structural model path coefficients, (ii) coefficients of determination R^2, and (iii) the predictive relevance Q^2.

Figure 2. EI model testing results. *p < .05; **p < .01.



Standardized betas (β) for the path coefficients measure the strength and direction of the significance of the structural model (Wijethilake et al., 2016). According to Chin (1998) and Hair et al. (2014), path coefficients must be above 0.20 in order to be meaningful predictors. The model presented all path coefficients above 0.20, demonstrating that the relationships maintained are significant. However, following Chin (1998) and Hair et al. (2014), a bootstrapping technique (5000 re-samples) is employed to generate standard errors and t-statistics that permit the evaluation of the statistical significance for the relationships hypothesized within the research model. Figure 2 shows the results. All correlations among latent variables are statistically significant.

Moreover, Table 3 reports that, as hypothesized, environmental corporate culture and commercial orientation have a positive relationship with EI level. Therefore, H1 and H2 are supported.

The Coefficient of Determination (R^2), which measures the predictive accuracy, is the central criterion for judging the quality of the partial least squares structural equation modeling (Chin, 1998; Wijethilake et al., 2016). The R^2 of the model is 0.43, which greatly exceeds the 0.1 minimum level proposed by Falk and Miller (1992), indicating that it is a good explanatory model. Concerning the cross-validated redundancy measure (Q^2), it assesses the model's predictive relevance, i.e., if the model has the ability to predict the reflective indicators of endogenous latent variables. Stone-Geisser's Q^2 value was calculated by referring to a blindfolding sample reuse technique with a data omission distance (D) equal to 6 (Wold, 1982). Q^2 values larger than zero for a particular endogenous construct indicate the path model's predictive relevance. The Q^2 value of the model is above zero (0.154), which indicates the satisfactory predictive relevance of the model.

Table 3. Testing the EI model hypotheses.

Hypotheses	Supported or rejected	Coefficient (related to path analysis)	p-value (related to path analysis)
H1. Environmental corporate culture is positively related to firms' EI level.	Supported	0.201	0.035*
H2. Commercial orientation is positively related to firms' EI level.	Supported	0.232	0.014*

*p < 0.05

5. Discussion and Conclusions

Testing the structural model by means of PLS-SEM, the study offers a multidimensional measurement of EI level that previous studies fail to provide. The analysis of the relationship of environmental corporate culture and commercial orientation with EI level also provides evidence about important reasons that motivate companies to be environmentally friendly.

Firstly, the results shown in Figure 2 enhance the significance of contemplating product, process, organizational and marketing EI dimensions, as they are all important. Unlike several research studies that only analyze product and process EI types (Doran and Ryan, 2016; Castellacci and Lie, 2017; Rodríguez and Wiengarten, 2017), the explicative level of the other two dimensions (organizational and marketing) are stronger in the agri-food sector. Among all four, organizational EI is the most significant (β = .843), followed by marketing EI (β = .808). Product and process EI dimensions also display significance, though less than the other two (β = .360 and β = .613, respectively).

These results call into question the effectiveness of measurements used in most previous EI investigations that do not consider all EI types. The findings also lend support to the defense of some authors (BID, 2007; García-Granero et al., 2018) who advocate the introduction of organizational and marketing EI practices to obtain an efficient analysis of the state of EI in any sector or country. Consequently, the results imply that any EI research should contemplate the four dimensions to offer an analysis which more closely resembles business reality.

Secondly, another interesting finding is the positive relationship that environmental corporate culture has with the EI level of agri-food firms. In line with the results of other investigations (Parr, 2009; Bossle et al., 2016; Dangelico, 2016), greater environmental awareness of the company is reflected in a higher predisposition to introduce more environmentally-friendly practices. In this context, the role of senior staff is a key factor in promoting green values throughout the company (Andriopoulos, 2001; Halbesleben et al., 2003; Rajala et al., 2016). Managers can have a great influence on assessing the conditions for a successful implementation of EI by their organizations.

Additionally, this investigation also found that commercial orientation is a significant driver that encourages firms to be more eco-innovative in the agri-food sector. Moreover, those firms that are more customer and competitor oriented are more open to implementing ecological practices with the aim of reaching environmental requirements and demands. According to Narver and Slater (1990), Deshpandé (1999) and Rkein and Andrew (2012), customer and competitor orientation are the two most important commercial orientation items, along with the motivation of results such as acquired competitive advantage or growth in markets (Salomon and Shaver, 2005; Weerawardena and O'Cass, 2004). Thus, organizations with commercial orientation might develop EI according to consumer preferences and changes in market conditions with the aim of pursuing reduction of costs, improvement of company reputation, and operational efficiency increase in terms of an output gained to run a business operation.

5.1 Concluding Remarks

This study presents novel empirical research in this field, showing a multidimensional EI level measurement. The analysis argues that a better understanding of the complex relationship between EI and environmental corporate culture and commercial orientation in the agri-food sector is crucial to attain sustainable development.

Today, it is well-known that EI is necessary to achieve the transition towards 'greener' production process, distribution and consumption. However, although product, process, and organizational innovations are commonly taken into consideration in studies related to EI in several industrial sectors, the relationship between marketing practices and EI is scarcely contemplated. Unlike most studies, the present one focuses on highlighting the key role of each EI dimension in stimulating sustainable development. This is particularly relevant in the agri-food sector due to its capacity to generate socio-economic growth and its high capacity of adaptiveness to international market requirements.

The model developed in this study offers empirical evidence on the positive relationship between environmental corporate culture and commercial orientation and EI. A practical contribution for companies to implement EI involves two aspects. On one hand, regarding environmental corporate culture, acquiring more environmentally-friendly human capital is essential to promote more sustainable work habits that enhance EI. On the other hand, in order to improve EI level, this study provides a conceptual framework that explains which eco-practices should be implemented, while the adoption of EI represents an opportunity for achieving environmental standards and satisfying customers' needs. From a research perspective, this multidimensionality approach should be taken into account to properly study EI implementation in other sectors and/or regions. It suggests that environmental corporate culture and commercial orientation are connected to business decisions on implementing EI practices. What is more, it enhances the importance that marketing and organizational dimensions can have, the same as product and process types when analyzing business EI practices.

The presented study has several limitations which could encourage future works. For example, the analysis is focused on the Spanish agri-food export sector and the data are collected in one period, offering static results. Also, the measurement variables are limited, and other omitted factors may influence these complex relationships. Although the study's findings can be extended to other well-developed economies, it would be interesting for future research to replicate it in other countries and sectors with the aim of being able to compare different economies and business groups. Finally, exploring the EI level over an extensive period of time with the aim of analyzing the evolution of different green practices over the years is a worthwhile direction for future research.

CHAPTER 6

A PATH TOWARD SUSTAINABILITY THROUGH THE CIRCULAR ECONOMY PHENOM: INDICATORS FROM SPANISH AGRI-FOOD SECTOR

A PATH TOWARD SUSTAINABILITY THROUGH THE CIRCULAR ECONOMY PHENOM: INDICATORS FROM SPANISH AGRI-FOOD SECTOR

Abstract

The agri-food sector in Spain plays is vital to socioeconomic development, yet its daily activities also cause environmental deterioration (use of natural resources, greenhouse emissions, waste generation and land degradation). In this sense, the circular economy (CE) paradigm is positioned as an effective path towards promoting the responsible and cyclical use of resources, contributing to sustainable development. Thus, quantifying circularity is crucial for designing policies to achieve the balance between economy and environment and promote CE among companies. New circularity metrics are being developed for this purpose but are often analyzed independently. This paper aims to build a solid theoretical framework on CE metrics in the agri-food sector, seeking to: (i) identify the indicators that should be applied to measure circularity, (ii) evaluate the current eco-efficiency performance of the agri-food sector, based on the Spanish case of study, and (iii) provide recommendations to decision-makers regarding the benefits of moving from traditional linear systems to a circular production system, adopting the principles of sustainable development. This investigation shows the heterogeneity of CE subindicators related to green business awareness, green inputs, and waste, water and energy management. The results of empirical analysis reveal the existence of two well-differentiated circular groups in Spanish agri-food firms. The analysis also reveals that the adoption of different strategies, such as biodegradable packaging, environmental advisory or environmental audits, represents an opportunity to improve eco-environmental performance. The research conducted also suggests that a set of circularity indicators should be used to assess CE instead of a mono-dimensional indicator.

Keywords: circular economy, agri-food sector, circular indicators, economic sustainability.

1. Introduction

According to the OECD (2012), the world population is going to surpass 9,000 million by 2050. This fact makes it necessary to increase food production by 70% in that same year. In this context, the agri-food sector has become a key factor in the path towards achieving this objective. However, the sector must face the challenge of increasing its production to supply the world market, while also looking for new, more environmentally-friendly production methods. The agri-food industry is one of the key contributors to environmental impacts. On the one hand, the production of food requires the use of resources such as fuel, land, water and raw materials. On the other hand, the application of chemical inputs, such as fertilizers or fungicides, creates direct emissions of nitrous oxides contributing to climate change (Scherhaufer et al., 2018). Indeed, there is a great potential in the sector to reduce environmental pressures related to the use of limited natural resources by developing more sustainable business models. Moreover, the growing awareness for human health due to the undesirable effects of hazardous synthetic chemical inputs has encouraged the search for eco-friendly alternatives (De Corato, 2020).

In this international context, the circular economy (CE) model has gained widespread recognition in recent years due to the goal of maintaining components, materials and products at their highest utility in order to eliminate waste. However, defining CE is not an easy task. A recent literature review found 114 different CE definitions (Kirchherr et al., 2017). These numerous definitions apply the 3R principles (Reduce, Reuse and Recycle), yet some of them failed to notice the need for a systematic change. What is more, many definitions did not highlight the role of business models and consumers as CE agents. Thus, this review came to the conclusion that the definition provided by the Ellen MacArthur Foundation is the most prominent. According to the authors, CE can be defined as “an industrial system that is restorative or regenerative by intention and design. It replaces the ‘end-of-life’ concept with restoration, shifts towards the use of renewable energy, eliminates the use of toxic chemicals, which impair reuse, and aims for the elimination of waste through the superior design of materials, products, systems, and, within this, business models” (Ellen MacArthur Foundation, 2012 p.7). Therefore, CE is characterized by low consumption of materials, elimination of inputs from fossil or non-renewable sources, low pollution levels and high circulation rates (Jun and Xiang, 2011). As a result, it contributes to the three dimensions of sustainable development (society, economy and environment) as well as towards achieving the main sustainable development goals, such as hunger, health and wellness (Zabaniotou, 2018).

The application of CE in agriculture has been studied by several investigations from different points of view. Some authors assess the methodologies and indicators that can be applied to obtain an accurate analysis method of CE. Elia et al. (2017) evaluate a set of indicators and methodologies according to five CE characteristics provided by the European Environmental Agency (EEA, 2016). Iacovidou et al. (2017) review the methods for achieving resource recovery from waste to promote CE. Pauliuk (2018) proposed a framework of indicators to be used in CE analysis. Furthermore, the European Academies' Science Advisory Council provides a list with more than 300 indicators that could potentially be used to measure progress in CE (EASAC, 2016). Other studies are focused on CE analysis in a specific context of study. Global applications have been presented in the studies carried out by Patricio et al. (2018) and Grimm and Wösten (2018), focusing on mushroom production. Other authors, such as Fernandez-Mena et al. (2016), Kristensen et al. (2016), Pagotto and Halog (2015) and Caruso et al. (2019), concentrate on the whole agri-food sector. However, most of the research on CE in the agricultural sector analyzes mono-dimensional indicators (Strazza et al., 2015; Tua et al., 2019; Kuranska et al., 2019; Loizia et al., 2019), which results in a methodology unable to provide recommendations for holistically achieving CE objectives. Few are those that include a combination of various kinds of indicators (Genovese at al., 2017; Aravossis et al., 2019; Marino and Pariso, 2020). One example is Moraga et al. (2019), who emphasize that a set of indicators should be used to analyze CE. Furthermore, as Corona et al. (2019) highlight in a literature review on circularity metrics, more research on the topic is necessary to address the difficulties of measuring CE goals.

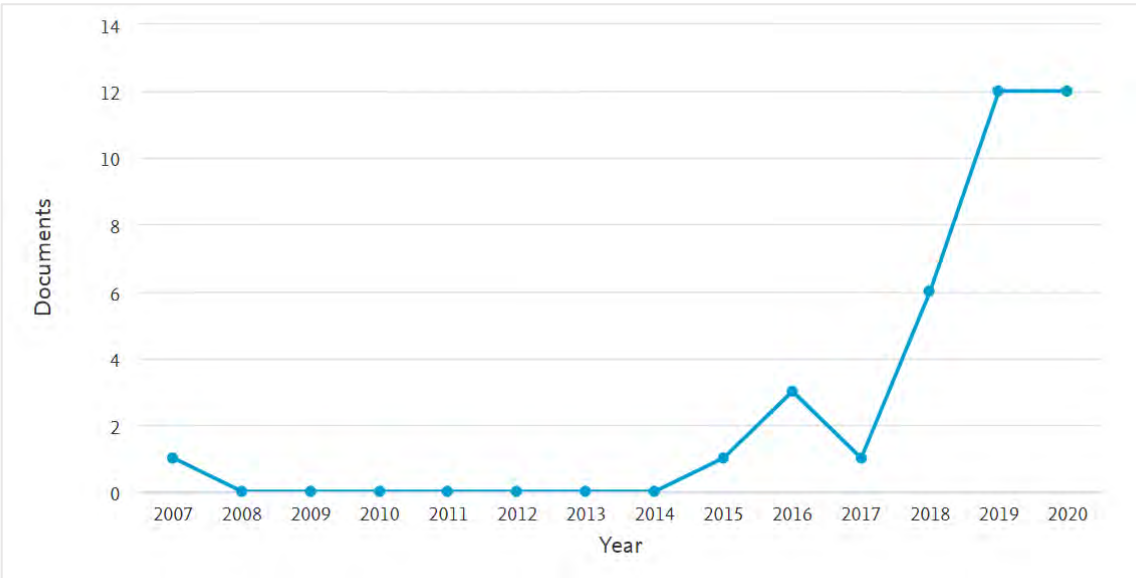
Consequently, the purpose of this study is to offer an overview of the emerging academic literature on CE indicators in the agricultural sector with the aim of obtaining an accurate framework of reference to evaluate the agri-food application of CE objectives. Subsequently, this circularity indicators framework has been applied to the Spanish agri-food sector. To the best of the authors' knowledge, there are no studies which provide a complete review of CE indicators in agriculture or a comprehensive analysis of the topic applied to these features of the sector in Spain. Thus, this investigation goes beyond the scope of CE application, aiming to investigate the contribution of circular strategies in agri-food companies to sustainable development.

The remainder of this paper is organized as follows: Section 2 provides the theoretical framework on CE indicators in the agri-food sector. Section 3 explains the case study and the methodology procedures. Next, Section 4 presents the results of the empirical analysis. Finally, Section 5 concludes the study, summing up the main findings and presenting suggestions for future research.

2. Theoretical Framework: An Overview of Circular Economy Indicators in the Agri-food Sector

The methods used by the literature to analyze CE are evaluated to identify the most common indicators utilized in the agri-food sector to be environmentally sustainable. It is necessary to mention that twenty years ago, the CE phenom was a topic that was not in the focus of interest. As shown in Figure 1, the numbers of publications on CE in the agriculture field has significantly increased 12-fold since 2017. This result emphasizes the relatively novel nature of this field of research and the increasing attention it draws.

Figure 1. Number of publications per year (2007-2020)



Environmental Science is the subject which has contributed most to the development of this topic, accounting for 39% of the total publications, followed by Social Science (17%), Energy (12%), and Agricultural and Biological Sciences (9%) (Figure 2). This distribution of publications is a good indication that the research findings were also likely to be applied to the environmental field, as opposed to the scarce attention received by the agri-food sector, despite its close ties to the environment. What is more, in regard to the most active countries conducting agri-food circularity studies, Italy has the most research (9 articles). It is followed by China (4 articles), and Spain and the United Kingdom (both with 3 articles) (Figure 3).

Figure 2. Percentage of publications per subject (2007-2020)

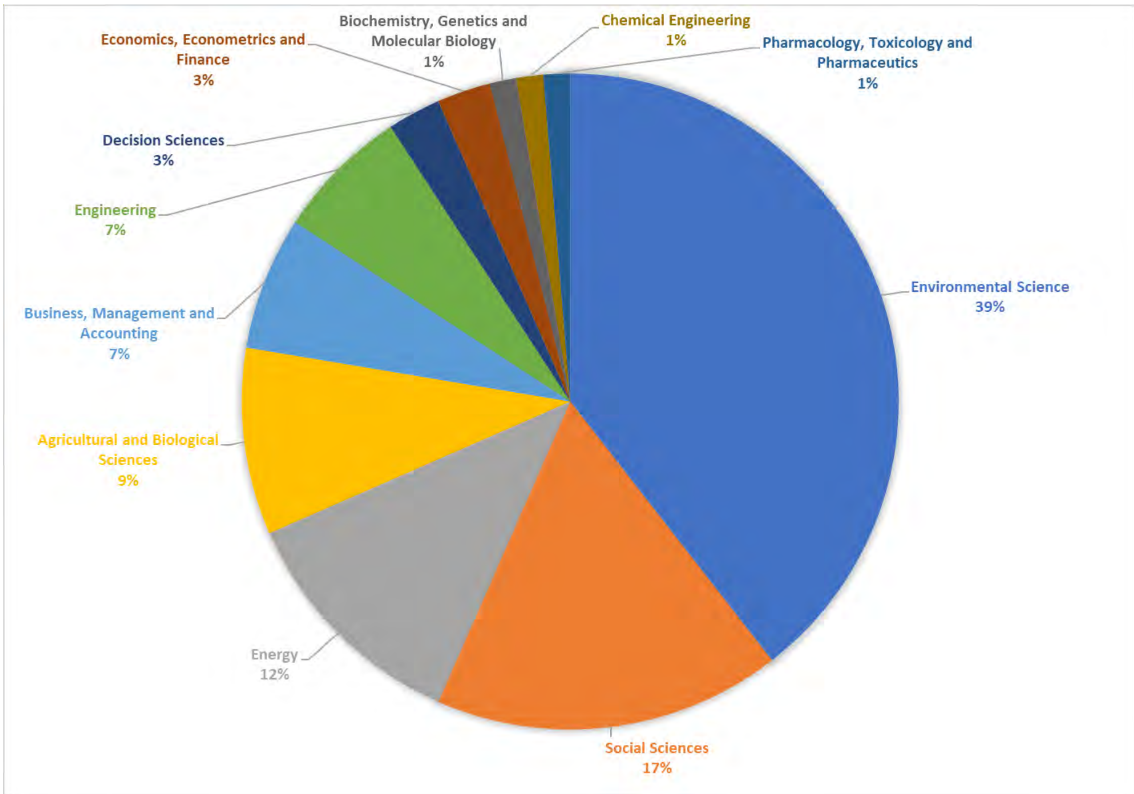
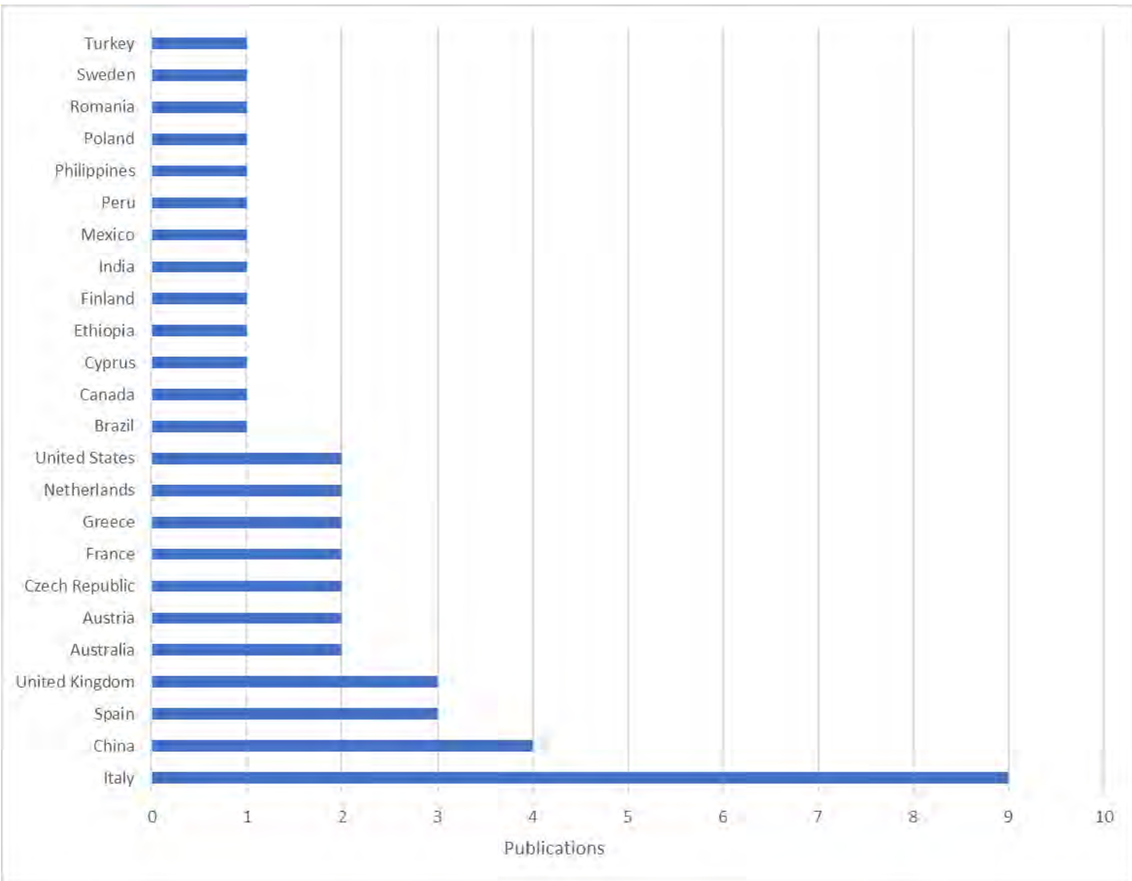


Figure 3. Number of publications per country (2007-2020)



Concerning the most common indicators of CE in the agri-food sector, Table 1 emphasizes key findings from the literature review, which are described below.

Table 1. Agri-food circular economy indicators.

CE indicator	CE sub-indicator	References
Green business awareness	Environmental corporate culture	Newton and Harte (1997) García-Granero et al. (2020)
	Corporate social responsibility	Istudor and Suciu (2020)
	Eco-social business model	Matrapazi and Zabaniotou (2020)
	Environmental objectives	Frosch and Gallopoulos (1992) Tibbs (1992) Williams et al. (1993) Kemp and Pearson (2007)
	Green human resources	BID (2007) Peng and Liu (2016)
	Green values	Parr (2009)
	Environmental audits	Hamner (2006) BID (2007) Montalvo (2003, 2008) Eltayeb (2009) Zailani et al. (2012) Boons and Lüdeke-Freund (2013)
	Environmental advisory services	Del Brio and Junquera (2003) BID (2007) Scarpellini et al. (2012) De Jesús Pacheco et al. (2016)
	Environmental quality certifications	Hamner (2006) Eltayeb (2009) Chiarvesio et al. (2015) Uscebrka et al. (2009) Hernández-Rubio et al. (2018)
Environmental-friendly inputs	Non-renewable inputs decrease	Pagotto and Halog (2015)
	Biofertilizers	Yilmanz Balaman et al. (2018)
	Organic fertilizers	Moretti et al. (2020)
	Optimizing raw materials	Marino and Pariso (2020)
	Biological control Traceability Ecological/integrated production	Sönmez and Mamay (2018) Codex Alimentarius Commission (2006)

Table 1. Continued.

CE indicator	CE sub-indicator	References
Reuse/Recycled packaging	Recycling packaging	Pauer et al. (2019) Seresova and Koci (2020)
	Reused packaging	Tua et al. (2019)
	Biodegradable packaging	Ivankovic et al. (2017)
Waste management	Waste level	Strazza et al. (2015) Kalmykova et al. (2016) Genovese et al. (2017) Yilmanz Balaman et al. (2018) Aravossis et al. (2019) Gravagnuolo et al. (2019) Kuranska et al. (2019) Loizia et al. (2019) Marino and Pariso (2020) Fernandez-Mena et al. (2020) Srivastava et al. (2020) Moretti et al. (2020) Santagata et al. (2020)
Water/energy management	Water use	Aravossis et al. (2019) Gravagnuolo et al. (2019) Ignacio et al. (2019)
	Energy use	Barros et al. (2020) Hussain et al. (2020) Sharma et al. (2020)

2.1. Green Business Awareness

The effect of environmental corporate culture on environmental firm performance is a subject that is increasingly attracting attention. Most studies have shown that organizational attitudes, governance and cultures may affect firm sustainability (Bleischwwitz et al., 2012; Bossle et al., 2016; Dangelico, 2016; Ortiz-de-Mandojana et al., 2016; Tsai and Liao, 2017; García-Granero et al., 2020). The approach of green awareness in an organization towards a given environmental issue makes that firm more likely to implement sustainable practices (Liao, 2018). For instance, companies may implement new manufacturing practices that prevent pollution, or they may adopt efficient environmental management systems (Eiadat et al., 2008; Wijethilake et al., 2016). Indeed, corporate environmental performance is regarded as a key driver of improving CE strategy (Porter and Kramer, 2006; Glavas and Mish, 2015; Wijethilake et al., 2016). For example, the number of environmental objectives included in production plans and operations or the inclusion of environmental plans in production processes are a good indicator of how environmentally-friendly a company is (Frosch and Gallopoulos, 1992; Tibbs, 1992; Williams et al., 1993; Kemp and Pearson, 2007). Furthermore, spreading green values within the organization could promote a firm's implementation of green business practices (Parr, 2009). In this sense, the role of managerial agency in a firm proves to be a key factor. Senior staff can encourage employees to be more innovative and respectful with the environment (Anderson, 1998; Andriopoulos, 2001; Halbesleben et al., 2003). Rajala et al. (2016) illustrate the role of the managerial agency in driving environmentally sustainable practices in a company and a green business model orientation. The importance of managers in environmental corporate culture has also been analyzed by other researchers (e.g. O'Connor and Ayers, 2005; Hojnik and Ruzzier, 2016a). Moreover, BID (2007) and Peng and Liu (2016) accentuate the importance of introducing the analysis of the green human resources of a firm as an indicator, as this represents its innovative efforts.

Additionally, Newton and Harte (1997) emphasized the significant impact that environmental corporate culture has on environmental practices, representing a key circularity indicator. Recently, various studies have contemplated green business awareness as a good indicator of circularity in the agri-food sector. For instance, Istudor and Suciu (2020) introduce the indicator corporate social responsibility to analyze the sustainability of the food retail sector in the EU. Similarly, Matrapazi and Zabaniotou (2020) introduce the indicator eco-social business model in the circularity analysis of the food waste sector.

In another line, authors such as Hamner (2006), BID (2007), Montalvo (2003, 2008), Eltayeb (2009), Zailani et al. (2012) and Boons and Lüdeke-Freund (2013) support the implementation of external environmental audits as a good indicator of the business intention of learning how to be more circular. The hiring of environmental advisory services is another variable analyzed by the literature in this CE phenom (Del Brio and Junquera, 2003; BID, 2007; Scarpellini et al., 2012; de Jesus Pacheco et al., 2016).

Currently, increased popular awareness of the environmental and health problems associated with the production and consumption of pollutants goods has resulted in a call for the use of environmental quality standards certifications which guarantee the safety of the products customers consume (Hamner, 2006; Eltayeb, 2009; Chiarvesio et al., 2015). Private standards certifications such as GlobalGap or Grasp are used in the European food sector for this aim. However, these certification processes are not only marketing tools to maintain consumer trust in the high quality of products; but they also take into account animal welfare and environmental protection (Uscebrka et al., 2009; Hernández-Rubio et al., 2018).

2.2. Environmentally-friendly Inputs

The inputs used to make a product determine its characteristics and at the same time its environmental impact. Thus, reducing the use of pollutant inputs or substituting them for cleaner materials contributes towards decreasing the level of waste and CO2 emissions. In this context, the materials used to make a product comprise one of the indicators that many studies highlight as one of the factors necessary for creating products that are more environmentally friendly.

Moretti et al. (2020) highlight on the substitution of mineral fertilizers for recycled organic ones to promote CE mitigation of N20 emissions. In the same line, Yilmanz Balaman et al. (2018) and Yilmaz et al. (2018) insist on the use of biofertilizers and biomass in the first phase of the agri-food production chain. Other authors such as Genovese et al. (2017) and Marino and Pariso (2020) emphasize the importance of optimizing the use of raw materials to obtain products.

Additionally, the decrease in the use of non-renewable inputs is also a key aspect of environmental efficiency in a product (Pagotto and Halog, 2015). In this panorama, ecological production is positioned as a new agricultural production method committed to efficiency in the use of fertilizers and organic amendments, water and energy (Cajamar, 2020). According to the Codex Alimentarius Commission (1999), ecological/integrated production promotes and improves the health of the agroecosystem in particular biodiversity, biological cycles and soil biological activity. It emphasizes the use of management practices, preferring these to the use of external inputs on the farm, considering that regional conditions will require locally adapted systems. This is achieved by employing, whenever possible, cultural, biological and mechanical methods, as opposed to the use of synthetic materials, to fulfill each specific function within the system. Thus, ecological/integrated production removes the use of pollutant inputs, such as synthetic fertilizers and pesticides, and also reduces the use of non-renewable energy (FAO, 2019).

Furthermore, biological control and traceability methods are two indicators of environmental sustainability due to their use as effective pest control tools (Sönmez and Mamay, 2018) and the fact that they encourage the improvement of food safety levels (Codex Alimentarius Commission, 2006). This is especially relevant in a context where the increase in food crises place population health in danger.

2.3. Reuse or Recycled Packaging

Some environmental policies have focused on packaging, for example the Directive 94/62/EC in the European Union (EU). The reason for this is the large amount of waste that disposable packaging generates and its negative environmental impact (González-Torre et al., 2004). Thus, the use of returnable packaging, which can be reused, contributes by increasing product efficiency while reducing waste and resource consumption. Some examples of relevant publications on the environmental benefits of using returnable packaging are Rogers and Tibben-Lembke (1998), Duhaime et al. (2001) and Twede and Clarke (2005). In this line, Stock (1992), Carter and Ellram (1998) and Silva et al. (2013) focus their studies on the reduction of waste and the improvement in resource efficiency resulting from the use of returnable packaging. What is more, Zailani et al. (2012) emphasize the need for design innovation in reusable packaging in order to enhance sustainability. Tua et al. (2019) underline the effectiveness of packaging reuse practices in terms of environmental impact. In the same line, other authors (Hart, 1995; Shrivastava, 1995; Christmann, 2000) highlight the importance of packaging design so it can be reused in order to improve firms' sustainable performance.

Various authors (Zailani et al., 2012; Wever and Vogtländer, 2014; Wilkström et al., 2016) debate the importance of including 'sustainable' packaging design to fulfill ecological requirements and to encourage customers to reduce food waste as well as recycle packaging. The key problem is determining which kind of packaging can be treated as sustainable. According to Wilkström et al. (2016), the following attributes have been taken into account to achieve sustainable packaging: easy to empty, easy to clean, easy to separate into different fractions, easy to fold, provides information about how to sort, contributes to extending time between packaging date and expiration date, and contains the desired quantity.

Furthermore, numerous studies uphold the implementation of recycled packaging as a key aspect in CE across the agri-food sector in recent years. For example, Serevosa and Koci (2020) introduce an indicator related to packaging recycling to examine the latter's environmental benefits. According to Pauer et al. (2019), the implementation of recycled food packaging can help to make production processes more circular What is more, biodegradable packaging is positioned as a key tool in several sectors to satisfy the environmental requirements of the market as it is made of non-pollutant materials (Ivankovic et al., 2017).

2.4. Waste Management

The level of waste in a process is considered one of the main causes of pollution and, consequently, one of the great sustainability challenges for food systems. Some authors emphasize the need to keep waste to a minimum to be sustainable (Shrivastava, 1995; Norberg-Bohm, 1999; Cheng and Shiu, 2012). In fact, the environmental impact of food waste covers all emissions derived from the different steps of the food supply chain. In this sense, FAO indicated that if food waste was a country, it would be the third biggest CO2 producer after China and the USA. Thus, food waste management is considered an extremely important socio-environmental issue.

Several researches have addressed this topic. Marino and Parisso (2020) have introduced various indicators related to waste in order to analyze the progress towards achieving CE objectives in 28 EU member states. Fernandez-Mena et al. (2020) consider the indicator "waste management" in a study carried out with the aim of developing a theoretical tool to explore opportunities for reaching CE in agro-business. In the same line, Srivastava et al. (2020) and Gravagnuolo et al. (2019) emphasize the need to introduce waste management practices as a strategic plan for a successful change towards sustainability business models.

Recently, the concern for levels of food waste has expanded the search for new practices that can contribute towards fighting this problem. The common expression of food loss and waste includes a share of total food production which was originally intended for human consumption, but not consumed (Gustavsson et al., 2011). In this sense, Ciccullo et al. (2021) highlight the role of technologies as a solution to tackle food waste. Moreover, authors such as Chaboud and Daviron (2017) and De Steur et al. (2016) defend the reduction of food loss and waste as an economic gain for all actors in the supply chain. Meanwhile, other studies such as Gustavsson et al. (2011), Timmermans et al. (2014) and Chaboud and Daviron (2017) also position the reduction of food waste as an environmental gain as it also generates a waste of land, water, energy and inputs. Thus, decreasing food waste contributes towards reducing the pressure on natural resources. Furthermore, several other investigations have contemplated waste management as an opportunity to create energy or power. Santagata et al. (2020) focus their study on Napoli's agro-industrial economy on the conversion of waste into biodiesel. In this line, Kuranska et al. (2019) defend the development of chemical components based on waste. Moreover, Kalmykova et al. (2016) defend waste regeneration as a key practice to reduce negative environmental impact.

2.5. Water or Energy Management

The total use of water or energy is a widely-used method in economic literature for analyzing the environmental impact of processes. The negative impact of climate change may also include more extreme weather, like more periods with excessive rainfall and others with low rainfall, resulting in droughts. In addition, in relatively dry climates, small changes in precipitation can cause significant changes in natural recharge of groundwater, and this situation can be even more severe in the food production sector due to fluctuations in production and shortages in food supply (FAO, 2010). The balance between food demand and available water for agriculture is a global issue, and water shortage has become the main constraint on food security worldwide (Hanjra and Qureshi, 2010). In addition, water security is the basis for food security. Water resource scarcity leads to variable grain production, which is considered the source of real food crisis. Thus, water management is the key to ensuring that more food can be produced for the growing population (Bertilsson, 2012). Agriculture is the sector responsible for most water use, consuming 70% of total water use in the world. Therefore, improving agricultural water productivity is an important measure for ensuring global food security, economic development and social stability, as well as diminishing adverse effects on human health (UNESCO, 2012). Consequently, agriculture is one of the sectors where the use of water has been most analyzed and many studies include the optimization of water usage to measure farmers' environmental impact (Azad and Ancev, 2014; Galdeano-Gómez et al., 2017; Piedra-Muñoz et al., 2017, 2018). Kang et al. (2016) provide a practical application on high-efficient agricultural water use in China, introducing a novel irrigation method and integrative methods in the Shiyang River Basin of Northwest China. Muga and Mihelcic (2008) investigate the sustainability of different wastewater treatment technologies; whereas Bouwer (2000) more storage of protected water, including long-term storage to collect water reserves during times of water surplus for use in times of water shortage. According to Gravagnuolo et al. (2019), water management strategies are essential when aspiring to more sustainable business models that help to preserve ecosystems. In this context, studies such as Aravossis et al. (2019) or Ignacio et al. (2019) include indicators associated with water management in the search of tools to obtain CE values.

Other works defend CE development including energy management models (Hussain et al. (2020). In this line, studies such as Barros et al. (2020) and Sharma et al. (2020) introduce waste-to-energy techniques which help to reduce energy in order to create a nexus towards circular business models. The use of renewable energy and environmentally-friendly technologies are also essential aspects to develop circularity models. Frondel et al. (2008) highlight the environmental benefits of introducing end-of-pipe technologies in manufacturing processes, whereas Guziana (2011) concludes that clean technologies are more proactively innovative than the former. In this line, Garrod and Chadwick (1996), in a survey of environmental strategies carried out by companies located in the South of England, determined that investment in clean technology is one tool that can be implemented to fulfill ecological requirements. Finally, additional articles exist which address the importance of introducing renewable energies in company processes in order to improve the quality of life for current and future generations and to meet public environmental objectives (Lacerda and Van den Bergh, 2014; Nesta et al., 2014; Nicolli and Vona, 2016).

3. The Case Study

The previous literature review provides an overall view of agri-food CE indicators and hence a practical framework to carry out an empirical analysis of how the Spanish agricultural sector has applied CE objectives so far.

3.1. Sample and Data Gathering

The Spanish sector of fresh fruits and vegetables, specifically located in the southeast region (provinces of Almeria, Granada and Murcia), has been chosen for the empirical analysis due to the importance of Spain as the leading exporter of fresh fruits and vegetables in the EU and one of top three world exporters, along with the USA and China. The exportation of these products in 2017 reached 13.8 million tons and nearly 15,000 million euros. In this context, the Spanish provinces of Almeria, Granada and Murcia contribute to these figures by more than fifty percent (Spanish Agriculture Ministry, 2019).

This sector constitutes a key economic activity, representing 24% of GDP (Gross Domestic Product) and 27% of employment (Galdeano-Gómez et al., 2013). Greenhouses are the principal feature of production in this area (Rodríguez-Rodríguez et al., 2012) and they require intensive use of resources and generate considerable amounts of waste and residues (e.g., packaging materials, fertilizers, plastics, etc.). On the other hand, the agri-food sector also contributes to the development of services (e.g., financing, consulting, R&D, etc.) and an associated auxiliary industry with a strong environmental orientation (e.g., fertilizers, bees, seeds, etc.), which accounts for approximately 32% of GDP in the area (Aznar-Sánchez et al., 2011; Galdeano-Gómez et al., 2017).

The empirical analysis uses data from agri-food firms in the period 2017-2018 and is based on a survey to provide a CE evaluation at firm level. The data were collected using a questionnaire targeted at the environmental management of the companies. The survey was designed specifically for this purpose based on field studies and the relevant literature on EI (EASAC, 2016; Moraga et al., 2019). Next, the survey instrument was pre-tested on five firms' environmental quality managers, and the questions were selected and modified according to their comments and suggestions. Following these steps, the final questionnaire was structured in two main sections: (1) company economic and financial information, and (2) a series of items on CE indicators.

According to the Iberian Balance Sheet Analysis System (*Sistema de Análisis de Balances Ibéricos* in Spanish, SABI), 302 firms commercialized fresh fruit and vegetables in the provinces of Almería, Murcia and Granada during that period. The sample was simple randomly selected without replacement. The final number of valid surveys was 93. This represents a satisfactory response rate of 30.8% (Menon et al., 1996).

Table 2. Profile of the final sample.

Variable	Description	Frequency
Legal form	Limited liability companies (SL in Spanish)	50
	Anonymous society (SA in Spanish)	6
	Agrarian society of transformation (SAT in Spanish)	12
	Cooperatives	11
Age (years)	<15	31
	15-30	34
	30-45	9
	≥45	5
Number of employees	<50	25
	50-250	31
	≥250	23
Operating income (mill. €)	<10	28
	10-43	32
	≥43	19
Commercialization volume (mill. kg)	<10	27
	10-50	36
	50-100	8
	≥100	8
Percentage of commercialization volume allocated to European market (%)	<50	6
	≥50	73
Percentage of commercialization volume in fruits (%)	<50	65
	≥50	14
Percentage of commercialization volume in vegetables (%)	<50	14
	≥50	65

The final sample companies are all internationalized and commercialize fresh fruit and vegetables production to the EU. According to European legislation (European Commission, 2009), the sample includes 9 micro companies (fewer than 10 employees), 19 small companies (10-49 employees), 37 medium-size companies (50-249 employees), and 28 large companies (250 or more employees). More details about the sample are shown in Table 2.

3.2. Methodology

Several statistical techniques were used in order to achieve the homogeneity and heterogeneity in CE indicators among agri-food companies (Hair et al., 1999).

Firstly, the non-hierarchical cluster analysis (Ward's method) was used to find the number of groups that maximizes heterogeneity among them (Kobrich et al., 2003). The results, presented in a dendrogram, help to decide that two is the optimal number of clusters in the sample: Group 1 (the lowest circularity firms) and Group 2 (the highest circularity firms).

Once the optimal number of groups was obtained, k-means cluster was applied, choosing the Euclidean distance as the distance measure (Hair et al., 2006). It allocates every data point to the nearest cluster whereas keeping the centroids, previously calculated for each group, as small as possible. Next, a one-way ANOVA was carried out with the aim of testing the statistical differences between the clusters (Kuswardhani et al., 2014; Nunes et al., 2014).

Finally, Pearson's *r* coefficients were estimated to measure linear correlation between the CE sub-indicators and some characteristics of the companies (Wilcox, 2005).

3.3. Definition of Variables

The literature analysis provides a framework of CE indicators in the agri-food sector. Based on this foundation and according to the specific characteristics of the context of study, the most relevant sub-indicators were chosen to be applied to the empirical analysis.

There is a common criterion throughout the literature for evaluating the environmental corporate culture. This circularity sub-indicator refers to green organizational capabilities, ecological organizational commitments and environmentally-friendly organizational philosophies. Adapted from previous studies (Williams et al., 1993; Montalvo, 2003, 2008; Scarpellini et al., 2012; de Jesus Pacheco et al., 2016), it includes five 5-point Likert scale items related to the introduction of environmental objectives and plans, environmental implementation practices and compliance with environmental initiatives. In the case of the other green business awareness sub-indicators, a great deal of the literature introduces variables such as implementation of external environmental advisory and audits, and environmental quality staff (Frosch, 1994; Boons and Ludeke- Freund, 2013; de Jesus Pacheco et al., 2016; Peng and Liu; 2016). In addition, based on Uscebrka et al. (2009), Chiarvesio et al. (2015) and Hernadez- Rubio et al. (2018), other green business awareness sub-indicators are included in the analysis related to environmental quality standards certifications (which includes most common certifications, such as GLOBALG.A.P., GRASP, ISO 14001 and ISO 9001).

In accordance with FAO (2012), the percentage of ecological production was added as a sub-indicator of environmentally-friendly inputs. Ecological production removes the use of pollutant inputs such as synthetic fertilizers and pesticides as well as decreases the use of non-renewable energy. Also, biological control and traceability were added as environmentally-friendly input sub-indicators based on Sönmez and Mamay (2018).

Related to the reuse and recycled packaging circularity indicator, the percentage of reuse and recycled packaging sub-indicator was contemplated following the recommendations of Pauer et al. (2019) and Serevosa and Koci (2020). This CE indicator also encompasses the biodegradable packaging sub-indicator in accordance with Ivankovic et al. (2017).

The CE water management sub-indicator was calculated following the approach proposed by Tang et al. (2013) and Piedra-Muñoz et al. (2018). The efficiency of water usage was measured by the sum up of three items: (i) Environmental certifications, and, if present, to what extent were they related to efficient water use; (ii) water use efficiency plan; (iii) improvement, innovation or new technology for reducing water use.

Finally, the guidelines proposed by Callejón et al. (2010) were followed to calculate the circular sub-indicator waste management. According to the authors, the amount of plant waste, phytosanitary packaging waste, and plastic waste are the three largest groups of residues in agriculture.

4. Trends and Perspectives Towards Circular Economy. Evidences from Spanish Horticultural Sector.

Table 3 presents a brief description of the CE sub-indicators measured in the study in order to provide a profile of the sustainability level in the Spanish agri-food sector.

Table 3. Summary statistics for the circular economy sub-indicators.

Indicator	Sub-indicator description	Measurement scale	Minimum	Maximum	Mean	Stan. Desv.
Green business awareness	Environmental corporate culture	Likert scale (0-5)	0	5	3.75	0.86
	Green human resources	Natural numbers	0	60	5.46	8.58
	Environmental audits	Dichotomous scale	0	1	0.44	0.50
	Environmental advisory services	Dichotomous scale	0	1	0.46	0.50
	Environmental quality certifications	Natural numbers	0	11	4.44	2.57
	GLOBALG.A.P.	Dichotomous scale	0	1	0.86	0.35
	GRASP	Dichotomous scale	0	1	0.74	0.44
	ISO14001	Dichotomous scale	0	1	0.12	0.33
	ISO9001	Dichotomous scale	0	1	0.15	0.36
Environmentally - friendly inputs	Biological control	Dichotomous scale	0	1	0.80	0.4
	Traceability	Dichotomous scale	0	1	1	0.11
	Ecological production	Percentage	0	1	0.21	0.33

Table 3. Continued.

Indicator	Sub-indicator description	Measurement scale	Minimum	Maximum	Mean	Stan. Desv.
Reuse/Recycled packaging	Recycled packaging	Percentage	0	1	0.44	0.38
	Reused packaging	Percentage	0	1	0.53	0.44
	Biodegradable packaging	Dichotomous scale	0	1	0.27	0.44
Waste management	Vegetable waste	Cubic meters in thousands	1,071.06	4,083.10	3,078.18	212.96
	Phytosanitary packaging	Tons	812.25	3,514.54	2,513.77	1,670.6
	Plastic waste	Tons	10,506.25	18,491.16	15,244.32	9,226.83
Water management	Water use efficiency	Likert scale (0-5)	0	5	1. 672	0.979

The results show that ecological production is the sub-indicator associated with the environmentally-friendly input indicator with the lowest implementation despite being a key factor in the development of greener production methods. This sub-indicator does not reach 25% of the total agricultural production. Nevertheless, the green human resources in charge of verifying that the production methods comply with the environmental requirements display a good mean value in relation to the companies' average size in the sector. This value reaches 60 in the largest companies, highlighting the importance that the sector places on meeting environmental standards.

Other evidence from the sector representing the efforts made to achieve a balance between economic and environmental efficiency is the implementation of environmental quality certifications. As previously shown in Table 2, the companies in the sector have an average of over four environmental certifications, reaching even eleven in some companies. What is more, those environmental certifications directly related to food safety, such as GLOBALG.A.P or GRASP, are implemented in over 70% of companies. However, those environmental certifications related to quality management systems, such as ISO9001 or ISO14001, are implemented in less than 20% of companies. These data underline the high priority that companies give to quality guarantees for consumers.

The empirical evidence from the sector also makes it possible to identify a notable weakness in some green business awareness indicators. Despite manifesting high environmental business awareness, practices such as environmental audits or environmental advisory services are utilized in less than 50% of companies. This point reflects that there is great potential for improvement. Receiving advice from environmental experts is essential to increment environmental gains while avoiding economic costs.

The results also reveal another weakness related to the use of recycled or reused packaging sub-indicators. The use of reused packaging barely represents 53%, while the use of recycled packaging only represents 44%. Moreover, the use of biodegradable packaging only accounts for 27%. This percentage reflects the great need to extend this practice among companies in the sector. As Pauer et al. (2019) mention, more environmentally-oriented food packaging leads to the benefits of becoming more circular. Thus, expanding the use of greener packaging becomes an essential tool towards achieving more sustainable economies.

In addition, an exploratory factor analysis was conducted because the data collected are reported using a single informant from each company and from the same questionnaire (Cheng et al., 2014). The results reveal that the first factor captures only 24% of the variance, which demonstrates a low threat of common method bias. Next, a non-hierarchical cluster analysis (Ward's method) was applied, prior to the k-means cluster analysis, in order to find the number of groups that maximizes the differences between them, as mentioned in Section 3. Thus, two different groups were identified analyzing the results obtained in the dendrogram (Figure A1, appendix A). In order to confirm the number of clusters selected, the Calinski test was performed. The two-group solution with a Calinski–Harabasz pseudo-F value of 88.22 was the largest, indicating that the two-group solution was the most distinct compared with the three-group (71.83), four-group (54.50) and five-group (47.01) solutions. Thus, two different groups were identified: Group 1, consisting of firms with a lower level of circularity implementation; and Group 2, comprised of firms with a higher level of circularity implementation. The results are shown in Table 4, which displays the values of the main variables.

Table 4. Characteristics of identified clusters and test statistics of one-way ANOVA.

		Eco-innovative firms' clusters					
		Group 1 *N=29*		**Group 2** *N= 48*			
		Low		**High**			
Indicator	**Sub-indicator**	**Mean**	**Std. Dev.**	**Mean**	**Std. Dev.**	***F***	***p*-value**
Green business awareness							
	Environmental corporate culture	3.63	0.87	3.90	0.76	12.70	.000
	Green human resources	1.31	0.76	6.69	6.75	18.14	.000
	Environmental audit	0.19	0.42	0.65	0.49	17.33	.000
	Environmental advisory	0.22	0.44	0.65	0.49	14.70	.000
	Environmental quality certification	3	2.29	5.15	2.30	15.68	.000
	GLOBALG.A.P.	0.38	0.34	0.94	0.25	7.172	.009
	GRASP	0.59	0.41	0.83	0.37	6.044	.016
	ISO 14001	0.03	0.18	0.17	0.32	3.104	.082
	ISO 9001	0.03	0.18	0.19	0.30	3.385	.054
Environmentally-friendly input							
	Biological control	0.58	0.40	0.96	0.15	22.29	.000
	Traceability	0.97	0.11	1	0.00	1.670	.200
	Ecological production	0.12	0.24	0.31	0.31	9.57	0.003
Reused/Recycled packaging							
	Recycled packaging	0.30	0.37	0.53	0.38	6.788	.011
	Reused packaging	0.45	0.44	0.59	0.43	1.707	.195
	Biodegradable	0.24	0.43	0.27	0.44	0.080	.195
Waste management							
	Vegetable waste	3,075.04	203.1	3,079.83	211.4	123.2	.000
	Phytosanitary packaging	2,513.15	443.0	2,514.03	401.2	79.47	.000
	Plastic waste	14,192.4	174.2	18,126.6	148.8	80.12	.000
Water management							
	Water use efficiency	1.51	0.05	1.69	0.06	62.09	.000

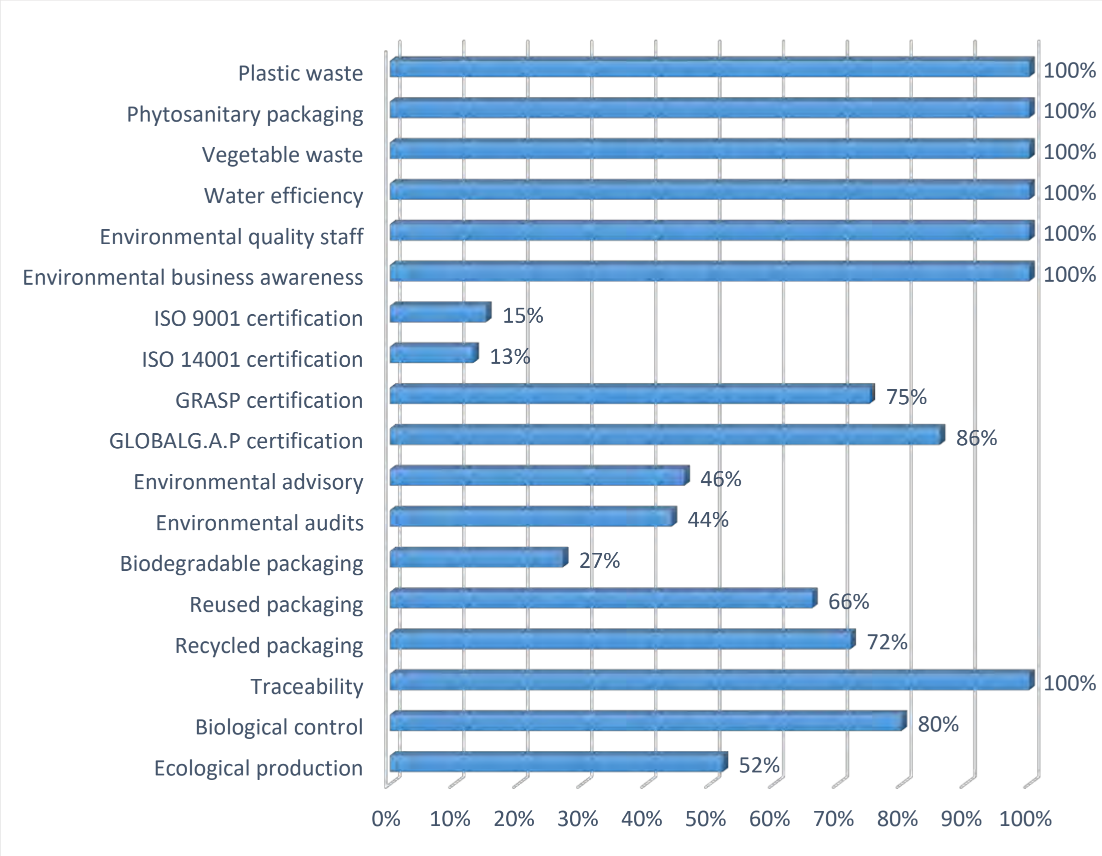
Table 4 also shows the analysis of the variance of the cluster analysis (one-way ANOVA analysis). All the green business awareness sub-indicators, except "GRASP" and "ISO", differ statistically between groups with a level of likelihood of 5% (p-value <

0.05). The results also reveal that the environmentally-friendly input sub-indicators, such as “biological control” and “ecological production”, contribute to the differentiation between groups; as well as “water management” and “waste management” sub-indicators.

In order to understand those company characteristics that make firms more circular, a Pearson correlation analysis was used (Table D1, appendix D). It was applied to examine the relationship between the CE sub-indicators and the following profile variables: legal form, operating income, solvency rate, number of employees, and commercialization volume. With an error of less than 5%, the analysis reveals that number of employees and commercialization volume are factors with significant correlation with several sub-indicators, such as green human resources, environmental quality certifications, waste management and water management. In addition, there is an important interrelationship between legal form and the sub-indicator green human resources, while operating income also has a high correlation with environmental quality certifications and water and waste management. What is more, the analysis also reveals the strong relationship between the green human resources of a company and the implementation of environmental quality certifications, recycled packaging, water management and waste management.

Furthermore, Figure 4 indicates the percentage of companies that implement each CE indicator. As shown, the majority of the sub-indicators are implemented by more than 50% of the sector.

Figure 4. Percentage of companies that implement CE sub-indicators.



The greatest strengths are environmental quality certifications, such as GLOBALG.A.P and GRASP, traceability, biological control and the use of recycled packaging. In contrast, the use of biodegradable packaging, expert environmental advisory and environmental certification related to quality management systems display scarce implementation, constituting starting points for improving CE performance.

5. Conclusions

The agri-food sector is one of the most important industries in Spain in terms of economic revenues. Indeed, this industry supplies the indispensable food commodities throughout Europe. Thus, the development of a sustainable and efficient production process is essential for maintaining competitiveness, reducing negative environmental externalities, decreasing the use of natural resources and preserving ecosystems. In this context, the development of green business awareness, the use of eco-friendly inputs, the introduction of recycled packaging and the implementation of waste, water and energy management techniques mark the path towards achieving this goal.

This study presents novel empirical research in the CE field, developing a multidimensional framework on CE indicators which is applied to Southeast Spain's horticultural sector. The analysis presents a better understanding of the complex relationship between circular indicators, CE objectives and sustainability.

The investigation led to the conclusion that those CE indicators closely related to market demand, such as environmental quality certifications, traceability or biological control, are widely implemented among the companies of the sector. The reason lies in the fact that the adoption of these practices represents an opportunity to fulfill environmental standards requirements and satisfy customers' needs. Areas related to ecological production or biodegradable packaging display great potential for improvement. The implementation of these practices is closely linked to the environmental and human well-being. On the one hand, the use of biodegradable packaging contributes to the reduction of enormous amounts of waste, which goes in hand in hand with the level of CO2 emissions. On the other hand, the increase in ecological production to detriment of the conventional production involves a reduction in the use of pollutant inputs such as standard fertilizers or pesticides, which will result in higher quality and safer food.

Moreover, although the use of agricultural energy is of particular interest in the context of CE, a lack of data for these indicators has been detected. In this sense, more efforts should be made with the aim of developing an energy management method that can help to analyze the introduction of renewable energies as well as the reduction of conventional energy consumption in order to create a stronger nexus towards more circular business models.

The research also draws attention to the circular capacity for improvement that the sector represents in relation to the implementation of environmental audits or environmental advisory. Less than 50% of agri-food companies do not use these services; however, their implementation involves the analysis of the circular capacity of each company by an expert, which would generate opportunities to improve economic-environmental impact at a lowest cost. For that purpose, it is necessary that regulators actively encourage companies to carry out these circular practices, offering tax benefits for those that implement them or offering services without cost. The main limitation for adopting circular practices is the large investment required. For this reason, smaller companies with the lowest operating income represent a burden to the development of CE.

Practical contributions for companies and regulators emerge from these results. On the one hand, in the case of companies, acquiring more environmentally-friendly awareness about the development of ecological production and greener packaging is essential for promoting more sustainable work habits that enhance CE. On the other hand, as for governments and regulators, this study provides a conceptual framework that explains which CE indicators should be taken into account when developing policies that seek to promote sustainability. It has been proven that legally required practices and those required by the stakeholders are the most widely implemented. Thus, new policies on biodegradable packaging, energy management, environmental advisory and environmental audits are the key to turning sector weaknesses into strengths. This is the path to promote CE objectives.

The present study has several limitations, which could encourage future works. For example, the analysis is focused on the Spanish agri-food sector and the data are collected in one period, offering static results. Although the study's findings can be extended to other well-developed economies, it would be interesting for future research to replicate it in other countries and sectors with the aim of being able to compare different economies and business groups. Finally, exploring the CE indicators over an extensive period of time with the aim of analyzing the evolution of sustainable practices over time is a worthwhile direction for future research.

CHAPTER 7

GENERAL CONCLUSIONS

GENERAL CONCLUSIONS

This study aims to contribute to the development of a solid theoretical ground in the EI field, analyzing this phenom from a multidimensional perspectice. The methodology applied was a combination of literature review, bibliometric analysis, cluster analysis, chi-squared test, and Partial Least Squares based-structural equation modeling method (PLS-SEM). To apply PLS-SEM, a novel EI second-dimension structural model was developed to obtain an efficient measurement.

The results of the investigations can be summed up in the following two main points.

1. Eco-innovation as a Key Tool Towards Sustainability

With regard to the first objective of this investigation, the present study revises the EI academic literature in order to identify the main research trends and characteristics. Some conclusions can be summed up regarding the Chapter 2. It might be highlighted that the EI task has been experimented a substantial growth since 2007, due to the particular interest that economic, business and environmental subjects have in the development of environmentally-friendly economic models. In this context, European institutions and countries have been those that contribute most to this development.

Nevertheless, despite the evolution experimented, evidence suggests that the vast majority of the studies include indicators that are chosen in rudimentary ways. Besides, another weakness emerges from the literature review related to the fact that very few researches contemplate the EI analysis from a multidimensional perspective, including product, process, organizational and marketing dimensions. The wide range of studies only include product, process or organizational green dimension, obviating the impact that some international organizations are claiming for marketing eco-indicators. Consequently, only a part can be seen instead of the whole elephant (Kemp, 2009, p.103).

Concerning to the second and third point of this investigation, thirty green indicators have been identified in the literature, which must be accomplished to obtain an accurate

EI analysis and build a theoretical framework to evaluate it. Related to product dimensions, six indicators have been detected focused on greener inputs and sustainable products. Associated to process dimension, ten indicators have been distinguished corresponding to reneweble energies, recycling, and optimizing the use of resources. Concerned to organizational dimension, nine indicators have been recognized related to green networks with stakeholders, and R&D investments. Finally, regarding to marketing dimension, three indicators have been empathised linked to green packaging and quality certifications.

Furthermore, the literature analysis demonstrates that, despite most of the EI research is centred on high-tech sectors, an especial interest is enormously raising about EI in the agri-food sector since 2012. As Chapter 3 emphasizes, a term of interest change is experimented toward sustainability development, eco-innovation, environmental impact, agriculture, food production, and alternative agriculture. Countries such as Italy, United Kigdom, Spain or Netehrlands lead the search for greener food production methods, because of being countries where the agri-food sector contributes to the economy of the region in large proportion and, at the same time, it is closely linked to environmental externalities.

This analysis is essential for several reasons. It provides a guide to which practices must be implemented to obtain greener business models and fulfill the environmental requeriments. Also, it helps to obtain an efficient EI measurement from a multidimensional approach. In addition, it claims the increasingly importance that scholars are giving to EI activities in the agriculture sector.

2. Environmental Economics in Spanish Agri-food Sector

EI is a key element in the achievement of more efficient economies minimizing negative externatilies as well as preserving ecosystems. Thus, regarding the fourth and fifth objectives of this study, the foundation originated from the literature analysis has been applied to a low-tech sector with high-environmental implication: agri-food context. Two levels well-diferenciated of eco-innovative firms emerge from the multidimensional analysis of EI in Spanish agri-food sector carried out in Chapter 4. The analysis reveals that the most eco-innovative firms are those with major economic capacity, being neccesary to implement stimulus policies enhancing small and medium size companies (SMEs) to implement new greener production practices. Moreover, the significant differences between both groups are related to the implementation of organizational and marketing eco-practices. The most eco-innovative companies pay more attention to environmental quality certifications, environmental audits and environmental advisory. What is more, they focus their efforts in implementing those green practices which are required for markets and regulators, such as environmetal quality certifications or biological controls. However, other indicators like waste levels, energy or water consumption, and R&D investments are ignored, being neccesary the regulation of these key environmental practices.

The cluster analysis highlights some weaknesses in the implementation of recycled and biodegradable packaging as well as the materials recycling, becoming these practices a key posibility of improvement toward achieving the circular economy objectives.

Furthermore, the multidimensional analysis carried out in Chapter 5 puts into question the effectiveness of the precedents EI studies, which only contemplated product and process EI dimension. The PLS-SEM analysis emphasizes the enormous significance that organizational and marketing eco-practices have in the agri-food sector´s EI performance. Thus, it is necessary not underestimating any green dimension and including the multidimensional perspective of EI in any investigation. Additionally, this chapter reaches the sixth objective of this research proving the possitive effects that environmental awareness and commercial orientation have in the company decision to be greener. In fact, those companies with greater environmental awareness among their staff are more likely to implement EI practices. In the same line, the customer and competitor oriented firms are more open to look for new environmentally-friendly business models in a context characterized by an increased sensibility to human and environmental health.

Related to the seventh ambition, Chapter 6 has developed new circularity metrics that contribute to the transtition from traditional linear systems to circular production sytems. The findings manifest that environmental quality certifications, traceability or biological control green practices are widely implemented owing to fulfill environmental standards requirements and satisfy customers' needs. The results also evidence the big potential of improvement that circular practices such as ecological production, biodegradable packaging and energy management present. These practices represent a key opportunity to create a stronger nexus towards more circular business models, reducing the CO2 emission levels and contributing to the development of safer products.

3. Limitations and Future Studies

This study has identified two main limitations. On the one hand, the EI framework developed is applied to Spanish agri-food sector. Thus, it will be interesting analyzing the agri-food EI phenom in other countries in order to obtain comparisons and conclusions that can be applied in different contexts. On the other hand, the purpose of this investigation is analysing the EI multidimensionality aspects in the agri-food sector. In this sense, applying this methodology to other sectors will allow to generalise conclusions. Consequently, it will enable to obtain the significance of each EI dimension in other areas and go beyond boundaries in the path towards building a solid theoretical ground in the field. Aditionally, it would be interesting to repply this investigation in the future in order to contemplate the economical sustainability evolution in Spanish agri-food sector and analyze the effectiveness of the policies implemented.

4. Final Considerations

The main purpose of this investigation is clarifying the complex EI phenom, creating a frame of reference to evaluate it in a multidimensional way. This is a key element in the path towards the building of a solid theoretical and empirical foundation that helps researches and regulators to understand this process and elaborate economic, social and environmental policies.

The transition towards greener economies requires polices that promote the change towards environmental business model while enhance the implementation of eco-friendly production practices, especially in those companies which their less economic and financial capacity causes an excessive cost of implementation. In this regard, understanding which eco-innovative practices can represent an opportunity of being greener as well as contribute to major circular levels, affords governments the possibility to draft policies that encourage companies to be more sustainable and firms to implement ecological practices in a more efficient way.

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APPENDICES

APPENDIX A

CLUSTER AND PAIRWISE CORRELATION COEFFICIENTS ANALYSIS

Figure A1. Cluster dendrogram.

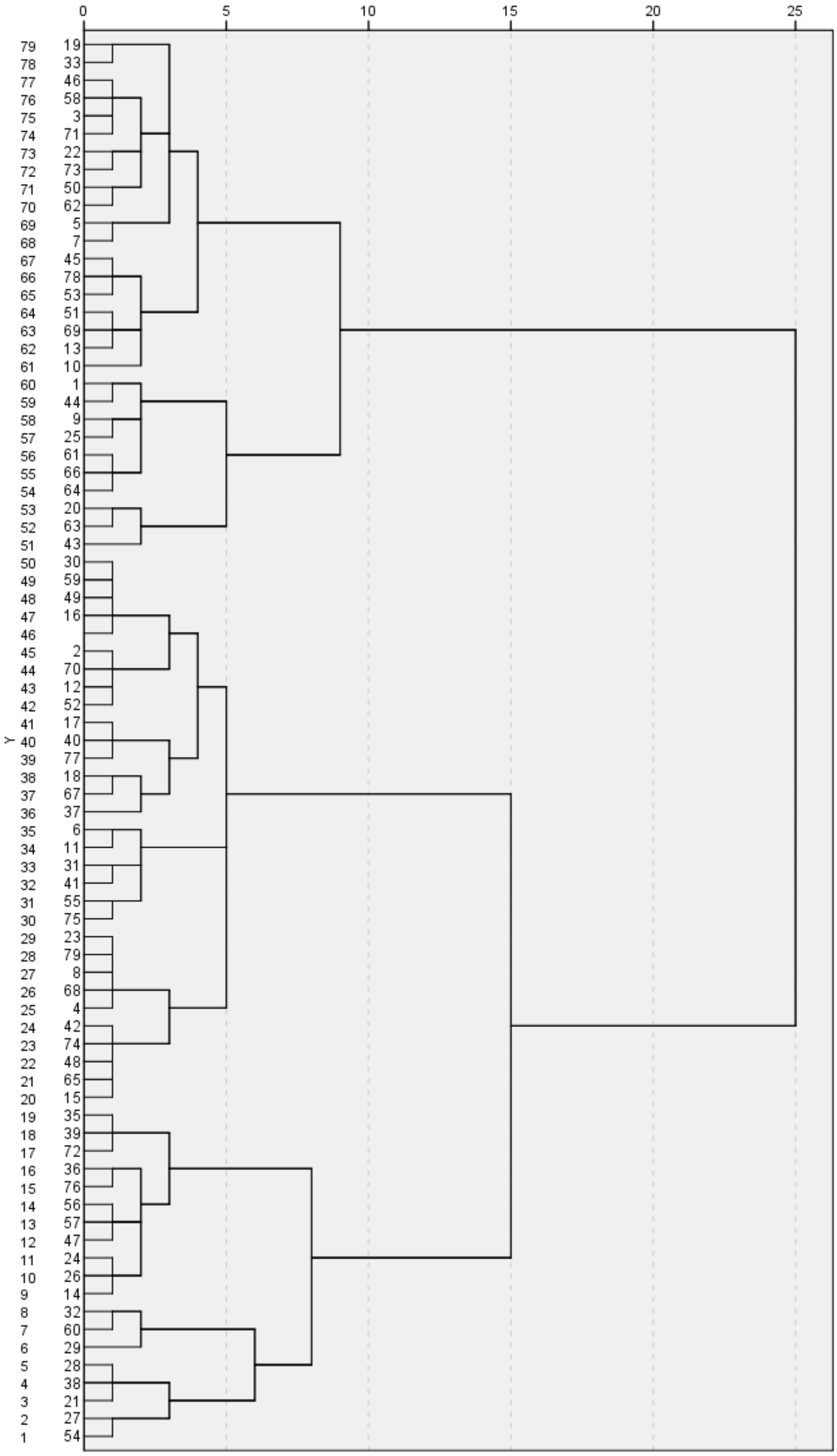

Table A1. Pairwise correlation coefficients of variables.

	Ct	***Ep***	***Bc***	***Qs***	***Aud***	***Ax***	***Cp***	***Certf***	***Ggp***	***Gsp***	***Rpkg***	***Bpkg***	***Rm***	***Lb***
Ct	1	0.149	0.084	0.068	0.012	0.034	–077	–243	–333	–255	–203	–052	–178	0.400
Ep	0.149	1	0.187	0.155	0.257	0.295	0.311	0.273	0.351	0.337	0.156	0.172	0.103	0.223
Bc	0.084	0.187	1	0.253	0.408	0.113	0.038	0.256	0.140	0.226	0.150	0.095	0.020	0.105
Qs	0.068	0.155	0.253	1	0.259	0.208	0.044	0.383	0.381	0.334	0.188	0.161	0.228	0.126
Aud	0.012	0.257	0.408	0.259	1	0.465	0.278	0.474	0.291	0.231	0.163	0.156	0.024	0.120
Ax	0.034	0.295	0.113	0.208	0.465	1	0.256	0.339	0.206	0.152	0.112	0.082	0.009	0.250
Cp	–077	0.311	0.038	0.044	0.278	0.256	1	0.436	0.271	0.275	0.107	0.013	0.147	0.357
Certf	–243	0.273	0.256	0.383	0.474	0.339	0.436	1	0.491	0.473	0.399	0.165	0.191	0.134
Ggp	–333	0.351	0.140	0.381	0.291	0.206	0.271	0.491	1	0.535	0.343	0.018	0.298	0.038
Gsp	–255	0.337	0.226	0.334	0.231	0.152	0.275	0.473	0.535	1	0.334	0.141	0.250	0.031
Rpkg	–203	0.156	0.150	0.188	0.163	0.112	0.107	0.399	0.343	0.334	1	0.178	0.408	–081
Bpkg	–052	0.172	0.095	0.161	0.156	0.082	0.013	0.165	0.018	0.141	0.178	1	0.175	–095
Rm	–178	0.103	0.020	0.228	0.024	0.009	0.147	0.191	0.298	0.250	0.408	0.175	1	–022
Lb	0.400	0.223	0.105	0.126	0.120	0.250	0.357	0.134	0.038	0.031	–081	–095	–022	1

APPENDIX B

MULTICOLLINEARITY ANALYSIS

Table B1. Multicollinearity analysis.

Measurement ítems	**VIF Values**
Commercial orientation	
Customer orientation	1.242
Achieve competitive advantage	1.741
Improve corporative image	1.619
Growth in market	1.482
Product EI	
Ecological/integrated production	1.207
Biodegradable packaging	1.041
Recycling packaging	1.163
Process EI	
Packaging control system implemented	1.016
Green technology investment	1.010
Green patent number	1.011
Recycling materials	1.014
Organizational EI	
Environmental advisory implemented	1.540
Environmental audit implemented	1.588
Cooperation with stakeholders	1.321
Environmental quality staff	1.306
Marketing EI	
Environmental quality standard certifications	1.416
Environmental management system certifications	1.131
GlobalGap certification	1.406
GRASP certification	1.142

APPENDIX C

COMPOSITE RELIABILITY ANALYSIS

Table C1. Step 1 build-up approach method.

Measurement ítems	**Factor loading**	**p-value**
Environmental corporate culture (CR = .911)		
Degree of importance of implementing environmental plans and objectives	0.924	0.000
Degree of importance of achieving environmental objectives	0.909	0.000
Degree of importance of the company' staff being environmentally respectful	0.825	0.000
Degree of importance of the company' environmental initiatives investment	0.770	0.000
Degree of importance of the company' environmental impact	0.648	0.000

Table C2. Step 2 build-up approach method.

Measurement items	**Factor loading**	**p-value**
Environmental corporate culture (CR = .910)		
Degree of importance of implementing environmental plans and objectives	0.924	0.000
Degree of importance of achieving environmental objectives	0.909	0.000
Degree of importance of the company' staff being environmentally respectful	0.825	0.000
Degree of importance of the company' environmental initiatives investment	0.770	0.000
Degree of importance of the company' environmental impact	0.648	0.000
EI level (CR = .736)		
Product EI	0.512	0.002
Process EI	0.548	0.001
Organizational EI	0.748	0.000
Marketing EI	0.742	0.000

APPENDIX D

CLUSTER AND PEARSON CORRELATION ANALYSIS

Figure D1. Cluster dendogram.

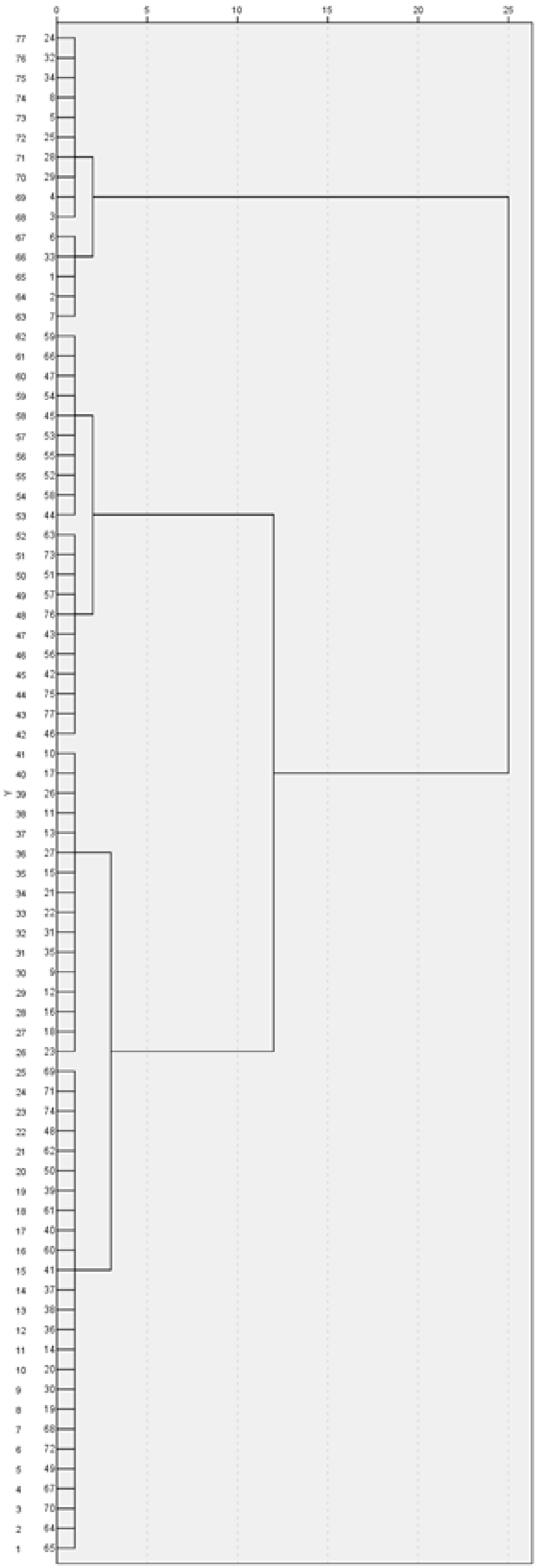

Table D1. Pearson correlation coefficient of variables.

Variable	Legal form	Operating income	Solvency rate	Employees number	Commercialization volume	Emvironmental corporate culture	Ecological production	Biological control
Legal form	1	-0.014	-0.063	0.156	-0.071	-0.042	-0.147	0.072
Operating income		1	-0.114	.741**	.956**	0.121	0.123	0.208
Solvency rate			1	-0.119	-0.091	-0.074	0.070	0.197
Employees number				1	.671**	0.196	0.167	.249*
Commercialization volume					1	0.149	0.096	0.175
Emvironmental corporate culture						1	0.164	0.140
Ecological production							1	.246*
Biological control								1

* p-value < 0.05; ** p-value < 0.01

Table D1. Continued.

Variable	Traceability	Green human resources	Environmental quality certifications	GLOBAL G.A.P.	GRASP	ISO 14001	ISO 9001
Legal form	-0.093	.292**	0.038	-0.048	0.016	-0.074	-0.040
Operating income	0.061	.515**	.450**	.230*	.305**	.387**	0.149
Solvency rate	0.122	-0.091	-0.112	-.264*	-.315**	-0.001	0.211
Employees number	0.070	.689**	.490**	.264*	.349**	.260*	0.018
Commercialization volume	0.028	.398**	.362**	0.197	.264*	.353**	0.100
Emvironmental corporate culture	.390**	.264*	0.224	0.166	0.156	0.145	0.071
Ecological production	0.073	0.038	.236*	0.054	0.212	0.056	0.051
Biological control	0.224	.264*	.376**	.431**	.354**	-0.013	0.103
Traceability	1	0.091	0.199	.281*	0.194	0.042	0.044
Green human resources		1	.468**	.247*	.317**	0.199	0.120
Environmental quality certificatons			1	.604**	.696**	.371**	.411**
GLOBAL G.A.P.				1	.689**	0.149	0.158
GRASP					1	0.215	0.141
ISO 14001						1	.461**
ISO 9001							1

* p-value < 0.05; ** p-value < 0.01

Table D1. Continued.

Variable	Recycled packaging	Biodegradable packaging	Reused Packaging	Water use	Vegetable waste	Phytosanitary packaging waste	Plastic waste
Legal form	0.161	0.074	0.138	0.088	0.125	0.102	0.048
Operating income	0.198	0.033	0.050	.353**	.392**	.529**	.566**
Solvency rate	-0.204	-0.197	-0.209	-0.058	-0.116	-0.156	-0.165
Employees number	.295**	0.118	0.070	.332**	.334**	.526**	.524**
Commercialization volume	0.130	0.015	0.027	.328**	.332**	.451**	.488**
Emvironmental corporate culture	0.155	0.159	0.043	0.014	-0.003	0.011	-0.084
Ecological production	0.148	0.088	0.057	0.062	-0.007	0.062	0.101
Biological control	0.187	0.157	0.196	0.215	.252*	0.183	0.172
Traceability	0.073	0.068	-0.041	0.076	0.118	0.020	0.005
Green human resources	.350**	0.154	0.185	.347**	.313**	.464**	.476**
Environmental quality certificatons	.407**	0.157	.238*	.339**	.397**	.474**	.497**
GLOBAL G.A.P.	.232*	0.157	.294**	.316**	.402**	.377**	.341**
GRASP	.324**	0.148	.321**	.345**	.353**	.442**	.437**
ISO 14001	0.194	-0.123	0.002	0.075	0.128	.230*	.271*
ISO 9001	0.116	-0.053	-0.011	0.100	0.186	0.109	0.220
Recycled packaging	1	0.180	.317**	.241*	0.132	.268*	.312**
Biodegradable packaging		1	0.218	0.029	0.045	-0.041	0.001
Reused Packaging			1	0.214	0.134	0.169	0.210
Water use				1	.770**	.707**	.769**
Vegetable waste					1	.686**	.732**
Phytosanitary packaging waste						1	.785**
Plastic waste							1

* p-value < 0.05; ** p-value < 0.01

APPENDIX E

PUBLISHED PAPERS

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Review

Eco-innovation measurement: A review of firm performance indicators

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ABSTRACT

Increased awareness on sustainability has influenced business organizations to improve their environmental performance and efficiency. In this context, eco-innovation implementation is positioned as a target for organizations to be more sustainable in order to reduce negative externalities and reach governments' green requirements and consumers' demands. The aim of this paper is to provide a critical review of literature on eco-innovation performance indicators. This study identifies the 30 firm performance indicators most cited by researchers and classifies them into four different green innovation types, i.e. product, process, organizational and marketing. A substantial gap has been found throughout the literature on this issue as studies do not include a complete combination of the key performance indicators across the four types of eco-innovation. This information is necessary to obtain an accurate measurement of eco-innovation level and it is useful to companies and stakeholders for performance evaluation. Moreover, understanding which performance indicators are more suitable for measuring the level of environmental innovation affords governments the possibility to draft policies that encourage companies to be more sustainable and firms to implement green practices in a more efficient way.

Contents

1. Introduction

In recent years, a great deal of research has focused its attention on the impact that the improper use of natural resources has on the environment. This trend, along with the heightened awareness about environmental problems, the limitation of natural resources and the increasing world population, highlights the need to discover new ways of using these resources more efficiently in order to achieve a balance between consumption requirements and sustainability.

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0959-6526/

According to the OECD (2012), the world population will surpass 9000 million in 2050. Thus, at a time when it will be necessary to increase production of food and other products, topical problems like global warming, deforestation, water pollution, biodiversity loss, excessive generation of waste, and the use of chemical substances will imply a decrease in both productivity and the availability of goods and services. In this context, firms and industries receive special attention as they are considered to contribute most to perpetuating these problems, yet they have the capacity to provide appropriate solutions instead (Remacha, 2017). However, in order to do so, new environmental-friendly production methods as well as improvements in product characteristics, organizational capabilities and marketing practices are required to achieve greater respect for the environment. This objective can be reached by encouraging firms and countries to implement eco-innovations, especially in sectors with considerable environmental impacts in terms of pollution and water and energy consumption, such as agriculture (FAO, 2017).

These innovations, also known as green innovations or environmental innovations, are attracting increasing interest among researchers as a key factor for achieving economic, social and environmental objectives (Läpple et al., 2015). Defining eco-innovation (EI) is not an easy task, although several authors address this topic. According to Kemp and Pearson (2007, p.7), EI is "the production, assimilation or exploitation of a product, production process, service or management or business method that is novel to the organization (developing or adopting it) and which results, throughout its life cycle, in a reduction of environmental risk, pollution and other negative impacts of resources use (including energy use) compared to relevant alternatives". Oltra and Saint Jean (2009, p.1) defined it as "innovations that consist of new or modified processes, practices, systems and products which benefit the environment and so contribute to environmental sustainability", while Kemp and Arundel (1998) and Rennings and Zwick (2003) define environmental innovations as new and modified processes, equipment, products, techniques and management systems that avoid or reduce harmful environmental impacts. For Fussler and James (1996), eco-innovation is the process of developing new products, processes or services which provide customer and business value but significantly decrease environmental impact. Other definitions are also found in works such as Carrillo-Hermosilla et al. (2010), Jänicke (2012) and Tamayo-Obergozo et al. (2017). But, the discussion relative to the definition of EI not only concern researchers, also world organizations discuss this topic. The Eco-Innovation Observatory (2012, p.8) considers it the "introduction of any new or significantly improved product, process, organizational change or marketing solution that reduces the use of natural resources and decreases the release of harmful substances across the whole life-cycle." In the case of the European Commission (2013, p.4), "eco-innovation projects will therefore aim to produce quality products with less environmental impact, whilst innovation can also include moving towards more environmental-friendly production processes and services. Ultimately, they will contribute towards the reduction of greenhouse gases or the more efficient use of various resources." The Oslo Manual (OECD, 2005) defines innovation as the implementation of a new or significantly improved product (good or service) or process, a new marketing method, or a new organizational method in business practice. According to Europe INNOVA (2006), eco-innovation is the creation of novel and competitively priced goods, processes, systems, services, and procedures designed to satisfy human needs and provide a better quality of life for all, with a minimal life-cycle use of natural resources (materials including energy, and surface area) per unit output, and a minimal release of toxic substances. Furthermore, it is necessary to mention that each author and organization considers different points of view, but all the definitions include two main effects of EI (Hojnik and Ruzzier, 2016b): fewer adverse effects on the environment and more efficient use of resources. These common issues are taken into consideration in this study as the eco-innovation concept.

A wide range of studies on eco-innovation concepts, consequences and drivers have been published, primarily because EI is commonly believed to play a key role in the quest for greater efficiency and sustainability. Nevertheless, studies on its implementation are rather scant (Kemp, 2009). Implementation refers to realization for use according to a European project entitled "Measuring eco-innovation (MEI)" (Kemp and Pearson, 2007, p.7). Therefore, this study focuses on those indicators that measure the implementation of eco-innovations in economic activity. A great deal more of comprehensive research on EI implementation is considered essential in order to identify those eco-innovation performance indicators (EIPI) which allow it to be efficiently measured. In consequence, it would promote progress towards the constitution of a body of knowledge that facilitates not only companies but also governments to implant environmental plans that ensure higher sustainability. As Triguero et al. (2013) mention, a lack of effectiveness of environmental regulation exists. For this reason, a change in the current regulatory framework is needed to enhance EI because environmental regulations play an important role in stimulating EI and combating negative environmental externalities (Ekins, 2010; Demirel and Kesidou, 2011).

The main aim of this article is to offer an overview of the key performance indicators which measure EI at firm level, particularly from the product, process, organizational and marketing perspectives, according to the classification introduced by Macron et al. (2017). To this end, we review the academic literature on EIPI utilizing 104 full articles. No studies were found which provided a comprehensive analysis of the subject from the four EI perspective types. Thus, the paper contributes to the literature in three ways. Firstly, this study provides an academic contribution. As Cooper and Edgett (2008) and Ehrenfeld (2008) note, you cannot manage what you do not measure. In this line, this study offers an overview of key EIPI, contributing to develop a body of knowledge to analyze the level of EI implementation from the point of view of product, process, organizational and marketing perspectives and helping to fill the existing gap concerning this subject. Furthermore, an overview of EIPI makes it possible to create compound indicators for measuring level of environmental innovation and, subsequently, comparing said levels between countries, sectors or companies (Angelo et al., 2012). Secondly, providing a set of EIPI is a useful base for managers to know which of them should be used to evaluate its performance and diagnose in which EI perspective improvements could be introduced to reduce negative externalities and at the same time add more environmental value and provide a competitive advantage. Finally, due to the fact that EI policies require a holistic view according to Cheng et al. (2014), the current study helps to understand the possible performance indicators for implementing EI.

The remainder of this paper is organized as follows. Section 2 explains the research method and the lines of research used to find and select the publications analyzed. Section 3 shows a descriptive analysis of the findings highlighting the evolution of the research on this subject. In addition, this section analyzes the countries, journals and sectors in which the topic is most widely discussed. Next, Section 4 presents the discussions and contains reviews on EIPI, grouping them into four types of green innovation. This section also introduces a set of key EIPI. Finally, Section 5 concludes the study, discussing the main findings and giving suggestions for future research.

2. Research method

The manner by which EI is measured is evaluated to identify the potential performance indicators necessary for achieving greener and more sustainable procedures. Thus, a systematic literature review has been carried out following the methodology suggested by Tranfield et al. (2003). This approach is also in line with the previous systematic reviews on eco-innovation (e.g., De Medeiros et al., 2014; De Jesús Pacheco et al., 2016; or Hojnik and Ruzzier, 2016b).

This method was chosen as it makes it possible to include large amounts of information contributing to provide a comprehensive view of the field for researchers, answers questions regarding this specific topic and discover new opportunities for future research (De Jesús Pacheco et al., 2016). Furthermore, a systematic review effectively provides a practical perspective as an overall view of EIPI, contributing to create a body of knowledge on this subject in order to determine how to implement ecological practices and policies in the future.

The methodology followed for the literature review included two main phases: Firstly, the extraction and selection of publications in the desired areas; and, secondly, the analysis of the publications retrieved to identify key EIPI. In particular, the systematic literature review followed a five-step scheme according with Tranfield et al. (2003) that included: (i) problem definition; (ii) selection of sources; (iii) selection of studies; (iv) critical appraisal and evaluation; and (v) synthesis.

First, the problem is defined: in line with the overall objective of the research, the aim of the systematic review was to identify the most cited performance indicators used for measuring the level of EI implementation. Then, the selection of sources and studies is conducted, followed by the description.

Taking into consideration that a systematic literature review must be focused not only on published articles in journals but also on "gray literature" as well (Petticrew and Roberts, 2012), we based the bibliometric analysis on Scopus and Web of Science (WoS) databases in the first stage (Díaz-García et al., 2015; Morioka and de Carvalho, 2016). These databases are considered the most important source of data for scientific research and include titles from Emerald, Elsevier, Springer, Willey, Taylor & Francis or JStor (Bonisoli et al., 2018). Then, a cross-reference analysis and a search in the databases of the main international organizations were conducted with the two-fold aim of analyzing those references that are of interest to the present subject of study and completing the literature review.

Once the literature sources were established, a search based on determining keywords combinations was carried out to select studies. Keywords were selected taking into consideration the main words related to this field and the words most used by researchers. According to Angelo et al. (2012), "environmental innovation" is the term most commonly used in review papers (65%), followed by "eco-innovation term" (22%) and "green innovation" (13%). Therefore, the keywords used for this stage are mainly combinations of the aforementioned terms, along with some eco-innovation implementations. Table 1 presents the keyword combinations used for the search mechanism and the corresponding results for each database. Keyword combinations are reported in rows while databases are reported in columns. The research timeframe covered the period from January 1990 to December 2017.

The key terms "environmental innovation", "eco-innovation" and "green innovation" embrace an extensive range of sub-topics in spite of being used in conjunction with the four types of EI and also with green practices like "design product", "renewable energy" or "recycling materials". Therefore, search strings were established with the aim of filtering the review and articles being searched. The following fields were selected: Agricultural and Biological Sciences, Environmental Science, Business Science, Economic Science, Ecological Science and Engineering Science. This defined a specific scope for the search and excluded papers whose focus was not relevant to the present study. From this search method, 2,491 papers were found and, as the word combinations were introduced into both databases, 1,969 duplications (79%) had to be removed. Then the title and abstract of each paper were read. Thus, 203 were potentially relevant to this review. After analyzing these complete papers, only those focusing on the EI implementation, i.e. on indicators that measure the implementation of eco-innovations in economic activity, became our set of sources.

The previous procedure led to an initial list of 53 pre-selected articles on eco-innovation implementation. After that, we conducted a cross-reference analysis in order to identify other relevant contributions. Consequently, 51 new references were added.

After analyzing the papers that represent the object of our analysis, the EIPI retrieved were clustered in four different types of EI (product, process, organizational and marketing EI) according to Macron et al. (2017). This classification is described in more detail in the following sections.

3. Results

The selection process described in the previous section yielded a list of 104 publications. This literature review focused on four types of publications. Most of the publications have been classified as journal papers (85), followed by books or book chapters (15) and other related academic publications (4). Table 2 summarizes the range and frequency of the reviewed journals in the field of eco-innovation implementation. A notable 41% (35 articles) of the articles were published in the Journal of Cleaner Production, and approximately 7% (6 articles) were published in Research Policy. An additional 2% came from the Academy of Management, Journal of Sustainable Development, Journal of Business Ethics, Technovation, Business Strategy and the Environment, Ecological Economics, Packaging Technology and Science, International Journal of Production Economics, Research Technology Management, and Journal of Business Logistics; each respectively contributing 2 articles. Finally, 25 other articles were taken from 25 different journals.

An analysis was then conducted in order to determine the main areas of research, the years with the most studies published, and the countries on which most literature is focused (Dangelico, 2015; Caldera et al., 2017).

Over the past two decades, EI has been addressed from different perspectives with the main aim of understanding the motivation for its implementation and how it could be promoted. It should first be noted that studies on this subject have focused on the main factors that prompt firms to innovate in this field. These factors are called "drivers". Research on this topic presents and describes the various dimensions that characterize EI. In contrast, the most recent articles focus on the indicators which measure EI in different sectors and countries (Cheng and Shiu, 2012). Fig. 1 shows how the number of publications on the environmental innovation field has significantly increased, up to four times since 2007. This result emphasizes the relatively novel interest on this field of research and the increasing attention that it is receiving. Specifically, in the year 2015 there is a high point in the number of publications due to an increase in studies about which factors motivate the introduction of green practices and about the analysis of eco-innovation impact at environmental and firm levels, particularly in the Journal of Cleaner Production and Innovation Management Policy and Practices. Figs. 2 and 3 below display the countries and sectors that have caused this increase in publications.

Fig. 2 shows the geographic distribution and number of articles

Table 1
Keyword combinations used for the search mechanism and the results for each database.

Key Concept	Search String	Scopus	WoS
Eco-innovation	"Eco-innovation"	382	418
Eco-innovation	"Environmental innovation"	317	314
Eco-innovation	"Green innovation"	173	276
Eco-innovation	"Ecological innovation"	47	58
Eco-innovation	"Measuring innovation" AND "Environment"	12	8
Eco-innovation and product innovation	("Eco-innovation" OR "Environmental innovation" OR "Green innovation") AND ("Product innovation" OR "Product Design" OR ("Product innovation" AND "Recycling materials"))	173	145
Eco-innovation and process innovation	("Eco-innovation" OR "Environmental innovation" OR "Green innovation") AND ("Process innovation" OR "Process efficiency" OR ("Renewable energy" AND "Process improvement"))	66	46
Eco-innovation and organizational innovation	("Eco-innovation" OR "Environmental innovation" OR "Green innovation") AND ("Organizational innovation" OR "Organizational change")	32	16
Eco-innovation and marketing innovation	("Eco-innovation" OR "Environmental innovation" OR "Green innovation") AND ("Marketing innovation" OR "Marketing practices")	5	3

Table 2
Number of articles published in different journals (1990–2017).

Journal name	Number of articles	Percentage
Journal of Cleaner Production	35	41%
Research Policy	6	7%
Academy of Management Journal	2	2%
Sustainable Development	2	2%
Journal of Business Ethics	2	2%
Technovation	2	2%
Business Strategy and the Environment	2	2%
Ecological Economics	2	2%
Packaging Technology and Science	2	2%
International Journal of Production Economics	2	2%
Research Technology Management	2	2%
Journal of Business Logistics	2	2%
Administrative Science Quarterly	1	1%
Environmental Innovation and Societal Transitions	1	1%
Management Service Quality	1	1%
Resources, Conservation and Recycling	1	1%
Policy Sciences	1	1%
Harvard Business Review	1	1%
International Journal of Operations and Production Management	1	1%
Journal of Marketing Channels	1	1%
Journal of Remanufacturing	1	1%
Interfaces	1	1%
California Management Review	1	1%
Futures	1	1%
Strategic Management Journal	1	1%
Dyna	1	1%
Clean Technologies and Environmental Policy	1	1%
Energy Economics	1	1%
Journal of Environmental Economics and Management	1	1%
SAM Advanced Management Journal	1	1%
Energies	1	1%
Environmental and Resource Economics	1	1%
Journal of Economic Literature	1	1%
The Leadership Quarterly	1	1%
Academy of Management Review	1	1%
Sustainability	1	1%
Management Decision	1	1%
Total	85	

by countries, analyzing the literature published in this field since 2007, the year in which the number of publications about EI began to increase considerably. The graph shows that Spain is the country with the highest number of publications, followed by the United Kingdom, Italy, France and China.

Moreover, Fig. 3 displays the main subject areas of EI studies. The field with the most research is Business and Management (42.1%), followed by Engineering (29.9%) and Social Science (22.1%). This distribution of publications could indicate that the research findings were also likely applied to the industrial and energy sectors. In contrast, the green innovation field receives scant attention in Agricultural literature (4.4%), particularly when we consider how closely linked this sector is to the environment.

Analyzing Figs. 2 and 3, we can come to the follow conclusion. The countries with a greater number of publications on EI are those with a business network constituted by small and medium size firms. In this context, it is evident that they focus their EI studies on the Business and Management sector, making this sector the main subject area for EI papers. However, countries like Spain, Italy or France have a strong agricultural economic sector which is the engine of the economy in many of its regions. Thus, more studies about this sector would be necessary taking into account the

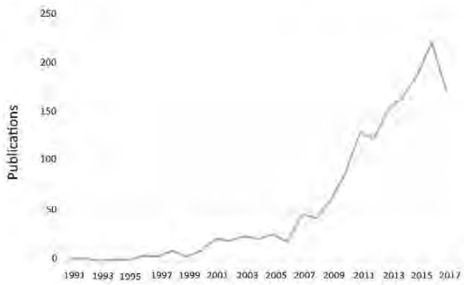

Fig. 1. Eco-innovation publications by year (1990–2017).

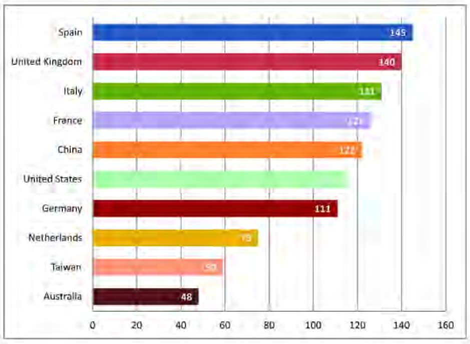

Fig. 2. Eco-innovation publications by country (2007–2017).

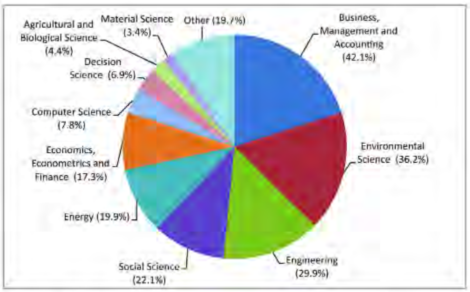

Fig. 3. Eco-innovation publications by subject area (2007–2017).

considerable impact that the agriculture has on the environment and its close relationship with the use of natural resources.

4. Discussion: overview of research on eco-innovation performance indicators

Key findings from the systematic literature review are detailed below. The findings emphasize 30 key EIPI. In this study they were clustered into four groups, as was shown in Table 3: (i) product innovation; (ii) process innovation; (iii) organization innovation; and (iv) marketing innovation. Thus, this Section is structured into four parts, one for each type of EI, as it has been mentioned in previous sections. To construct this classification, we followed the review by Macron et al. (2017, p. 84). According to this work, product innovations (i) "can take the form of major or minor changes in the material used, in the technical specification and in the characteristics of the product or service"; process innovations (ii) "are intended to reduce costs, increase quality and provision of the products or services and include improved techniques in auxiliary support activities"; organizational innovations (iii) "refer to new or significantly improved routines, business models, methods and actions that change firms' practices, relations and decisions"; and marketing innovations (iv) "can occur through changes in product design, product placement, communication, new methods of product delivery, promotion or pricing strategies. Moreover, significant changes in product packaging are also considered important marketing innovations".

Table 3 presents a set of key EIPI retrieved from the analysis of the papers selected in Section 2. The articles were included in at least one category, and some articles are included in more than one. For example, Rodríguez and Wiengarten (2017) was considered to correspond to three different types of eco-innovation (EI), i.e. product, process and organizational, and, accordingly, this reference appears linked to these three types in the classification.

The set of key EIPI established in Table 3 highlights the performance indicators most cited by the EI literature to analyze and measure the EI in different sectors and countries, offering a state of art in this topic. It is discussed in the following section.

4.1. Product eco-innovation

The materials used to make a product as well as the product characteristics themselves have an impact on the environment. Thus, numerous research studies on how to implement environmental innovations have focused on improving the type and quality of inputs and product sustainability in order to reach current environmental requirements and to decrease negative externalities. More specifically, this study of the literature found 7 EIPI based on EI products (1).

Related to the determinants of the product's characteristics and, in turn, its environmental impact, the literature enhances the inputs used to make a product as one of the major points to have in consideration to implant EI. In this sense, reducing the use of dirty inputs (1.5) or substituting them for cleaner or less polluting materials (1.1) contributes to decreasing waste and CO^2 emissions. The materials used to make a product comprise one of the EIPI that a great deal of research highlights as one of the factors necessary for creating products that are more environmental-friendly.

Some authors emphasize the importance of reducing or optimizing the use of raw materials (1.3) to obtain products (e.g., Eder, 2003; Hellström, 2007; Crabbé et al., 2013). The utilization of raw materials as an input in product manufacturing has a significant negative impact on the environment for two reasons. Firstly, its consumption ultimately increases (Agrawal and Ülkü, 2011). Secondly, the decarbonation of raw materials increases carbon dioxide (CO^2) emissions (Ishak et al., 2016). Thus, reducing the use of raw materials (1.3) by a sector or a company is a performance indicator that should be taken into consideration for measuring EI and sustainability level. In this line, Pigosso et al. (2010) support products whose raw materials are obtained from other products as a way to reduce contaminants. Also, Eder (2003) focuses attention on the necessity of substituting raw materials (1.3) for cleaner alternatives.

Using new cleaner materials or new inputs with lower

Table 3
Eco-innovation key performance indicators analyzed by the literature.

Eco-innovation types	Eco-innovation performance indicators	References
Product Eco-innovation (1)	Use new cleaner material or new input with lower environmental impact (1.1)	Theyel (2000) Eder (2003) BID (2007) Crabbé et al. (2013) Doran and Ryan (2016) Sierra-Pérez et al. (2016) Castellacci and Lie (2017) Rodríguez and Wiengarten (2017)
	Use of recycled materials (1.2)	Van Hemel and Cramer (2002) Cheng and Shiu (2012) Dalhammar (2015) Macron et al. (2017)
	Reduce/optimize use of raw materials (1.3)	Eder (2003) Hellström (2007) Pigosso et al. (2010) Crabbé et al. (2013)
	Reduce number of product components (1.4)	Hellström (2007) Cheng and Shiu (2012) Doran and Ryan (2016) Castellacci and Lie (2017) Rodríguez and Wiengarten (2017)
	Eliminate dirty components (1.5)	Eder (2003)
	Product with a longer life cycle (1.6)	Van Hemel and Cramer (2002) Hellström (2007) Asif et al. (2012) Ye and Zhang (2013) Bakker et al. (2014) Dalhammar (2015) Aziz et al. (2016)
	Product ability to be recycled (1.7)	Garrod and Chadwick (1996) Bakker et al. (2014) Dalhammar (2015) Castellacci and Lie (2017) Rodríguez and Wiengarten (2017)
Process Eco-innovation (2)	Reduce chemical waste (2.1)	Theyel (2000)
	Reduce use of water (2.2)	Alkaya and Demirer (2015) Azad and Ancev (2014) Piedra-Muñoz et al. (2018)
	Reduce use of energy (2.3)	Van Hemel and Cramer (2002) Cheng and Shiu (2012) Alkaya and Demirer (2015) Doran and Ryan (2016) Castellacci and Lie (2017) Rodríguez and Wiengarten (2017)
	Keep waste to a minimum (2.4)	Shrivastava (1996) Norberg-Bohm (1999) Cheng and Shiu (2012)
	Reuse of components (2.5)	Hellström (2007) Dalhammar (2015)
	Recycle waste, water or materials (2.6)	Van Hemel and Cramer (2002) Cheng and Shiu (2012) Doran and Ryan (2016) Castellacci and Lie (2017) Rodríguez and Wiengarten (2017)
	Environmental-friendly technologies (2.7)	Garrod and Chadwick (1996) Frondel et al. (2008) Guziana (2011)
	Renewable energy (2.8)	Johnstone et al. (2010) Lacerda and Van den Bergh (2014) Nesta et al. (2014) Nicolli and Vona (2016)
	R&D (2.9)	Cohen and Levinthal (1990) Florida (1996) BID (2007) Kemp and Pearson (2008) Cainelli et al. (2015) Rodríguez and Wiengarten (2017)
	Acquisition of machinery and software (2.10)	BID (2007) Kesidou and Demirel (2012) Cainelli et al. (2015) Rodríguez and Wiengarten (2017)
	Acquisition of patents and licenses (2.11)	Griliches (1990) Lanjouw and Mody (1996) Jolly and Philpott (2004) Oltra et al. (2008) Johnstone et al. (2010) Kesidou and Demirel (2012) Cainelli et al. (2015)

(*continued on next page*)

Table 3 (*continued*)

Eco-innovation types	Eco-innovation performance indicators	References
		Rodríguez and Wiengarten (2017)
Organizational Eco-innovation (3)	Green human resources (3.1)	Amabile et al. (1996) Anderson (1998) Andriopoulos (2001) Halbesleben et al. (2003) Naffziger et al. (2003) O'Connor and Ayers (2005) BID (2007) Kemp and Pearson (2008) Montalvo (2003, 2008) Boons and Lüdeke-Freund (2013) Chen and Chang (2013) Tseng et al. (2013) Hojnik and Ruzzier (2016a) Peng and Liu (2016) Rajala et al. (2016)
	Pollution prevention plans (3.2)	Frosch and Gallopoulos (1992) Tibbs (1992) Kemp and Pearson (2008)
	Environmental objectives (3.3)	Williams et al. (1993)
	Environmental audit (3.4)	Baram and Partan (1990) Garrod and Chadwick (1996) Hamner (2006) BID (2007) Kemp and Pearson (2008) Montalvo (2003, 2008) Eltayeb (2009) Zailani et al. (2012) Boons and Lüdeke-Freund (2013)
	Environmental advisory (3.5)	Del Brío and Junquera (2003) BID (2007) Scarpellini et al. (2012) De Jesûs Pacheco et al. (2016)
	Invest in research (3.6)	Porter and Van der Linder (1995) Horbach (2008)
	Cooperation with stakeholders (3.7)	Cramer et al. (1991) Frosch and Gallopoulos (1992) Cramer and Schot (1993) Frosch (1994) Florida (1996) Anderson (1998) Becker and Dietz (2004) Hamner (2006) Chen (2008) Eltayeb (2009) De Marchi (2012) Matos and Silvestre (2013) Segarra-Oña and Peiró-Signes (2014) Ghisetti and Reinnings (2014) Ghisetti et al. (2015) Ghisetti and Pontoni (2015) Roscoe et al. (2015) Bossle et al. (2016) Rodríguez and Wiengarten (2017)
	New markets (3.8)	Blättel-Mink (1998) Niinimäki and Hassi (2011) Loorbach and Wijsman (2013)
	New systems (remanufacturing systems and transport systems) (3.9)	Stock (1992) Blättel-Mink (1998) Carter and Ellram (1998) Moore (2005) El Korchi and Millet (2011) Asif et al. (2012) Ye and Zhang (2013) Bakker et al. (2014) Iritani et al. (2014)
Marketing Eco-innovation (4)	Returnable/reusable packaging (4.1)	Stock (1992) Hart (1995) Shrivastava (1995) Rosenau et al. (1996) Carter and Ellram (1998) Rogers and Tibben-Lembke (1998) Christmann (2000) Duhaime et al. (2001)

Table 3 (*continued*)

Eco-innovation types	Eco-innovation performance indicators	References
	Green design packaging (4.2)	Van Hemel and Cramer (2002)
		Twede and Clarke (2005)
		Zailani et al. (2012)
		Silva et al. (2013)
		Löfgren (2005)
		Martin et al. (2006)
		Henriksson et al. (2010)
		Langley et al. (2011)
		Cheng and Shiu (2012)
	Quality certifications (4.3)	Juul (2012)
		Zailani et al. (2012)
		Plumb et al. (2013)
		Wever and Vogtländer (2014)
		Lindh et al. (2016)
		Wilkström et al. (2016)
		Hamner (2006)
		Eltayeb (2009)
		Chiarvesio et al. (2015)
		Li and Hamblin (2016)

environmental impact (1.1) is also used in EI literature as an indicator of a product's level of efficiency (e.g., Doran and Ryan, 2016; Castellacci and Lie, 2017; Rodríguez and Wiengarten, 2017). Theyel (2000) highlights the necessity of using cleaner or less polluting materials in a review based on the plastics and resins sector and the ink manufacturing sector in the US chemical industry; while Crabbé et al. (2013), in a study on Flemish production firms, emphasize the importance of innovating to obtain sustainable materials which contribute to making products more respectful of the environment. Also, BID (2007) recognizes the use of new sustainable materials (1.1) as an indicator of the innovation effort of a company. Other empirical market studies note the importance of using cleaner materials (1.1) to reduce the negative environmental impact of firms. According to Sierra-Pérez et al. (2016), introducing the use of cork to replace non-renewable materials in the construction sector decreases ecological impact. Eder's research (2003) highlights eliminating the use of dirty or polluting components (1.5) to make a product in order to obtain fewer contaminant products.

Other performance indicators related to the inputs used in manufacturing show the improvement in product efficiency. One of these indicators is the use of recycled inputs (1.2). According to Dalhammar (2015) and Macron et al. (2017), the use of recycled materials (1.2) is an essential performance indicator of green innovation. In accordance with this concept, Van Hemel and Cramer (2002) and Cheng and Shiu (2012) emphasize that the use of recycled product components (1.2) is another tool for manufacturing more sustainably. Similarly, research conducted by Hellström (2007) highlights the reduction of the number of product components (1.4) as another successful indicator of product EI. Along this line, other authors introduce the indicator "reduce material per unit of output" (1.4) in the research to measure the level of efficiency of a product (e.g., Doran and Ryan, 2016; Castellacci and Lie, 2017; Rodríguez and Wiengarten, 2017).

Analyzing the EI literature is demonstrated the product characteristics are strongly correlated with environmental impact. A product's durability (1.6) and ability to be reused (1.7) are the two most relevant characteristics studied by the EI literature as they are directly linked to product efficiency, reduced consumption of resources, and lower gas emissions. Hellström (2007), Bakker et al. (2014) and Aziz et al. (2016) present the long-life product (1.6) as an effective tool for obtaining a greater level of environment sustainability. Dalhammar (2015) discusses product durability (1.6) and the technical guarantees on life cycle as improvements which can provide more environmental efficiency, while Van Hemel and Cramer (2002), in their study which analyzes the environmental performance of the US chemical industry, introduce an investigation to extend product lifetime (1.6) by providing a list of the main solutions for achieving sustainability. Moreover, Asif et al. (2012), Ye and Zhang (2013) and Bakker et al. (2014) highlight remanufacturing as a strategy to extend product lifetime (1.6).

Additionally, Dalhammar (2015), Castellacci and Lie (2017) and Rodríguez and Wiengarten (2017) introduce the ability of a product to be recycled (1.7) after use as a key performance indicator for measuring EI level. This practice leads to the reduction of waste as it extends product life at the same time. Along this line, Garrod and Chadwick (1996) carried out a survey of companies located in the South of England to determine how firms had handled the increase of environmental pressures. Their analysis identified several firm performance indicators that were implemented, one which was the recycling of part of the used final product (1.7). Also, Bakker et al. (2014), in their study on household products, emphasize the recycling of products (1.7) as an essential tool in order to achieve greener practices.

4.2. Process eco-innovation

The environmental impact of a company is not only due to what the company produces but also how the company manufactures its products. Groenewegen et al. (1996) have established the relationship between the manufacturing processes of a company and negative environmental impact. Thus, it is necessary to take into consideration improvements in manufacturing processes and include relevant EI indicators in order to efficiently measure levels of environmental innovation. This study of the literature has identified 11 EIPI based on improvements in manufacturing processes (2).

The total use of water or energy is a widely-used method in EI literature for analyzing process improvement. Alkaya and Demirer (2015), in a review of the Turkish chemical industry, use the indicators "reduce water consumption" (2.2) and "reduce energy consumption" (2.3) to study the sustainability of the sector's production processes and whether companies attempt to fulfill green requirements. In the same way, irrigated agriculture is one of the sectors where the use of water has been most analyzed. Many studies measure the effects of eco-innovations aimed at optimizing water usage on farmers' environmental impact (Azad and Ancev, 2014; Piedra-Muñoz et al., 2017, 2018). Other works which follow this line include: Van Hemel and Cramer (2002), who analyze a group of 77 small and medium sized companies (SMEs); Cheng and

Shiu (2012), who measure EI from the perspective of implementation; Doran and Ryan (2016), who base their review on the Irish Community Innovation Survey; Castellacci and Lie (2017), who focus their study on manufacturing firms in Korea; and Rodríguez and Weingarte (2017), who study several German industries and highlight energy reduction (2.3) in the manufacturing process as a performance indicator to measure environmental efficiency.

The level of waste (2.4) in a process is also analyzed as a cause of pollution. Thus, Shrivastava (1996), Norberg-Bohm (1999) and Cheng and Shiu (2012) emphasize the importance of introducing new technologies with the aim of reducing waste to a minimum. Theyel (2000) expands on this reasoning by proposing the idea of reducing chemical waste (2.1) in production processes as much as possible. According to the Van Hemel and Cramer (2002) study, which focused on the US chemical industry, firms that innovate in terms of reducing chemical waste (2.1) are leaders in adopting environmental practices.

Materials-saving is another key performance indicator for measuring EI and the efficiency level of a process. This indicator can be viewed from two perspectives. On the one hand, the reuse of components or materials (2.5) attracts attention as a positive way of being greener in the manufacturing process (Hellström, 2007; Dalhammar, 2015). On the other hand, the recycling of waste, water, materials or inputs (2.6) is another means of reducing negative environmental impact. Thus, some authors introduce the indicator "recycled waste, water and materials" (2.6) in their studies to measure environmental innovativeness (e.g., Doran and Ryan, 2016; Castellacci and Lie, 2017; Rodríguez and Wiengarten, 2017). Furthermore, according to Van Hemel and Cramer (2002) the eco-indicator "recycling of materials" (2.6) is the most successful among firms to improve their environmental performance.

The level of investment carried out by a company is a relevant performance indicator of its effort to be greener. In this context, some authors analyze company investment in patents (2.11) as a means of achieving environmental innovations to improve energy consumption and material efficiency (Kesidou and Demirel, 2012; Cainelli et al., 2015; Rodríguez and Wiengarten, 2017). In a study on renewable technology, Johnstone et al. (2010) identify the number of patents (2.11) as a measurement indicator of EI. Additionally, Griliches (1990), Lanjouw and Mody (1996), and Jolly and Philpott (2004) shows that patents are a good indicator for measuring innovation activity level. Furthermore, the European Comission contemplates the "eco-patents" as an indicator of the level of innovative activity in the environmental field and as a way for studying eco-innovations (Oltra et al., 2008).

Nevertheless, not all company research efforts and investments are always patented. Thus, in addition to the number of patents, other practices exist that this indicator does not take into consideration (Oltra et al., 2008; Artz et al., 2010). For this reason, although the number of patents is strongly correlated with research and development (R&D) spending, it is necessary to include the indicator "number of patents" along with others such as acquisition of machinery and software (2.10) or R&D investments (2.9) to achieve a more accurate view of the innovative reality of a firm. R&D activity (2.9) is treated by some authors as a key performance indicator in the EI process. In fact, it has been shown that firms which implement R&D activities (2.9) are more likely to be environmentally innovative than firms that are not R&D active since the former have a higher absorptive capacity (Cohen and Levinthal, 1990; Cainelli et al., 2015). According to Florida (1996), firms that are R&D active (2.9) improve their productivity and reduce negative environmental impact. Thus, some authors (e.g., BID, 2007; Kemp and Pearson, 2008; Rodríguez and Weingarte, 2017) introduce the indicator R&D (2.9) to measure EI and subdivide it into internal or external R&D.

In addition, other authors (e.g., Kesidou and Demirel, 2012; Cainelli et al., 2015; Rodríguez and Wiengarten, 2017) focus their studies on the acquisition of machinery (2.10) as a key factor for the purpose of more efficient use of energy and materials. BID (2007) also illustrates the importance of incorporating new capital assets, i.e., hardware and software (2.10), in order to implement ecological innovations in a company.

The use of renewable energy (2.8) and environmental-friendly technologies (2.7) are two more relevant EIPI emphasized by the literature in this field as ways of achieving more efficient manufacturing processes, making them crucial for addressing global environmental aims. Frondel et al. (2008) highlight the environmental benefit of introducing *end-of-pipe* technologies (2.7) in manufacturing processes, whereas Guziana (2011) concludes that clean technologies (2.7) are more proactively innovative than the former. Along this line, Garrod and Chadwick (1996), in their survey of environmental strategies carried out by companies located in the South of England, determined that investment in clean technology (2.7) is a tool that can be implemented to fulfill ecological requirements. Moreover, other articles address the importance of introducing renewable energies (2.8) in company processes in order to improve quality of life for current and future generations and to meet public environmental objectives (e.g., Lacerda and Van den Bergh, 2014; Nesta et al., 2014; Nicolli and Vona, 2016).

4.3. Organizational eco-innovation

Chen (2008) illustrates the importance of the relationship between green intellectual capital and the competitive advantage of firms. Chen's study, which focused on the Taiwanese information and electronics industry, emphasizes the positive correlation between these two indicators. According to its findings, there are three types of green intellectual advantage: green human capital, green structural capital, and green relational capital. Furthermore, the study identified 9 EIPI related to organizational eco-innovation (3). Said indicators are introduced below.

Green human capital (3.1) refers to the collective knowledge, skills, creativity, experience and capabilities of employees. In this sense, based on a study of the In-Bond industry in the northern region of Mexico, Montalvo (2003) highlights the influence of managerial characteristics (3.1) on EI and the environmental-economic risks of developing cleaner technologies and manufacturing processes. Other studies (e.g., Montalvo, 2008; Boons and Lüdeke-Freund, 2013; Chen and Chang, 2013) support this idea arguing that senior staff (3.1) can encourage employees to be more creative, innovative and respectful with the environment. According to Andriopoulos (2001) and Halbesleben et al. (2003), leaders (3.1) with appropriate green perspectives play a key role in facilitating organizational creativity as well as the implementation of environmental innovations. Amabile et al. (1996) highlight creativity (3.1) as a starting point for innovation. Furthermore, Rajala et al. (2016), in a study of the US-based carpet manufacturer Interface, illustrate the role of the managerial agency (3.1) in driving environmentally sustainable practices in a company in order to unite firm culture and firm orientation with a green business model. The relationship between employing managers who are more in tune with environmentally conscious practices and greener business models based on better ecological performance and higher investments in environmental initiatives has also been highlighted by other researchers, e.g., Anderson (1998), O'Connor and Ayers (2005), and Hojnik and Ruzzier (2016a). In this line, Naffziger et al. (2003) and Tseng et al. (2013) establish the relationship between the presence in a company of a manager with a higher level of environmental (3.1) concern and the time and money invested in environmental initiatives. Moreover, Peng and Liu (2016), in a study which explores the determinants of EI, include the indicator "managerial environmental awareness" (3.1) in order to measure green innovation. In addition, BID (2007) and Kemp and Pearson (2008) accentuates the importance of green human resources (3.1) as an indicator which shows the innovative effort of a firm.

Green structural capital includes organizational capabilities, organizational commitments, organizational culture and philosophies, patents, copyrights, etc. Some of these have been analyzed in the previous section as processes of EI. Nevertheless, organizational cultures and philosophies can also be considered an organizational EI. According to Battisti (2008), it is not only important for firms to generate innovations; innovations must be adopted and used by firms, incorporated into their routines and their company philosophy. Thus, environmentally-oriented culture is another green performance indicator that should be taken into account by the literature for measuring EI. In a review carried out by Williams et al. (1993), this indicator, i.e. environmentally-oriented culture, is measured using the number of environmental objectives (3.3) included in production plans and operations. The reviews of Frosch and Gallopoulos (1992), Tibbs (1992) and Kemp and Pearson (2008) also highlight the inclusion of environmental plans (3.2) in production processes.

From the point of view of several researchers (e.g., Baram and Partan, 1990; Hamner, 2006; Zailani et al., 2012), conducting external environmental audits (3.4) is another good performance indicator for measuring the level of company commitment to environmental requirements. In their study based on a firm survey, Garrod and Chadwick (1996) also introduce environmental audits (3.4) as a growing indicator used to achieve EI. Ecological audits (3.4) provide firms with knowledge as to whether their green innovation is being effective and, depending on the result, firms can implement new ecological practices to reduce their environmental impact. Thus, Kemp and Pearson (2008) enhances auditing systems as a key organizational innovation for the environment. In addition, consulting services (3.5), which ensure compliance with environmental standards, constitute another tool that has the potential to increase the EI level of a company (e.g., Del Brío and Junquera, 2003; Scarpellini et al., 2012; De Jesús Pacheco et al., 2016). According to this, BID (2007) enhances the outsource consulting and technical assistance (3.5) as green innovative strategies.

Investment in research (3.6) is another key point that firms should introduce in their corporate culture. Although controlling pollution can be effective, it is not always the most efficient way to satisfy environmental requirements. Therefore, restructuring a firm's approach toward environmental management, from pollution control to pollution prevention, may be the most ecologically-driven method (Gottlieb et al., 1995). Accordingly, investing in research becomes an effective tool for achieving this goal (Porter and Van der Linder, 1995; Horbach, 2008).

Green relational capital is defined as the relationships of the company with customers, suppliers, network members, and partners regarding environmental management and EI. Accordingly, cooperation with stakeholders (3.7) enhances the creation of competitive advantage and simultaneously helps to achieve environmental objectives (e.g., Matos and Silvestre, 2013; Roscoe et al., 2015; Rodríguez and Wiengarten, 2017). According to Cramer et al. (1991), Cramer and Schot (1993) and Frosch (1994), restructuring firm relationships with pressure groups (3.7) is an important factor for obtaining information about the environment and providing assistance to suppliers and customers. Furthermore, forming partnerships with these groups (3.7) affords greater possibilities to seek out solutions to environmental problems (Frosch and Gallopoulos, 1992) and to renew firm business models to make them greener and more sustainable (Anderson, 1998). Florida (1996) and Chen (2008) also highlight the close positive relationship between firm-supplier ties (3.7) and the creation of new environmental improvement opportunities. Cooperation with suppliers, universities and public research institutions (3.7) has three significant benefits. First, it provides the firm with knowledge (e.g., Ghisetti and Reinnings, 2014; Ghisetti and Pontoni, 2015; Bossle et al., 2016). Second, it allows a firm to obtain information with the aim of improving products and processes (De Marchi, 2012; Segarra-Oña and Peiró-Signes, 2014). Third, it makes it possible for the firm to develop technological capabilities necessary to generate innovation (Becker and Dietz, 2004; Ghisetti et al., 2015).

One well-known cooperation method (3.7) is to create supplier questionnaires. These surveys provide firms with information about their level of environmental commitment and the quality of their environmental characteristics, activities and practices. In addition, firms obtain an idea of what kind of image their activities produce in the eyes of stakeholders (Eltayeb, 2009; Hamner, 2006). This practice allows firms to correct non efficient activities and implement new, greener ones.

The development of new market niches (3.8) is considered by some researchers to be another useful tool for the purpose of implementing green innovations (e.g., Blättel-Mink, 1998; Niinimäki and Hassi, 2011; Loorbach and Wijsman, 2013) and introducing new systems (3.9) (Blättel-Mink, 1998). According to El Korchi and Millet (2011), introducing remanufacturing systems or reverse logistic channels (3.9) allows firms to reduce environmental impact by reducing waste and extending product life cycle. Asif et al. (2012) and Ye and Zhang (2013) believe multiple life cycle products (MLPs) (3.9) constitute an important strategy for developing sustainable products and that remanufacturing is the best tool for achieving this goal. Additional research supporting remanufacturing systems (3.9) has also been published in a number of other relevant works (e.g. Stock and Lambert, 2001; Moore, 2005; Bakker et al., 2014). Finally, implementation of new transport systems (3.9) based on new routes, short distances, and the replacement of diesel fuel is another means of applying green innovation (Iritani et al., 2014) and achieving less pollution through the reduction of CO^2 emissions.

4.4. Marketing eco-innovation

Marketing innovation activities are relevant performance indicators for implementing and measuring EI, as stated by BID (2007). However, marketing green innovation has received less attention than other types of EI in environmental literature, which by no means makes it any less important. This review has identified 3 EIPI based on marketing (4). Recently, certain research has focused on identifying the environmental marketing indicators that can measure the level of EI implementation in order to reduce the negative environmental impacts of companies; achieve greater efficiency; and find new ways to carry out ecological innovation in the four dimensions: product, process, organizational and marketing.

Some environmental policies have focused on packaging, for example, the Directive 94/62/EC in the European Union, the response to the large amount of waste disposable packaging generates and its negative environmental impact (González-Torre et al., 2004). Thus, the use of returnable packaging (4.1), which can be recycled and reused, contributes to EI by increasing product efficiency while reducing waste and resource consumption. Some examples of relevant publications on the environmental benefits of using returnable packaging (4.1) include Rogers and Tibben-Lembke (1998), Duhaime et al. (2001) and Twede and Clarke

(2005). In this line, Stock (1992), Carter and Ellram (1998) and Silva et al. (2013) focus their studies on the reduction of waste and the improvement in resource efficiency resulting from the use of returnable packaging. Furthermore, Zailani et al. (2012) emphasize the need for design innovation in reusable packaging in order to enhance sustainability. Similarly, more authors (e.g., Hart, 1995; Shrivastava, 1995; Christmann, 2000) highlight the importance of packaging design (4.2) that can be reused in order to improve the sustainable performance of firms. Other studies agree with this environmental innovation indicator (e.g., Rosenau et al., 1996; Van Hemel and Cramer, 2002). In the literature the importance of packaging design (4.2) to influence consumer interaction with products is demostrated (Löfgren, 2005). Jelsma (2016) illustrates, for example, that product attributes can determine consumer behavior. Some authors (e.g., Zailani et al., 2012; Wever and Vogtländer, 2014; Wilkström et al., 2016) question the importance of including 'sustainable' packaging design as a means to fulfill ecological requirements, discussing whether it encourages customers to reduce food waste and recycle packaging. In order to measure of the extent to which sustainable packaging has been implemented, a great deal of researchers have debated the attributes packaging must possess in order to be green, such as: easy to empty (Langley et al., 2011; Juul, 2012); easy to clean (Langley et al., 2011); easy to separate into different fractions (Henriksson et al., 2010) easy to fold (Martin et al., 2006); provides information about how to sort (Henriksson et al., 2010; Langley et al., 2011); contributes by extending time between packaging date and expiration date (Plumb et al., 2013; Lindh et al., 2016); and contains the desired quantity (Lindh et al., 2016). According to Cheng and Shiu (2012), simplifying packaging is also a necessary way to obtain sustainable packaging.

Although the main focus in the literature about EI marketing type is on packaging, customer buying decisions are not only influenced by traditional criteria like cost, quality, and delivery but also by green firm image and sustainable firm activities. This is due to the increase in market awareness of environmental problems. In this context, quality certifications (4.3) are the best way to show markets whether a firm is fulfilling environmental requirements. Product certification according to international standards, such as ISO 14001 or Globalgap, is an increasingly necessary requisite for companies wishing to gain entry to numerous markets. This issue has been addressed by various authors, such as Hamner (2006), Eltayeb (2009) and Chiarvesio et al. (2015). Additionally, Li and Hamblin (2016), in a study based on pharmaceutical manufacturing companies in Tianjin (China), introduced the indicator "ISO 14001" to analyze the impact that some factors (CO_2, packaging, waste …) have on cleaner production. In this context, standards certifications related to environmental management can be a good EI performance indicator to measure the efforts to accomplish the environmental requirements.

5. Conclusions and future research

EI implementation has received little attention in comparison with the wide range of studies published on EI concepts, consequences and drivers (Kemp, 2009). Thus, the present study looks to fill the existing gap, analyzing the literature on key EIPI, and synthesizes the most current research on this topic, adding value in the following ways. On the one hand, it offers an overview of which performance indicators are the most cited in the EI literature. In this line, this review contributes to develop a body of knowledge to analyze and measure the level of EI implementation that can potentially guide recommendations for future economic, social and environmental policies in order to reach current environmental objectives (Carrillo-Hermosilla et al., 2010; Boons and Lüdeke-Freund, 2013). This is particularly interesting because EI policies play a key role in the EI implementation as Rennings (2000), Del Río et al. (2010) and Wagner and Llerena (2011) mention. On the other hand, a set of EIPI was developed to show the most important performance indicators that must be included in the four types of EI (product, process, organizational and marketing), which can also be used as a guide to obtain an efficient environmental innovation measurement. Furthermore, this can be useful to create compound indicators for measuring level of environmental innovation and, subsequently, comparing said levels between countries, sectors or companies.

It is clear that the environmental impact of firms' daily activities such as CO_2 emissions, non-efficient use of resources, and high waste levels of water and energy, increases concern regarding their ecological performance. Thus, the implementation of EI is critically important due to the ever increasing demand for a cleaner environment. In this context, research works in business, environmental and economic literature are focused on trying to measure and analyze EI implementation levels in order to discover how environmental actors can reduce their negative environmental impacts, fulfill green requirements and be more efficient to ensure the well-being of current and future generations. The careful study of literature focused on measuring and analyzing EI implementation in different countries and sectors has generated the following conclusions. It is observed that a large portion of the literature on measuring EI are focused on product, process and organizational EI type. Thus, the 36% of the 30 key performance indicators identified corresponding to process EI, 30% to organizational EI and 23% to product EI. In this sense, marketing EI type has received little attention by the literature in spite of its increasingly known environmental impact. Moreover, the vast majority of literature on EI measurement is focused on the Business, Management and Engineering sector; thus, more studies should be carried out in sectors like agriculture due to its close relationship with the use of natural resources and environmental externalities. Our study also identified some weakness on existing studies on EI measurement. Most research has focused on exploring one or two types of EI (product, process, organizational or marketing EI), but not all four types in specific areas. This fact does not afford an efficient, comprehensive study on EI and, instead, offers a very limited vision of the level of EI in firms, sectors or countries. The most complete studies on this subject have been carried out by Doran and Ryan (2016), Castellacci and Lie (2017) and Rodríguez and Wiengarten (2017). However, they only investigate EI implementation in product and process type, so their conclusions do not accurately reflect the reality of the firm, and they can only provide a limited idea of the level of ecological innovation implementation. Another notable weakness in existing research on EI implementation is related to the performance indicators that are included. Choosing a complete combination of indicators in each EI type is not an easy task, and evidence suggests that the majority of studies include indicators that are chosen in rudimentary ways, with little attention given to which indicators add more environmental value in each sector and firm. Although some methods are better than others, no single method or indicator is ideal. Different methods should be applied for analyzing eco-innovation, as Kemp (2009, p.103) mentioned: "to see the whole elephant, instead of just a part". Consequently, it would be particularly interesting for future research to conduct studies in which all types of EI, as well as the most relevant green indicators in each type, are included. Future research that applies new questionnaires in different sectors can help to discover new ways of marketing. The inclusion of new indicators would help to fill existing gaps related to those EIPI that have already been identified. This is particularly useful when seeking to obtain an accurate measurement of EI level.

A number of limitations of this study can be cited. Firstly, it follows a strictly theoretical research method based on previous research. Future works could be aimed at studying actual case studies to identify what companies are actually doing. Secondly, another shortcoming is the search frame, as the database choice for the paper search could be expanded. Thirdly, one more limitation is related to the criteria initially used for the paper selection. Expanding criteria could lead to other EIPI not covered by this study. Thus, all these points are also opportunities for future research.

Finally, the results have corroborated that environmental innovation should be analyzed as a whole in order to have a sound method for measuring EI level including the four dimensions of EI (product, process, organizational and marketing) and a complete indicator combination in each type. Looking to the future, this research has provided much information with implications for industry, governments and academia to understand which EI indicators can be implemented by environmental stakeholders to reduce their negative environmental impact and become greener. This study also supplies a set of EI implementation indicators to aid practitioners and policy-makers in assessing the balance between company activities and sustainability. These are relevant opportunities to advance the academic perspective towards the constitution of a body of knowledge on this research topic.

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Multidimensional Assessment of Eco-Innovation Implementation: Evidence from Spanish Agri-Food Sector

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Abstract: Understanding eco-innovation is an essential endeavor to achieve global sustainable development. In this sense, further research on implementation is needed to expand knowledge beyond current boundaries. The aim of this paper is to contribute to this debate by conducting an original multidimensional analysis using Spanish agri-food sector data. The empirical methodology applies a combination of descriptive statistics, cluster analysis and the chi-squared test. Two groups of well-differentiated eco-innovative firms are identified, those with high and low eco-innovation implementation levels. Quality certifications, environmental consulting and cooperation with stakeholders are the variables that contribute most to distinguishing these two groups. The results also reveal that operating income volume, number of employees and commercialization volume are key factors to become more eco-innovative. In this sense, larger firms are found to have a higher level of eco-innovation implementation than small- and medium-sized enterprises. The main contributions of this work are fourfold. Firstly, it presents a comprehensive framework of eco-innovation implementation in its four dimensions (product, process, organizational and marketing). Secondly, it fills existing gaps in the literature by analyzing green organizational and marketing eco-practices. Thirdly, it expands the sectorial scope of eco-innovation research primarily focused on high-tech sectors. Finally, this study makes it possible to design certain policies for public and private decision makers.

Keywords: eco-innovation; implementation; multidimensional; agriculture; cluster analysis

1. Introduction

Eco-innovation (EI) is defined as the introduction of new products or significantly increasing a product/service's value, improving processes, and creating organizational changes and new marketing solutions that can minimize the use of natural resources (including material, energy, water and soil), as well as reduce the release of dangerous substances throughout a product life cycle [1]. This concept plays a crucial role in the transition towards more sustainability development economies [2,3]. Furthermore, when dealing with damage caused to the environment, EI is especially important in contexts where it is necessary to introduce new, cleaner production techniques and provide more efficient products and changes in business models [4–6]. Therefore, identifying the main EI practices implemented by different sectors can help public and private decision makers to understand what instruments need to be developed for the purpose of promoting EI.

In recent years, a number of works on EI practices have been conducted. Although the Inter-American Development Bank recognizes that organizational and marketing EI practices are key points for developing more sustainable economies [7], most of the research conducted has focused only on product and process EI dimensions [8–10]. In these cases, the conclusions obtained do not accurately contemplate all eco-practices and can only provide a limited overview of the EI reality that exists within different sectors. Therefore, there are very few studies which provide a comprehensive framework for the analysis of EI in its main environmental dimensions (product, process, organizational and marketing), and they only contemplate a certain type of firm (e.g., small and medium size or multinationals) in non-European markets [11,12]. Furthermore, the vast majority of EI studies are focused on the industrial sector [13,14]. For this reason, it is necessary to expand the sectorial scope of this topic to develop more efficient green practices, regulations and policies. As Gente and Pattanaro [15] highlight, further research on EI implementation is needed to expand knowledge beyond current boundaries and achieve global sustainable development goals (SDGs). In this sense, despite the fact that they have received very limited attention, two sectors of great environmental importance are agriculture and exports [16–18]. In the case of the exports sector, exporting firms face a highly complex environment as they are more exposed to global competition [19,20]. Some researchers have highlighted that it is precisely for this reason that these companies are more likely to introduce EIs [21,22], especially those directly related to a sector with significant environmental impact such as agriculture. For this reason, among others, agricultural innovation is vitally important for the successful development of the food production sector as well as for preserving the environment [23,24].

This paper contributes to filling these gaps in the literature by developing a comprehensive framework for evaluating EI implementation multidimensionally. Therefore, it elaborates a frame of reference, which makes it possible to analyze the EI practices implemented in the Spanish wholesale sector of fresh fruits and vegetables and, in turn, identify the characteristics, variables and green dimensions that contribute to differentiate the most eco-innovative companies.

For this purpose, a combination of descriptive analysis, cluster analysis and the chi-squared test were utilized [25]. The statistical analysis reveals the existence of two groups of eco-innovative firms with distinct levels of EI. The differences between the two groups are highly dependent on operating income level, number of employees and volume of commercialization.

2. Theoretical Framework

Different EI frameworks have been suggested in the literature for analyzing the level of EI implementation. Kemp and Pearson [26] recommend the environmental technology, organizational, product/service and green systems dimensions of innovation. Carrillo-Hermosilla et al. [27] and Kiefer et al. [28] propose using the design, user, product-service, and governance dimensions of EIs. Moreover, Rodriguez-Rodriguez et al. [29] and Galdeano-Gómez et al. [30] point out the importance of EIs to achieve synergies between socio-economic and environmental dimensions in the agri-food sector. Furthermore, with the aim to standardize critical aspects of EI studies, the Eco-Innovation Observatory (EIO) [31] considers EI the "introduction of any new or significantly improved product, process, organizational change or marketing solution that reduces the use of natural resources and decreases the release of harmful substances across the whole life-cycle." Following this guideline, some recent studies [11,12,32] propose four different main dimensions of EIs: product, process, organizational and marketing.

The present article builds upon the framework proposed by Marcon et al. [11] and García-Granero et al. [32] for analyzing EI implementation in an agri-food sector, because they provide a comprehensive overview of the main dimensions and subdimensions, accounting for the numerous individual characteristics of EI. In general, these four types of EI are complementary in many cases, so that the EI can be visualized with a holistic approach. Considering the close relationship with the environment that the agri-food activity has and the characteristics of companies (low-tech firms), the analysis of diverse dimensions can be important in order to offer a better view of EI implementation in this sector.

2.1. Eco-Innovation Dimensions

Product EI can be defined as the introduction of environmentally-friendly new products or significant improvements of product characteristics, such as advances in technical components and materials [33]. The theoretical framework on product EI is based on a vast line of research focused on the improvement of the type and quality of inputs used as well as on the sustainability of products with the aim of successfully complying with the current environmental regulations. Four main practices are contemplated in this approach. Some authors highlight the need to reduce the use of raw inputs in order to obtain less polluting products [14,34,35]. The use of cleaner materials or new inputs with lower environmental impact [7–10] is also proposed as a performance indicator. Marcon et al. [11] and Van Hemel and Cramer [36] analyze the use of recycled inputs. Besides, the product's ability to be reused [9,10] is a practice examined to reduce the level of energy and materials consumed at the same time it decreases CO_2 emissions and levels of waste [37].

According to Negny et al. [38], process EI modifies the organization's operational processes and systems, decreases unit costs of production, produces new or significantly improved eco-products and reduces environmental impact. A wide range of EI literature investigates those practices in the process dimension that firms implement with the aim of reducing their negative environmental impact. Most of these investigations introduce water and energy consumption [8,39] as EI indicators. For example, Alkaya and Demirer [40] apply them in a review of the Turkish chemical industry, Catellacci and Lie [9] utilize them to analyze the manufacturing sector in Korea, and Rodríguez and Weingarten [10] in a study on the German industry sector. Other process EI indicators contemplated by researches, which ensure the efficient use of natural resources while optimizing the level of waste in the production and commercialization processes, are the reuse of components or materials [35] and their recycling [8,10,36]. Moreover, the eco-indicator number of patents [41–44] is introduced by some authors to measure EI. Although patents could be an output of company research efforts and investments, the latter are not always patented. For this reason, it is also necessary to include other indicators such as R&D expenditure [7]. Some authors emphasize the importance of analyzing the level of investment in R&D activities to gain a better understanding of EI [10,45,46]. The practical use of renewable energy and environmentally-friendly technologies is also a well-known eco-innovator and a large number of works address this topic. Frondel et al. [47] highlight the environmental benefit of introducing end-of-pipe technologies in the manufacturing process. Garrod and Chadwick [37] emphasize the importance of investing in clean technologies in a study on English companies. In the same vein, Guziana [48] defends the innovative proactivity of clean technology.

Organizational EI can be explained as new or significant improvements in routines, methods and actions that improve firms' practices, relations and decisions with respect to the environment [11]. According to the findings of Chen [49], there are three types of green intellectual advantages, which encompass these essential corporate routines and practices [32]: human, structural and relational capital. Green human capital is attracting attention in the academic literature thanks to its impact on business decision-making. In this line, research such as Montalvo [50] and Chen and Chang [51] highlight the influence of green managerial characteristics in firm orientation towards an environmentally-friendly business model. Similarly, other authors uphold the role of senior staff in the green orientation business culture [52–55]. Furthermore, Banco Interamericano de Desarrollo (BID) [7] and Peng and Liu [56] underline the importance of introducing the analysis of a firm's green human resources as an indicator which shows its innovative efforts. On the other hand, green structural capital includes organizational capabilities, organizational commitments, organizational culture and philosophies, patents, copyrights, etc. Environmentally-oriented culture is an eco-innovator that has been analyzed for more than two decades by an extensive body of research. According to Williams et al. [57], introducing environmental objectives into production plans and operations is a useful variable for analyzing EI level, while for authors such as Frosh and Gallopoulos [58] and Tibbs [59], the implementation of external environmental audits is a good indicator of a company's intention of learning how to be more eco-innovative [60–62]. The hiring of environmental consulting services is another variable analyzed by the literature in this EI dimension [63–65]. In regard to green relational capital, the majority of the studies are focused on firm relationships with pressure groups [66–68] as a key factor to create new environmental improvement opportunities [49,69].

Marketing EI includes the implementation of new green marketing methods and refers to changes in product presentation, sales placement, communication, new methods of delivery, promotion or pricing strategies. Moreover, significant green changes in packaging are also considered important marketing EIs [11]. These innovation activities are relevant indicators for implementing and measuring EI as BID [7] emphasizes. However, marketing EI has received less attention than the other dimensions in environmental literature when analyzing the level of EI in a firm, sector or country [32]. The use of returnable packaging is the main practice studied by researchers [70–72], along with the use of recyclable packaging [36,73–75]. These green packaging design practices contribute towards reducing waste levels and the efficient use of resources [76,77]. What is more, biodegradable packaging is positioned as a key tool in several sectors to satisfy the environmental requirements of markets precisely because it is made of non-pollutant materials [78].

2.2. *Eco-Innovation in the Agri-Food Sector*

Innovation is positioned as a key factor in the discussion about the relation between agriculture and sustainability [79–82]. In fact, agricultural innovation is considered vital for the sustainability transition and achieving food security [83–85]. Thus, in recent years, some researches are focused on analyzing the EI phenom in this sector [16,86].

The increase in food crises, which place population health at risk, demands the implementation of new production practices that encourage the improvement of food safety levels. For this purpose, biological control and traceability implementation are two specific practices commonly carried out in the agri-food sector [87]. Barth et al. [86] point out the increment in product value that adds the traceability implementation. Galdeano-Gómez et al. [30] introduce the variable minimizing the use of fertilizers and phytosanitary product to measure the sustainability in the Spanish agricultural production. As a result, environmental sustainability is closely linked to biological control, as the latter is analogous to a high level of pest control [88].

Furthermore, the increase in population awareness about the environmental and health problems involved in the production and consumption of pollutant goods calls into question the need to use environmental certifications in order to achieve standards for safety and quality [86]. Certifications can be defined as a voluntary inspection process that audits and provides written assurance that a process, product or service meets a specific set of standards [89]. These standards prove the safety of the product customers consume [60,61,90]. In fact, there are several works that recommend the use of environmental certifications as an instrument for measuring EI [26,91–93]. Thus, private standards certifications, such as GLOBALG.A.P. (worldwide standard for Good Agricultural Practices) or GRASP (GLOBALG.A.P. Risk Assessment on Social Practices), are utilized in the European food sector as marketing tools to maintain consumer trust regarding the high quality of products, as well as to make considerations for animal welfare and environmental protection [94,95]. Recently, some studies introduced quality certifications in the EI analysis [93].

Other investigations highlight the importance of developing cooperation with stakeholders in the EI process [96,97]. Meanwhile, studies such us Drejeris and Miceikienė [98], Ulvenbland et al. [99] and Barth et al. [86] enhance the important value that a green organizational business model has in the transition towards sustainability. In this context, environmental attitudes, perceptions and intentions are included in the analysis of EI, and the staff environmental orientation is also a point of interest of investigations [86,98].

3. Materials and Methods

The research methodology was composed of the following main phases: a literature review, a survey questionnaire as a data collection tool, and, finally, a statistical data analysis including descriptive analysis, cluster analysis, and the chi-squared test. The three phases are detailed in the following section.

3.1. Definition of the Variables

A literature review based on Scopus and Web of Science (WoS) databases was conducted in order to identify contributions in the context of EI, not only to determine the variables, indicators and practices implemented, but also to identify what methodologies are applied to analyze EI.

García-Granero et al. [32] summarize the state of this field of research and highlight the main practices that have been taken into consideration by the literature to investigate how different sectors implement EI. This review determined which practices have a significant effect on the agri-food sector. Thus, the most relevant indicators and variables that should be measured were selected in order to analyze EI implementation in this sector (Table 1).

Table 1. Indicators and variables of eco-innovations included in the analysis.

Eco-Innovation Dimension	Eco-innovation Indicator	Description of the Variable		
		Name	Survey Question	Measurement Scale
Product EI	Ecological/integrated production	Ep	What percentage of the total production is dedicated to ecological/integrated production?	Percentage
Process EI	Biological control	Bc	Has your firm implemented biological control?	Dichotomous scale
	Recycled/reused materials	Rm	What percentage of the total use of plastics, pallets and packaging is recycled or reused?	Percentage
Organizational EI	Environmentally-oriented culture	Ct *	What is the importance of your company's environmental impact? What is the importance of adopting environmental plans and objectives in the company? What is the importance of achieving the environmental plans and objectives adopted? What is the importance of staff working with respect for the environment? What is the importance of investing in environmental initiatives? What is the importance of implementing EIs?	Likert scale (1–5)
	Quality staff	Qs	Percentage of employees working in the quality department?	Percentage
	Analysis laboratory	Lb	Does your firm have an internal analysis laboratory?	Dichotomous scale
	Environmental audit	Aud	Does your firm perform environmental audits?	Dichotomous scale
	Environmental consulting	Ax	Does your firm request environmental consulting from any expert?	Dichotomous scale
	Stakeholder cooperation	Cp	Does your firm cooperate with universities or R&D centers?	Dichotomous scale
Marketing EI	Quality certification	Certf	Number of quality certifications?	Natural numbers
		Ggp	Percentage of hectares certified with GLOBALG.A.P. certification?	Percentage
		Gsp	Percentage of hectares certified with GRASP certification?	Percentage
	Green design packaging	Rpkg	Use of recycled packaging?	Percentage
		Bpkg	Use of biodegradable packaging?	Dichotomous scale

* This variable is given by the average from the six survey questions. Source: own elaboration.

There is a common criterion throughout the EI literature for evaluating the level of product and process EI, regardless of the sector under analysis [8–10]. In the case of product EI, a great deal of the literature introduces variables that consider the improvement of the environmental characteristics of a product, either through the use of less polluting or reusable inputs [14,34,36]. As for process EI, most works analyze those variables related to the reuse, recycling or introduction of techniques that support the improvement of product quality [10,39]. However, with regard to organizational EI, while the vast majority of the EI studies in the last 20 years have focused on staff environmental culture and cooperation with stakeholders [52,58,100], other more recent studies have introduced practices such as environmental audits, environmental consulting or the implementation of environmental plans in daily business activity [7,26,62]. Similarly, while 20 years ago the EI literature did not contemplate marketing EI activities, subsequent studies highlight the introduction of green packaging and quality certifications as variables for measuring EI [39,60,61].

3.2. Sample and Data Gathering

This study is focused on the Spanish agri-food sector, specifically in the southeast region (provinces of Almeria, Granada and Murcia), due to the increase of production in this area and the adaptation process of ecological practices required in consumer markets in recent decades [30]. In this case, agricultural activity has a strong impact on the environment because it involves intensive use of resources, requires intensive transport and generates a considerable amount of waste [101]. These negative externalities have implied a constant adoption of innovations and eco-efficiency methods of production and commercialization in the sector's firms [93]. Moreover, Spain is the first exporter of fresh fruits and vegetables in the European Union and one of the three largest world exporters, together with the U.S. and China [102]. In terms of figures, Spanish exportation of these products reached 13.8 million tons in 2017, earning nearly 15 billion EUR [103]. In this context, the Spanish provinces of Almeria, Granada and Murcia contribute to these figures by more than 50 percent [95,104]. Figure 1 shows the location of this Spanish region.

Figure 1. Location map of the region of Almeria, Granada and Murcia in Spain.

To achieve the objectives proposed in this research, the data were obtained through surveys designed for this purpose. Questionnaires were aimed at staff who were closely involved in the EI aspects of the firms. All farming–marketing firms were contacted by telephone and all the individuals identified were then invited to participate in the survey via telephone or email. The survey was carried out in January and February 2019, coinciding with the production and commercialization season 2017–2018 (from September to July).

According to the Iberian Balance Sheet Analysis System (*Sistema de Análisis de Balances Ibéricos* in Spanish, SABI), 302 firms commercialized fruit and vegetables in the provinces of Almería, Murcia and Granada in 2017. The sample was randomly selected without replacement. The final number of valid surveys was 79. This represents a response rate of 22.32%, which is highly satisfactory. According to Menon et al. [105], the average top management survey response rate is in the range of 15–20 percent.

The descriptive analysis of the questionnaire responses from the sample of fresh fruit and vegetable commercialization companies is shown in Table 2.

Table 2. Profile of the final sample (frequencies for descriptive variables).

Variable	Description	Frequency (*N* = 79)
Age (years)	<15	31
	15–30	34
	31–45	9
	>45	5
Number of employees	<50	25
	50–250	31
	>250	23
Legal form	Limited liability companies (SL in Spanish)	50
	Anonymous society (SA in Spanish)	6
	Agrarian transformation company (SAT in Spanish)	12
	Cooperatives	11
Operating income (million EUR)	<10	28
	10–43	32
	>43	19
Commercialization volume (million kg)	<10	27
	10–50	36
	51–100	8
	>100	8
Percentage of commercialization volume in vegetables (%)	<50	14
	≥50	65
Percentage of commercialization volume allocated to European market (%)	<50	6
	≥50	73

This table indicates that limited liability companies dominate the sector (63.29%), followed by agrarian transformation companies (15.19%) and cooperatives (13.92%). The majority of the firms are between 15 and 30 years of age (43.04%). The figures also reveal that 39.24% of the firms have between 50 and 250 employees and 40.51% have operating incomes between 10 and 43 million EUR. Thus, these characteristics indicate that the sector is mainly represented by medium-sized companies. Furthermore, the survey also shows that 45.57% have a commercialization volume between 10 and 50 million kilos and 82.28% commercialize more than half of this volume in vegetables, meaning the sector is dominated by the fresh vegetable commercialization firms. In addition, 92.4% of the companies are European market oriented, as more than the half of their commercialized volume is allocated to this market.

3.3. Estimation Methods

Three statistical techniques were used: descriptive analysis, cluster analysis, and the chi-squared test [25,106,107]. Descriptive analysis provided a better understanding of the profile of companies in the sector. Cluster analysis is a multivariate statistical technique that is able to separate the sample into groups, achieving maximum homogeneity in each group and clearly differentiating between the groups. There are two main types of cluster analysis: non-hierarchical cluster and k-means cluster [108].

Firstly, the non-hierarchical cluster analysis (Ward's method) was used in this investigation to identify the number of groups that maximizes heterogeneity among them [109]. The results, presented in a dendrogram (see Appendix A, Figure A1), indicate that two is the optimal number of clusters in the sample: Group 1 (the lowest eco-innovator firms) and Group 2 (the highest eco-innovator firms).

Once the optimal number of groups was obtained, k-means cluster was applied, choosing the Euclidean distance as the distance measurement [110]. K-means cluster allocates every data point to the nearest cluster while keeping the centroids, previously calculated for each group, as small as possible. Next, a one-way ANOVA was carried out with the aim of testing the statistical differences between the clusters [25,111].

Finally, the chi-squared tests checked the relationship between the compositions of Groups 1 and 2 and the following profile variables: age of the company, operating income, number of employees, commercialization volume and percentage of commercialization volume in vegetables. The choice to use the chi-squared test was based on the relevance of knowing the main socio-economic factors that can affect firms' decisions to implement EIs [25,112].

4. Results

The main results of applying descriptive statistics, cluster analysis and the chi-squared test are presented below.

4.1. Descriptive Statistics

Table 3 presents a brief description of the EI variables measured in the study in order to provide a profile of the firm's eco-innovative level. Additionally, the correlation coefficients of variables are detailed in Appendix A (Table A1).

Table 3. Summary statistics for the EI variables in the sample.

Variable	Variable Name	Mean	Std. Dev.	Min.	Max.
Product EI					
Ep	Ecological/integrated production	0.21	0.33	0	1
Process EI					
Bc	Biological control	0.80	0.40	0	1
Rm	Recycled/reused materials	0.47	0.37	0	1
Organizational EI					
Ct	Environmentally-oriented culture	3.73	0.86	0	5
Qs	Quality staff	0.053	0.37	0	0.33
Lb	Analysis laboratory	0.15	0.36	0	1
Aud	Environmental audit	0.44	0.50	0	1
Ax	Environmental consulting	0.46	0.50	0	1
Cp	Stakeholder cooperation	0.42	0.49	0	1
Marketing EI					
Certf	Quality certifications	4.44	2.57	0	11
Ggp	GLOBALG.A.P. certification	0.64	0.36	0	1
Gsp	GRASP certification	0.52	0.41	0	1
Rpkg	Recycled packaging	0.44	0.38	0	1
Bpkg	Biodegradable packaging	0.27	0.44	0	1

The data show that the average percentage of employees in charge of controlling and managing the quality of the products as well as the production processes is below 5.5%. This figure is rather small in relation to the maximum percentage of staff in these areas, which reaches 33% in some firms. Nevertheless, the mean level of green organizational culture displays a high value (3.73), which is reflected in the high implementation of certain eco-innovative practices, such as biological control, environmental consulting or production certified with GLOBALG.A.P.

These preliminary data also reveal the sector's weakness in the implementation of some green practices, for example, recycling, the use of biodegradable packaging or the implementation of internal biological control laboratories. These practices display an average value below 0.5, which means a great deal must still be done to achieve greater environmental efficiency.

4.2. Cluster Analysis. Typology of Firms With Regards to Eco-Innovation Implementation

An exploratory factor analysis was conducted because the data collected were reported using a single informant from each company and from the same questionnaire in the same period [113]. Previously, variables were normalized with the aim of comparing different measuring instruments. The results reveal that the first factor captures only 28% of the variance, which demonstrates a low threat of common method bias. Next, a non-hierarchical cluster analysis (Ward's method) was applied, prior to the k-means cluster analysis, in order to find the number of groups that maximize the differences between them, as mentioned in Section 3. The results obtained in the dendrogram (Appendix A, Figure A1) were analyzed and two clusters appeared as the best solution. In order to confirm the number of clusters selected, the Calinski test was performed. The two-group solution with a Calinski–Harabasz pseudo-F value of 87.44 was largest, indicating that the two-group solution was the most distinct compared with the three-group (72.85), four-group (55.60) and five-group (48.03) solutions. Thus, two different groups were identified: Group 1, consisting of firms with a lower level of EI implementation; and Group 2, made up of firms with a higher level of EI implementation. The results are shown in Table 4, which displays the values of the main variables.

Table 4 also shows the analysis of the variance of the cluster analysis (one-way ANOVA analysis). All the variables, except "the use of biodegradable packaging," differ statistically between groups with a level of likelihood of 5% (p-value < 0.05). The results also reveal that the variables "number of quality certifications," "percentage of GLOBALG.A.P. certified hectares" and "percentage of GRASP certified hectares" are those that contribute most to the differentiation between groups; followed by the variables "biological control," "environmental consulting" and "cooperation with stakeholders."

Figure 2 presents the mean values of Groups 1 and 2 for the different quantitative variables measured on a numerical scale shown previously in Table 1. In contrast, Figure 3 displays the mean values of Groups 1 and 2 for the different qualitative variables and those quantitative variables measured on a percentage scale.

Table 4. Characteristics of identified clusters and test statistics of one-way ANOVA.

		Eco-Innovative Firm Clusters					
		Group 1 $N = 37$		Group 2 $N = 42$			
		Low		High			
Variable	**Variable Name**	**Mean**	**Std. Dev.**	**Mean**	**Std. Dev.**	***F***	***p*-Value**
Product EI							
Ep	Ecological/integrated production	0.10	0.24	0.31	0.37	9.57	.003
Process EI							
Bc	Biological control	0.58	0.50	0.98	0.15	22.29	0.000
Rm	Recycled/reused materials	0.35	0.33	0.59	0.37	10.80	0.002
Organizational EI							
Ct	Environmentally-oriented culture	3.42	0.87	4.03	0.65	13.65	0.000
Qs	Quality staff	0.07	0.08	0.04	0.05	3.46	0.067
Lb	Analysis laboratory	0.08	0.27	0.30	0.41	2.74	0.002
Aud	Environmental audit	0.19	0.42	0.65	0.49	17.33	0.000
Ax	Environmental consulting	0.22	0.44	0.65	0.49	14.70	0.000
Cp	Stakeholders cooperation	0.19	0.40	0.60	0.50	17.96	0.000
Marketing EI							
Certf	Quality certifications	2.61	1.91	5.98	1.85	69.63	0.000
Ggp	GLOBALG.A.P. certification	0.36	0.35	0.88	0.16	71.56	0.000
Gsp	GRASP certification	0.22	0.30	0.78	0.28	82.28	0.000
Rpkg	Recycled packaging	0.30	0.37	0.57	0.36	10.79	0.002
Bpkg	Biodegradable packaging	0.22	0.41	0.30	0.47	0.87	0.355

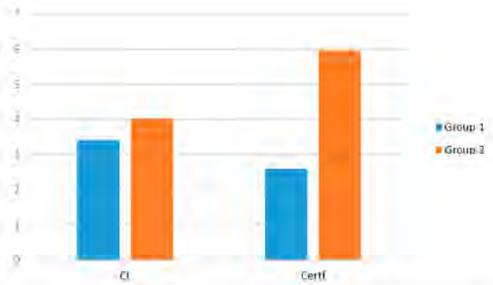

Figure 2. Average scores for Groups 1 and 2 in eco-innovations quantitative variables measured in number scale. Notes: Ct = Environmentally-oriented culture; Certf = Quality certifications.

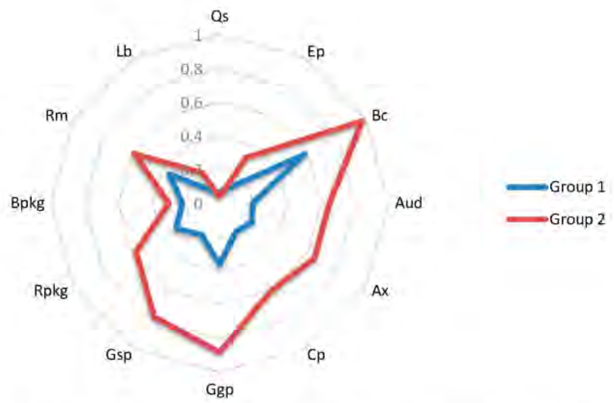

Figure 3. Average scores for Groups 1 and 2 in eco-innovations quantitative variables measured in percentage scale and qualitative variables. Note: Ep = Ecological/integrated production; Bc = Biological control; Rm = Recycled/reused materials; Ct = Environmentally-oriented culture; Qs = Quality staff; Lb = Analysis laboratory; Aud = Environmental audit; Ax = Environmental consulting; Cp = Stakeholders cooperation; Certf = Quality certifications; Ggp = GLOBALG.A.P. certification; Gsp = GRASP certification; Rpkg = Recycled packaging; Bpkg = Biodegradable packaging.

Group 2 is comprised of firms with higher environmental cultures. This orientation leads them to introduce environmental plans and aims into their daily activities. Also, the senior staff place the utmost importance on all company operations being environmentally respectful and fulfilling the environmental goals established. Thus, these firms conduct environmental audits and cooperate with environmental experts, universities and R&D groups in order to discover new ways to reduce their negative environmental impact. Moreover, these firms comply with a large number of certifications in order to meet the quality standards requested by consumers and markets. Furthermore, some firms in Group 2 have introduced internal laboratories with the aim of conducting random pesticide and insecticide controls to ensure levels of these inputs are kept to the minimum. Finally, their use of recyclable and biodegradable packaging is higher.

As for Group 1 companies, in the survey they also responded as having a high level of environmentally-oriented culture and display a slightly higher percentage of employees in the quality department than Group 2. Nevertheless, the results reveal low values of EI implementation in practices such as the number of quality certifications and the volume of ecological production commercialized. In addition, their cooperation with stakeholders as well as their use of recyclable packaging and their recycled material volume is still far from Group 2 implementation levels.

4.3. Chi-Squared Tests

In order to understand how and why the two groups are different, a chi-squared analysis was used to determine which characteristics in the two clusters differ [112]. The chi-squared test examines the relationship between the composition of groups and the following profile variables: age of the company, percentage of the commercialization volume in vegetables, operating incomes, number of employees and commercialization volume. With an error of less than 5%, the analysis revealed that the age of the company and the percentage of the commercialization volume in vegetables are not factors that contribute to differentiating the level of EI between groups, as shown in Tables 5 and 6.

Table 5. Observed and expected frequencies for age of the company in Groups 1 and 2.

Age of the Company (Years)			Less than 15	Between 15–30	Between 30–45	More than 45	Total
Group	1	Observed	17	17	2	1	37
		Expected	14.5	15.9	4.2	2.3	37
	2	Observed	14	17	7	4	42
		Expected	16.5	18.1	4.8	2.7	42

Pearson chi-squared: 4.570; $df = 3$; $p = 0.206$.

Table 6. Observed and expected frequencies for percentage of the commercialization volume in vegetables in Groups 1 and 2.

Percentage of the Commercialization Volume in Vegetables (%)			Less than 50	More than 50	Total
Group	1	Observed	8	29	37
		Expected	6.6	30.4	37
	2	Observed	6	36	42
		Expected	7.4	34.6	42

Pearson chi-squared: 0.726; $df = 1$; $p = 0.394$.

Table 7 presents the observed and expected frequencies for the operating income in Groups 1 and 2. The observed number of firms in Group 1 with operating incomes under 43 million EUR is higher than the expected frequency, while the observed number of firms in Group 2 with operating incomes above 43 million EUR is higher than the expected number. Thus, those firms whose operating incomes are above 43 million EUR are influenced by factors that drive them to be more eco-innovative.

Table 7. Observed and expected frequencies for operating income in Groups 1 and 2.

Operating Income (Thousands of Euros)			Less than 10,000	Between 10,000–43,000	More than 43,000	Total
Group	1	Observed	21	16	0	37
		Expected	13.1	15	8.9	37
	2	Observed	7	16	19	42
		Expected	14.9	17	10.1	42

Pearson chi-squared: 25.787; $df = 2$; $p = 0.000$.

Tables 8 and 9 present the observed and expected frequencies for the number of employees and the millions of kilos commercialized in Groups 1 and 2, respectively. The observed number of firms in Group 2 with more than 250 employees and a volume of commercialization over 50 million kilos is higher than the expected number. Therefore, firms with more than 250 employees and a volume of commercialization over 50 million kilos are influenced by factors that drive them to be more eco-innovative.

Table 8. Observed and expected frequencies for number of company employees in Groups 1 and 2.

Employees (number)			Fewer than 50	Between 50-250	More than 250	Total
Group	1	Observed	18	19	0	37
		Expected	11.7	14.5	10.8	37
	2	Observed	7	12	23	42
		Expected	13.3	16.5	12.2	42

Pearson chi-squared: 29.221; $df = 2$; $p = 0.000$.

Table 9. Observed and expected frequencies for commercialization volume in Groups 1 and 2.

Commercialization volume (millions of kilos)			Fewer than 10	Between 10–50	Between 50–100	More than 100	Total
Group	1	Observed	16	20	0	1	37
		Expected	12.2	16.9	3.7	4.2	37
	2	Observed	10	16	8	8	42
		Expected	13.8	19.1	4.3	4.8	42

Pearson chi-squared: 15.017; $df = 3$; $p = 0.002$.

5. Discussion

The statistical results highlight some weaknesses in EI implementation in the Spanish agri-food sector. On one hand, the sector does not place enough importance on the implementation of certain eco-innovative practices (e.g., waste level, water/energy consumption or R&D investments). Consequently, it also ignores other EI practices that are very important to achieve cleaner production and environmental sustainability in the sector.

On the other hand, regarding product EI, despite the fact that ecological and integrated production has increased in recent years, it continues to be lower than that of traditional production. As the cluster analysis demonstrates, the level of ecological or integrated production does not reach 50% of the total production. Regarding process EI, although all the sector companies implement traceability control due to its being legally required, biological control is not implemented by the whole sector, despite being a key factor in quality control of goods and ecosystems. These results demonstrate the need to implement eco-support policies along with more mandatory environmental policies, with the aim of urging companies to introduce eco-innovative practices in their daily activities. Environmental regulations are positioned as key drivers of EI initiatives [36] and have special influence on Spanish firms [114].

Concerning organizational EI, Group 2, which is comprised of the most eco-innovative firms, has a greater propensity to establish relationships with environmental experts and stakeholders in order to improve its environmental impact. As the descriptive analysis highlights, this group of companies not only regularly performs environmental audits and requests environmental consulting, but it also has a higher number of staff allocated to control the quality of goods and the production process. This description confirms the conclusion reached by González-Moreno et al. [115] regarding the need to create intense relationships with stakeholders in order to develop a fluent EI process in the food sector. Also, these findings are in line with other works that underscore the importance of relationships with pressure groups in the development of EI [28,65,116,117].

Regarding marketing EI, green packaging design is another point to address. The use of recycled or biodegradable materials is positioned as an environmental solution, but despite increased usage in recent years, its implementation is still low [78]. As the cluster analysis reveals, the use of recycling packaging is located far below 40% in Group 1 and the use of biodegradable packaging in both groups barely reaches 30%. Thus, in accordance with the recommendation of Ahmed and Alam [118], promoting the use of green packaging is an important environmental and marketing tool.

In environmental terms, it contributes significantly to reducing waste levels and CO2 emissions; while in terms of marketing, it contributes to market growth. Futhermore, as Verghese and Lewis [119] defend, cooperation in packaging systems ensures reductions in costs and increases in environmental efficiency. With regard to environmental certifications, they are a tool that is increasingly implemented by the sector and the indicators related to them contribute most to differentiating the EI level between groups, as the ANOVA analysis reveals. According to the findings of Segarra-Oña et al. [89], these certifications are indicative of incremental innovations.

The results also reveal that most of the sector companies are small- and medium-sized companies (75.9%); however, those companies with an income volume above 43 million EUR are more likely to implement eco-innovative practices. This is in line with Becheikh et al. [11], who point out that the innovation activity is more probable in large-sized firms. As Arranz et al. [120] states, the lack of EI development in firms can be caused by the perception of high costs, the need for financing and the lack of environmental knowledge. In this line, implementing policies that promote financial incentives as well as non-financial, such as seeking environmental partners, is a key factor to achieve cleaner production [115,120–122]. In accordance with the findings of Ghisetti and Pontoni [123], regulatory stringency has positive, significant effects on EI, and policy-makers need to introduce regulatory-standards in order to further promote sustainable transition. This is of great interest especially in the agri-food sector, highly linked to the use of natural resources and the food value chain. According to the SDGs, promoting EI the in agri-food sector contributes to encouraging companies to implement greener production methods with less amount of waste, use natural resources in an efficient way and obtain products more respectful to the public health, in accordance with the quality requirements [11,29,124].

6. Conclusions

This study conducts a multidimensional analysis of EI implementation. For that purpose, the study complies sets of variables for the four main dimensions of EI (product, process, organizational and marketing), utilizing data from a survey carried out ad hoc on the agricultural sector in the southeast of Spain. Thus, seeking to undertake much more than a mere conventional analysis of EI implementation and to expand the sectorial focus of study, the empirical analysis examined several types of EI practices implemented in an agri-food sector: Spanish wholesalers of fruits and vegetables.

The statistical analysis reveals that, despite having a group of more eco-innovative companies, the efforts made to reduce negative environmental externalities are mostly limited to large companies as they have more economic resources. In fact, the vast majority of the sector is composed of small-and medium-sized companies, which show less propensity to eco-innovate, especially in those green practices with higher costs of implementation, such as the use of recyclable and biodegradable packaging or the implementation of internal analysis laboratories for better control of pollutant input usage in the production of the goods. Moreover, although most of the companies are certified with quality certifications, not all of their production comes from farmers that are standard certified. In addition, regarding the group of less eco-innovative firms, the results highlight the need for an increase in their environmental awareness. For instance, although they responded in the survey as introducing environmental plans and aims in their daily activity, the insufficient degree of cooperation with environmental experts reveals that a great deal of work still remains to be done in order to achieve a sustainable production process. These results demonstrate the need to develop new financial and non-financial regulations that support innovation practices in the sector, especially for small- and medium-sized companies, while also taking into consideration the importance of organizational and marketing eco-dimensions.

6.1. Implications for Theory and Practice

Overall, this investigation develops a comprehensive framework for a multidimensional analysis of EI implementation in its four dimensions, filling the gap in the literature, which has focused mainly on analyzing product and process, and only includes organizational and marketing EI to some extent. Also, as most of the analyses of this issue are focused on the industrial sector, this research offers a new framework on the state of EI implementation in a high impact environmental sector: the agri-food sector. Thus, this study makes it possible to broaden the focus of analysis and develops a method of EI analysis that more closely resembles reality.

In addition, the findings of this research infer some policy implications for both public and private decision makers, contributing to the transition towards sustainable development. On one hand, it allows governments to know in which directions regulatory efforts should be focused. For example, they should promote more fiscal benefits and economic aid to encourage small- and medium-sized companies to implement greener practices, especially related to organizational and marketing dimensions. Small- and medium-sized companies have to make more efforts to bear the high costs of implementing eco-practices, so facilitating R&D cooperation with universities and research centers would support the assumption of these costs. In addition, decision makers should encourage the access of these types of companies to public funds specially destined for the development of ecological practices. On the other hand, it provides companies with knowledge on green practices that can be implemented to become more environmentally efficient, and also helps them to understand the importance of implementing EI practices in all dimensions in order to achieve cleaner production and develop sustainable production processes.

6.2. Limitations and Future Research

Like all empirical research, this study features some limitations, which could serve as reference for future works. Firstly, some relevant EI variables could not be measured (e.g., level of waste or recycling of materials) because the firms simply do not keep logs on certain data. Therefore, firms should be encouraged to register this important information, which would allow future works to focus on expanding the variables that have an influence on EI implementation. Secondly, a posterior EI analysis could be conducted to compare results with those initially obtained to determine their evolution over time. Thirdly, the study focuses on the Spanish agri-food sector, so it would be particularly interesting if future research conducted a similar analysis of other national and international agri-food sectors in order to make comparisons. Finally, the multidimensional assessment framework of EI implementation proposed by this paper could be applied to other sectors.

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Appendix A

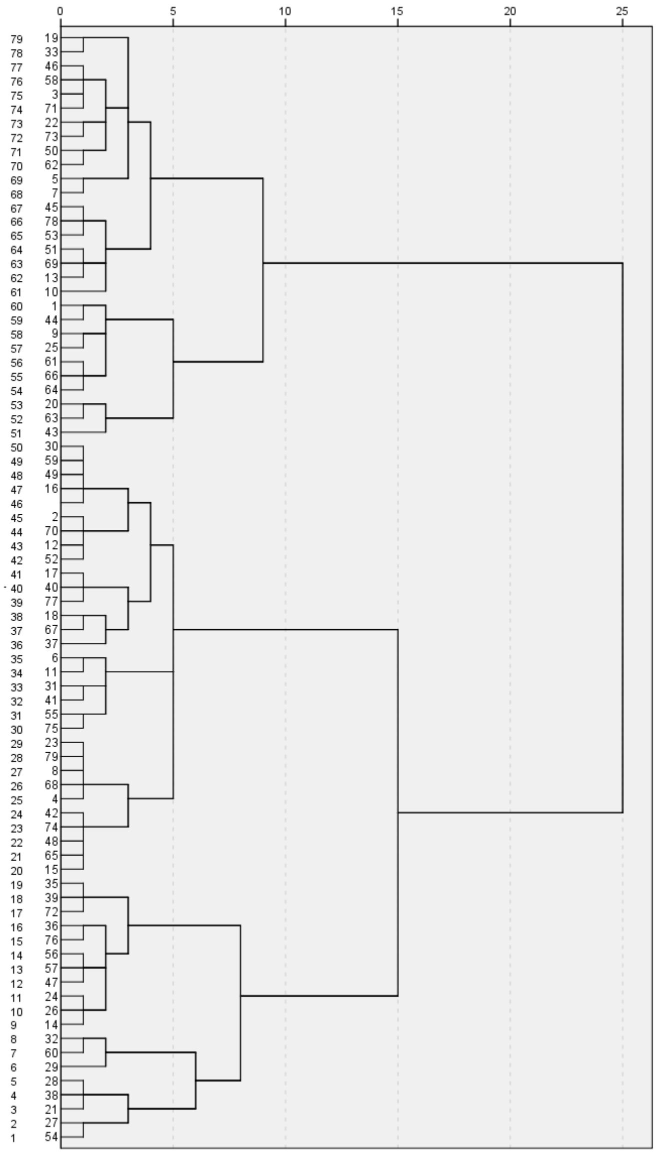

Figure A1. Cluster dendrogram.

Table A1. Pairwise correlation coefficients of variables.

	Ct	Ep	Bc	Qs	Aud	Ax	Cp	Certf	Ggp	Gsp	Rpkg	Bpkg	Rm	Lb
Ct	1	0.149	0.084	0.068	0.012	0.034	−077	−243	−333	−255	−203	−052	−178	0.400
Ep	0.149	1	0.187	0.155	0.257	0.295	0.311	0.273	0.351	0.337	0.156	0.172	0.103	0.223
Bc	0.084	0.187	1	0.253	0.408	0.113	0.038	0.256	0.140	0.226	0.150	0.095	0.020	0.105
Qs	0.068	0.155	0.253	1	0.259	0.208	0.044	0.383	0.381	0.334	0.188	0.161	0.228	0.126
Aud	0.012	0.257	0.408	0.259	1	0.465	0.278	0.474	0.291	0.231	0.163	0.156	0.024	0.120
Ax	0.034	0.295	0.113	0.208	0.465	1	0.256	0.339	0.206	0.152	0.112	0.082	0.009	0.250
Cp	−077	0.311	0.038	0.044	0.278	0.256	1	0.436	0.271	0.275	0.107	0.013	0.147	0.357
Certf	−243	0.273	0.256	0.383	0.474	0.339	0.436	1	0.491	0.473	0.399	0.165	0.191	0.134
Ggp	−333	0.351	0.140	0.381	0.291	0.206	0.271	0.491	1	0.535	0.343	0.018	0.298	0.038
Gsp	−255	0.337	0.226	0.334	0.231	0.152	0.275	0.473	0.535	1	0.334	0.141	0.250	0.031
Rpkg	−203	0.156	0.150	0.188	0.163	0.112	0.107	0.399	0.343	0.334	1	0.178	0.408	−081
Bpkg	−052	0.172	0.095	0.161	0.156	0.082	0.013	0.165	0.018	0.141	0.178	1	0.175	−095
Rm	−178	0.103	0.020	0.228	0.024	0.009	0.147	0.191	0.298	0.250	0.408	0.175	1	−022
Lb	0.400	0.223	0.105	0.126	0.120	0.250	0.357	0.134	0.038	0.031	−081	−095	−022	1

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Measuring eco-innovation dimensions: The role of environmental corporate culture and commercial orientation

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ABSTRACT

Eco-innovation (EI) is a complex process that involves product, process, organizational and marketing dimensions, each with its own determinants, characteristics and contributions to environmental business performance. Thus, analyzing EI activity is essential to obtaining a holistic view in order to achieve sustainable development. This study offers a multidimensional EI measurement and, what is more, evaluates its relationship with environmental corporate culture and commercial orientation drivers in a high environmental impact context, i.e., the agri-food sector. The proposed model was tested using the partial least-squares technique, which was applied to data collected from a sample of 93 companies located in southeast Spain. This study confirms the importance of several dimensions, namely marketing, organization and process, to corporate adoption of EI. Additionally, this research also reveals the positive relationship that both drivers, environmental corporate culture and commercial orientation, have with EI. The findings also suggest that theorists and practitioners must contemplate EI from the point of view of its four dimensions in order to achieve an efficient, more realistic analysis. Subsequently, this work carries some theoretical conclusions and implications for research and practice.

1. Introduction

Despite decades of academic and practitioner attention, interest in the analysis of the eco-innovation (EI) process continues to increase. In fact, growing awareness of climate change and environmental degradation makes it necessary for companies to implement EI to respond to consumers' environmental demands and regulatory requirements. In this context, there is a growing belief that the agri-food sector is a key factor in the development of more sustainable economies, mainly because of its multidimensional performance (Gómez-Limón and Sánchez-Fernández, 2010). The complex relationship of this sector with the environment (e.g., resource conservation, socioeconomic factors, etc.) positions EI as a significant element for achieving economic and environmental benefits (Galdeano-Gómez et al., 2017). Implementing EI allows companies and sectors to be more sustainable and, at the same time, to increase their competitiveness and productivity (Adams et al., 2012; OECD, 2013).

EI is defined as "the production, assimilation or exploitation of a product, production process, service or management or business method that is novel to the organization (developing or adopting it) and which results, throughout its life cycle, in a reduction of environmental risk, pollution and other negative impacts of resources use (including energy use) compared to relevant alternatives" (Kemp and Pearson, 2007 p.7). This complex process has been addressed from different perspectives in recent decades. From the firm-level perspective, a growing body of literature on EI drivers has been developed and there are common conclusions about which are the stimuli that motivate firms to implement greener practices. Some research defends the positive impact that internal characteristics have on a company's decision to be 'greener', such as firm size, solvency rate, social structure or personal circumstances (Feder et al., 1985; Diederen et al., 2003; Gardebroek, 2006; Knickel et al., 2009). In contrast, other authors focus their investigations on the influence that external environment has on a firm's reason for implementing EI. Some of the external factors most commonly considered by EI literature are the regulatory and institutional frameworks, for instance setting new standards, and the demand-pull drivers, i.e., market conditions (Reinnings, 2000; Horbach, 2008; Kesidou and Demirel, 2012; de Marchi, 2012; Doran and Ryan, 2016). Technology-push factor, i.e., advances in science and R&D, is also a key determinant of EI (Cleff and Rennings, 1999; Horbach, 2008; Ghisetti and Pontoni, 2015). Other works outline a combination of these factors that affect firms' EI adoption (Carter and Williams, 1959;

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Kleinknecht and Verspagen, 1990; Ghisetti and Pontoni, 2015). In this line, recent EI literature brings to the forefront the effect that firm commercial orientation as well as environmental corporate culture have on the business decision to implement eco-innovative practices, especially in agri-food firms (Rkein and Andrew, 2012; Rodríguez-Rodríguez et al., 2012; Ortiz-de-Mandojana et al., 2016; Tsai and Liao, 2017; Liao, 2018). Commercial orientation, as an organizational capability, significantly influences environmental business strategy and environmental corporate identity (Wang et al., 2018).

Regarding the EI implementation perspective, and despite its having generated considerable advances, there is no prior research that provides insights related to a complete and efficient EI measurement. Most studies in this field prove incomplete as they only consider EI implementation analysis from the product and process dimensions (Doran and Ryan, 2016; Castellacci and Lie, 2017; Rodríguez and Wiengarten, 2017). Very few studies contemplate the four EI dimensions, i.e., product, process, organization and marketing (Marcon et al., 2017; Astuti et al., 2018), and they only focus on the industrial sector and multinational companies. Furthermore, those works that are focused on the agri-food sector include a limited range of green indicators for assessing environmental performance (Rodríguez-Rodríguez et al., 2012; Galdeano-Gómez et al., 2017; El Bilali, 2018). In this sense, further investigations are necessary to develop a body of knowledge on this subject, especially due to the increased awareness of the importance that green marketing and organizational practices have on company environmental performance (BID, 2007; Marcon et al., 2017; García-Granero et al., 2018). Likewise, it is important to conduct research in the agri-industry due to a need for increased food production in a world combined with a need for better degrees of sustainability in the food value chain (Barth et al., 2017).

As some authors mention "you cannot manage what you do not measure" (Cooper and Edgett, 2008; Ehrenfeld, 2008). In this sense, this work aims to analyze EI implementation using a multidimensional approach. Therefore, the main objective is to develop a holistic EI implementation level model, regardless of firm size, and, more specifically, offer a multidimensional EI measurement including green product, process, organizational and marketing dimensions. In the same model, this study also tests the relationship between EI and firm features of environmental corporate culture and commercial orientation, within the agri-food sector. These go beyond the limitations established in other research, analyzing EI implementation in a context of study which differs from the industrial sector, while at the same time helping to understand this multifarious practice. In this way, we address the following research questions: 1) Is environmental corporate culture positively related to EI level? 2) Is commercial orientation positively related to EI level? 3) What is the relationship between EI level and its four dimensions (product, process, organization and marketing)? To answer these questions, a Partial Least Squares based-structural equation modeling method (PLS-SEM) was applied to the agri-food sector. In particular, we focus on the fruit and vegetable farming-marketing companies of southeast Spain, which operate in environments aimed at international markets and whose evolution has been notably marked by environmental issues (Galdeano-Gómez et al., 2013). These farming-marketing companies, acting as wholesalers in origin (i.e., located in the production areas), are characterized by an intensive horticulture and a commercial activity aimed at European countries. This agri-food system implies considerable amounts of waste and residues, intensive use of resources and water consumption (Rodríguez-Rodríguez, 2012). Therefore, these firms have an important role in overcoming externalities and moving towards a more environmentally-respectful production system (Galdeano-Gómez et al., 2017).

Consequently, this study makes two main contributions. First, this paper contributes to the stream of research providing a novel multidimensional EI measurement contemplating all types of companies, regardless of size. It offers a holistic view on which EI types provide greater opportunities to comply with environmental requirements. Secondly, this research also tests a more complex relationship between environmental corporate culture, commercial orientation and EI level in a sector closely linked to the environment: the agri-food sector. To our knowledge, there are no previous works that have studied all these aspects in the same empirical model; thus, a considerable research gap is herein addressed.

The present study is structured as follows. Section 2 presents the theoretical background, model and hypotheses. It also includes a brief conceptual delimitation of the different constructs (environmental corporate culture, commercial orientation and EI level) that shape the research model. Section 3 contains a description of the research methodology used to test the hypotheses posited. Subsequently, Section 4 provides a detailed description of the main results derived from the data analysis through Partial Least Squares (PLS) path-modeling. Finally, Section 5 presents the discussions, conclusions, implications and limitations of this study.

2. Background and hypotheses

EI activity is a complex process that includes a vast diversity of innovations which can be classified into four dimensions: product, process, organization and marketing (BID, 2007; Marcon et al., 2017; García-Granero et al., 2018). These four types of EI coexist in all sectors; thus, developing a scale to measure them by identifying their key performance factors is crucial to achieving an accurate measurement level of EI implementation.

Although the phenomenon of EI has received increasing attention in recent decades, most of the literature approaches this topic in a variety of industrial sectors (García-Granero et al., 2017). For example, Van Hemel and Cramer (2002) and Alkaya and Demirer (2015) highlight EI implemented in the chemical industry; Crabbé et al. (2013) study EI in companies from building industry, chemical industry, furniture manufacturing, medical equipment, metal processing and plastic processing industry; while Theyel (2000) focuses on the plastic and resin sector. More studies about EI in the industry have been carried out with the aim of exploring and explaining the EI process itself (Dalhamar, 2015; Castellacci and Lie, 2017; Rodríguez and Wiengarten, 2017). However, in recent years, there has been a trend towards highlighting the importance that the agri-food sector has in the sustainability transition and the role EI has as a competitive advantage for the future of these companies (Barth et al., 2017; García et al., 2018). In fact, the attention paid by institutions and businesses to the environmental and social implications of this sector has encouraged companies to improve their environmental performance. Moreover, as far as quality is concerned, consumers are increasing their demand for environmentally-friendly production methods (Carpentier and Ervin, 2002; Galdeano-Gómez et al., 2013). Sustainable agricultural development can enhance the nutritional quality of food and thereby produce positive health effects (Benbrook et al., 2013). Several studies address these questions and agree on the capacity that the agri-food sector has for implementing EI and adapting to these green demands (Galdeano-Gómez et al., 2017; Labella et al., 2017). One line of EI research in the agri-food sector is focused on analyzing a series of motivating factors that lead companies to adopt more sustainable practices. Lioutas and Charatsari (2018) contemplate the adaption to social requirements, environmental concern, convenience, economic incentives and the internal need to pursue change, such as factors related to EI adoption decisions. Guerrero-Lara et al. (2019) investigate the influence of legislation, administrative support and social-economic values on the promotion of EI in the Spanish agri-food sector. In the same context of study, Rabadán et al. (2019) focus their investigation on the influence that market green demand, regulation, cooperation and economic objectives have on firm EI strategy. As for other aspects, a great deal of the EI literature in the agri-food sector addresses the development of a framework, which enables the conceptualization of EI practices. (Dangelico et al., 2019). Galdeano-Gómez et al. (2013)

investigate the EI process and the synergies between the sustainability dimensions integrating technology and green practices oriented towards the efficient use of resources in ecological aspects. Rodríguez-Rodríguez et al. (2012) analyze the environmental performance contemplating technology, efficiency and environmental indicators related to environmental investment intensity or environmental audits. Other studies, such as Godoy-Durán et al. (2017) and Labella et al. (2017), use eco-indicators associated with product and process practices to analyze EI and measure sustainability. Furthermore, Langendahl et al. (2016) include commercial and organizational practices to conceptualize the sustainable innovation journey in the UK agri-food sector. Drejeris and Miceikienė (2018) and Shih et al. (2018) propose product and process green practices while also highlighting the important role that environmental oriented staff have in EI process in the Lithuanian and Asian agri-food sectors, respectively. What is more, Caffaro et al. (2019) analyze EI in the Italian agri-food sector by contemplating variables related to information and environmental attitude behavior. Nevertheless, despite the effort to offer an efficient measurement, these investigations only consider a sparse assortment of eco-indicators, not all EI dimensions. Thus, more empirical research is needed to discover a wide range of EI practices that are aimed at developing a solid theoretical foundation.

The proposed model was developed analyzing the extant literature on EI. Previous studies suggest that environmental corporate culture and commercial orientation have a significant impact on EI adoption (Newton and Harte, 1997; Rkein and Andrew, 2012; Liao, 2018; Wang et al., 2018). In addition, other researches defend the importance of taking into consideration the four EI dimensions to analyze the relationship between the different EI practices and the level of EI implementation (BID, 2007; Marcon et al., 2017; García-Granero et al., 2018). In this line, the sector's environmental performance is represented in six constructs: environmental corporate culture, commercial orientation, product EI, process EI, organizational EI and marketing EI. They are expected to support the efficient measurement of EI level. EI practices, environmental corporate culture, commercial orientation and EI level constructs are discussed in the following subsections.

2.1. Eco-innovation level

EI is a concept that has been widely examined by the economic, business and environmental academic literature from the perspectives of concepts, drivers and consequences. Nevertheless, studies on its implementation are scant (Kemp, 2009). In recent years, researchers have addressed EI from the measurement perspective with the aim of achieving an efficient way to analyze this complex process and fill the gap existing in the literature.

Several EI studies emphasize the necessity to introduce four EI dimensions, namely product, process, organization and marketing, in a sector's environmental performance (OECD, 2005; BID, 2007; Horbach, 2008; OECD, 2012; Triguero et al., 2013; García-Granero et al., 2018). Product EI is related to the product innovation involving environmentally-friendly materials, environmentally-friendly packaging, recovery of products and recycling, and eco-labelling (Chen et al., 2006; Chen, 2008). Process EI refers to a firm's ability to improve existing processes and develop new ones that increase resource savings and prevent pollution (Chen et al., 2006; Chen, 2008). Organizational EI can be explained as either a new or significant improvement in routines, business models, methods and actions that change a firm's practices, relations and decisions, with the aim of reducing adverse environmental impacts (Marcon et al., 2017). Within environmental management systems (EMS), marketing EI involves the integration of environmental aspects into product placement, communication, new methods of product delivery, promotion or pricing strategies (Marcon et al., 2017). Based on these definitions, it is evident that strong interrelationships exist between the four EI dimensions. Firstly, process EI modifies the organization's operational processes systems while simultaneously producing new or significantly improved eco-products, thereby reducing environmental impacts (Negny et al., 2012). Furthermore, it has been demonstrated that organizational EI facilitates the implementation of process EI and product EI (Murphy and Gouldson, 2000). Secondly, the implementation of marketing EI requires the introduction of green products and processes in order to conform to the environmental standards of the markets (García-Granero et al., 2018). However, EI literature analyzes EI activity by studying the EI dimensions separately, without taking into consideration how they are interconnected (Hallstedt et al., 2013; Lozano, 2013). Moreover, the majority of these studies fail to consider the impact that organizational and marketing dimensions have on environmental performance (del Río et al., 2010; Crabbé et al., 2013; Doran and Ryan, 2016; Ishak et al., 2016). In fact, the most complete investigations in this study area are mainly focused on three EI types (i.e., product EI, process EI and organizational EI), ignoring the relevance of EI marketing practices (Horbach, 2008; Rodríguez and Wiengarten, 2017). Thus, EI performance has never been properly examined, and only the studies carried out by Marcon et al. (2017) and Astuti et al. (2018) addressed all the green dimensions, though they only focused on the industrial sector and multinational companies.

2.2. Environmental corporate culture and the eco-innovation level relationship

The effect of environmental corporate culture on environmental firm performance is a subject that is attracting the attention of recent literature on EI. Most studies have shown that organizational attitudes, governance and cultures may affect firm EI (Bleischwwitz et al., 2012; Bossle et al., 2016; Dangelico, 2016; Ortiz-de-Mandojana et al., 2016; Tsai and Liao, 2017). According to Ajzen (1991), it is true that EI might be affected as attitude would naturally influence decisions. A positive attitude in an organization towards a given environmental issue makes it more likely to implement EI behavior (Liao, 2018). For instance, companies may implement new manufacturing practices that prevent pollution, or they may adopt efficient environmental management systems (Eiadat et al., 2008; Wijethilake et al., 2016). Indeed, corporate environmental performance is regarded as a key driver of improving EI strategy (Porter and Kramer, 2006; Glavas and Mish, 2015; Wijethilake wt al., 2016). For example, the number of environmental objectives included in production plans and operations or the inclusion of environmental plans in production processes are a good indicator about how environmentally-friendly a company is (Frosch and Gallopoulos, 1992; Tibbs, 1992; Williams et al., 1993; Kemp and Pearson, 2008). Furthermore, spreading green values within the organization could promote a firm's implementation of green business practices (Parr, 2009). In this sense, the role of managerial agency in a firm proves to be a key factor. Senior staff can encourage employees to be more innovative and respectful with the environment (Anderson, 1998; Andriopoulos, 2001; Halbesleben et al., 2003). Rajala et al. (2016) illustrate the role of the managerial agency in driving environmentally sustainable practices in a company and developing a green business model orientation. The importance of managers in environmental corporate culture has also been analyzed by other researchers (e.g. O'Connor and Ayers, 2005; Hojnik and Ruzzier, 2016a). Without question, there is a consensus in the EI literature on the positive effects that employing staff who are more in tune with environmentally-friendly practices and greener business models has on better ecological performance and higher level of environmentally oriented cultures (Anderson, 1998; O'Connor and Ayers, 2005; Hojnik and Ruzzier, 2016a).

According to Howard-Grenville and Bertels (2012), environmental corporate culture is what builds EI practices. Moreover, Newton and Harte (1997) emphasize the significant impact that environmental corporate culture has on environmental practices. Thus, these findings indicate that the link between environmental corporate culture and EI level is straightforward. However, in general, prior studies on EI only test this relationship in industrial and high-tech sectors (Peng and Liu, 2016; Magsi et al., 2018).

Based on the above findings, the following hypothesis is proposed:

Hypothesis 1 (H1): *Environmental corporate culture is positively related to firms' EI level in the agri-food sector.*

2.3. Commercial orientation and the eco-innovation level relationship

In a context marked by internalization and growing competition, companies seek ways of creating value for their customers by developing new practices that allow them to differentiate and capture market share for the main goal of surviving (Kumar and Reinartz, 2016; Crick, 2019). In this sense, firms' commercial orientation is a key tool for achieving this objective. Nevertheless, defining commercial orientation is not an easy task. The increasing reliance on market-based approaches defends this concept as a business philosophy surrounding the concept of creating value for customers in ways that competitors cannot imitate (Ellis, 2006; Jones and Shaw, 2018; Crick, 2019).

Behavioral and cultural theories suggest that commercial orientation is a practice focused on customers (Kohli and Jaworski, 1990; Narver and Slater, 1990; Rkein and Andrew, 2012). Most studies have shown that demand for corporate social responsibility has a significant effect on EI firm performance (Rehfeld et al., 2007; Kesidou and Demirel, 2012; Doran and Ryan, 2016). This point of view defends that the essence of commercial orientation is customer value. Thus, commercial orientation is related to customer orientation (Deshpandé and Webster, 1993; Mugisha et al., 2005; Rkein and Andrew, 2012).

Furthermore, given the importance of the relationships between an organization and other stakeholders beyond customers, such as competitors (Håkansson, 1982; Dwyer et al., 1987; Anderson and Narus, 1990; Crosby et al., 1990), other research highlights the importance of competitor orientation as an additional commercial orientation dimension (Narver and Slater 1990; Deshpandé, 1999; Martin et al., 2015). In this line, some studies have found the acquisition of a competitive advantage and the motivation of growth in the market to be strong drivers of EI firm performance (Salomon and Shaver, 2005; Weerawardena and O'Cass, 2004). In this sense, as EI is conducive to firm differentiation, it can help firms to gain market opportunities as well as improve their organizational image (Im and Workman, 2004; Cheng and Shiu, 2012; Liao, 2016).

In short, competitor orientation and customer orientation, as two key commercial orientation dimensions, encourage firms to implement green practices (Rkein and Andrew, 2012; Liao, 2018; Martin et al., 2015). Thus, it is important to highlight the relationship between commercial orientation and sector environmental performance (Crick, 2019). Therefore, based on this discussion, the following hypothesis is formulated:

Hypothesis 2 (H2): *Commercial orientation is positively related to firms' EI level in the agri-food sector.*

Figure 1 presents the conceptual model for EI.

3. Research method

The methodology used in this study is based on a survey to provide a multidimensional EI analysis at firm level. This section presents a discussion of the data collection process and the sample used for statistical analysis as well as the development of the EI measurement.

3.1. Sample and data collection

The agri-food sector located in the southeast Spanish region (Granada, Almeria and Murcia provinces) constitutes the reference for this empirical setting, which uses data for farming-marketing firms in the period 2017-2018. This sector constitutes a key economic activity, representing 24% of GDP (Gross Domestic Product) and 27% of employment (Galdeano-Gómez et al., 2013). Greenhouses are the principal feature of production in this area (Rodríguez-Rodríguez et al., 2012) and they require intensive use of resources and generate considerable amounts of waste and residues (e.g., packaging materials, fertilizers, plastics, etc.). On the other hand, the agri-food sector also contributes to the development of services (e.g., financing, consulting, R&D, etc.) and an associated auxiliary industry with a high environmental orientation (e.g., fertilizers, bees, seeds, etc), which accounts for approximately 32% of GDP in the area (Aznar-Sánchez et al., 2011; Galdeano-Gómez et al., 2017).

Furthermore, this sector clearly targets foreign markets and has a strong capacity for growth and adaptation to new demands. Over 60% of the production of these firms is exported, which accounts for over 35% of total Spanish agricultural exports and about 18% of all vegetables consumed in Europe (Cajamar, 2016). Thus, these firms must operate in a highly complex environment and deal with international competitors, regulations, standards and requirements, making EI implementation a highly relevant topic for this group (Antonietti and Marzucchi, 2014; Hojnik et al., 2018). Consequently, such firms have been evolving towards environmental adaptation with a more efficient use of resources and a reduction of environmental impact (Martos-Pedrero et al., 2019). This is particularly important in the agri-food context, where all supply chain members have a high environmental impact (Spielman and Birner, 2008; OECD, 2013). As a result, this agri-food model has drawn international attention, as several studies show (e.g., Galdeano-Gómez et al., 2013, 2017; Piedra-Muñoz et al., 2016; Godoy-Duran et al., 2017), and constitutes an adequate empirical frame of reference.

The data were collected using a questionnaire targeted at the environmental management of the companies. The survey was designed specifically for this purpose based on field studies and the relevant literature on EI (García-Granero et al., 2018). Next, the survey instrument was pre-tested on five firms' environmental quality managers, and the questions were selected and modified according to their comments and suggestions. Following these steps, the final questionnaire was structured in three main sections: (1) company economic and financial information, (2) perception of drivers influence, and (3) a series of items on process EI, product EI, organizational EI, and marketing EI.

According to the Iberian Balance Sheet Analysis System (*Sistema de Análisis de Balances Ibéricos* in Spanish, SABI), 302 firms commercialized fresh fruit and vegetables in the provinces of Almería, Murcia and Granada during that period. The sample was simple randomly selected without replacement. The final number of valid surveys was 93. This represents a satisfactory response rate of 30.8% (Menon et al., 1996).

The final sample companies are all internationalized and commercialize fresh fruit and vegetables production to the European Union. According to European legislation (European Commission, 2009), the sample includes 9 micro companies (fewer than 10 employees), 19 small companies (10-49 employees), 37 medium-size companies (50-249 employees), and 28 large companies (250 or more employees). With regard to EI, all companies implement product, process, organizational and marketing EI. 88 companies in the sample have some kind of environmental certification.

3.2. Measurement and variables

Previous studies have identified and validated the scales which measure EI variables (e.g., Damanpour et al., 2009), although none of them were specifically developed for EI. Thus, based on EI research and literature (BID, 2007; Rodríguez and Wiengarten, 2017; García-Granero et al., 2018), the present study expressly develops new scales with multiple items for EI, following the suggestions of Churchill (1979).

Once an initial set of EI items was ready, a pilot-test was performed to ensure its reliability and validity. Performing a pilot-test is an important step in the scale development process because it can remove

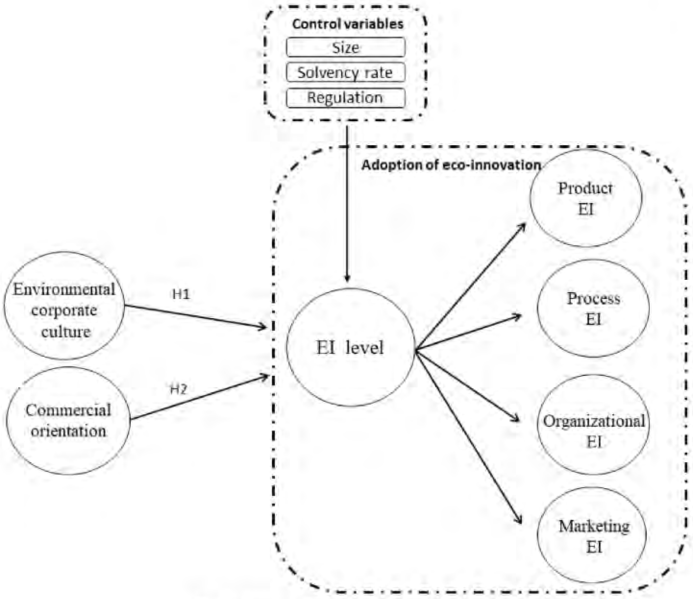

Fig. 1. Conceptual model for eco-innovation (EI)

any invalid items (Anderson and Gerbing, 1991; Cheng et al., 2014). For this purpose, five environmental managers from five different marketing-producer companies were asked to review and comment on the items, their clarity, ambiguity, completeness, readability and structure. As a result, 24 multi-item scales were generated, including three constructs (environmental corporate culture, commercial orientation and EI level).

Table 1 describes the multi-scales of each one of these items and Table 2 shows the descriptive analysis of them.

The reflective or formative relationships of the items with respect to their corresponding latent variables were proposed following the suggestions of Jarvis et al. (2003) and Mackenzie et al. (2005). According to these authors, commercial orientation, product EI, process EI, organizational EI and marketing EI constructs have a formative character because they are determined by their items, and present indicators that are established exogenously and are not correlated among one another (Chin, 1998). In contrast, the environmental corporate culture construct presents a reflective relationship as the items cover different aspects of the concept included in the construct (Podsakoff et al., 2006). Finally, the relationships between environmental corporate culture and commercial orientation constructs with EI construct, respectively, are both formative; meanwhile, the relationship between EI level construct and its first order structure (four dimensions) is reflective.

3.2.1. Variables

The environmental corporate culture variable refers to green organizational capabilities, ecological organizational commitments and environmentally-friendly organizational philosophies. Adapted from previous studies (Williams et al., 1993; Montalvo, 2003, 2008; Scarpellini et al., 2012; de Jesus Pacheco et al., 2016), it includes five 5-point Likert scale items related to the introduction of environmental objectives and plans, environmental implementation practices and compliance with environmental initiatives. What is more, adapted from Rajala et al. (2016) and Hojnik and Ruzzier (2016a), it includes one item related to the ecological preference of workers and staff.

The commercial orientation variable represents business orientation towards the identification of customer needs. Respondents were asked to answer four questions about the motivating factors to be more customer oriented, such as customer demand, acquisition of competitive advantage, improvement in corporative image and the growth in market (Weeranwardema and O'Cass, 2004; Kesidou and Demirel, 2012; Rkein and Andrew, 2012; Doran and Ryan, 2016). 5-point Likert scale items were used, ranging from "strongly disagree" (1) to "strongly agree" (5).

The EI level construct relates to these green practices that companies implement in order to be more environmentally friendly. Drawing upon previous research (BID, 2007; OECD, 2005; Marcon et al., 2017; García-Granero et al., 2018), this variable presents a second order structure formed by product EI, process EI, marketing EI and organizational EI constructs. Product EI is determined by three items: ecological production; use of biodegradable packaging input; and recycled packaging input (FAO, 2012). Process EI is assessed by four items: package control system; green technology investment; green patents; and recycling (Florida, 1996; BID, 2007; Johnstone et al., 2010; Dalhammar, 2015; Rodríguez and Wiegarten, 2017). Organizational EI is measured by four items that include: implantation of external environmental advisory and audits; cooperation with stakeholders; and environmental quality staff (Frosch, 1994; Boons and Lüdeke-Freund, 2013; de Jesus Pacheco et al., 2016; Peng and Liu, 2016). Based on Uscebrka et al. (2009), Chiarvesio et al. (2015) and Hernández-Rubio et al. (2018), marketing EI includes four items related to environmental certifications: environmental quality standards certifications (which includes most common certifications, such as Tesco Nature, Naturland and Integrated Production); environmental management system certifications (which includes other certifications, such as IFS Food, QS and ISO); volume of certified hectares with GlobalGap;

Table 1
EI multi-scale items and variables measurements

Variables and items	Measurement scale
Control Variables	
Solvency rate	Natural numbers
Size	Natural numbers
Regulation	Likert scale (1-5)
Commercial orientation	
Customer orientation	Likert scale (1-5)
Achieve competitive advantage	Likert scale (1-5)
Improve corporative image	Likert scale (1-5)
Growth in market	Likert scale (1-5)
Environmental corporate culture	
Degree of importance of implanting environmental plans and objectives	Likert scale (1-5)
Degree of importance of achieving environmental objectives	Likert scale (1-5)
Degree of importance of the company' staff being environmentally respectful	Likert scale (1-5)
Degree of importance of the company' environmental initiatives investment	Likert scale (1-5)
Degree of importance of the company' environmental impact	Likert scale (1-5)
Product EI	
Ecological/integrated production	Percentage
Biodegradable packaging	Dichotomous scale
Recycling packaging	Percentage
Process EI	
Packaging control system implemented	Dichotomous scale
Green technology investment	Thousand euros
Green patent number	Natural numbers
Material recycling	Percentage
Organizational EI	
Environmental advisory implemented	Dichotomous scale
Environmental audit implemented	Dichotomous scale
Cooperation with stakeholders	Dichotomous scale
Environmental quality staff	Natural numbers
Marketing EI	
Environmental quality standard certifications	Natural numbers
Environmental management system certifications	Dichotomous scale
GlobalGap certification	Percentage
GRASP certification	Percentage

Table 2
Descriptive analysis of the variables and items

Variables and items	Min.	Max.	Mean	Std. desv.
Control variables				
Solvency rate	0.27	3.06	1.17	0.44
Size	3	1200	220.9	295.2
Regulation	1	5	3.46	1.22
Commercial orientation				
Customer orientation	1	5	4.22	0.92
Achieve competitive advantage	1	5	3.62	0.95
Improve corporative image	1	5	4.03	1.00
Growth in market	1	5	3.70	0.78
Environmental corporate culture				
Degree of importance of implementing environmental plans and objectives	1	5	3.85	0.99
Degree of importance of achieving environmental objectives	1	5	3.76	1.11
Degree of importance of the company' staff being environmentally respectful	1	5	3.96	0.93
Degree of importance of the company' environmental initiatives investment	1	5	3.67	1.06
Degree of importance of the company' environmental impact	1	5	3.72	1.02
Product EI				
Ecological/integrated production	0	1	0.22	0.34
Biodegradable packaging	0	1	0.22	0.42
Recycling packaging	0	1	0.47	0.37
Process EI				
Packaging control system implemented	0	1	0.68	0.47
Green technology investment	0	280	19.52	53.48
Green patent number	0	8	0.52	1.57
Material recycling	0	1	0.48	0.39
Organizational EI				
Environmental advisory implemented	0	1	0.43	0.5
Environmental audit implemented	0	1	0.42	0.5
Cooperation with stakeholders	0	1	0.36	0.48
Environmental quality staff	0	28	4.78	5.58
Marketing EI				
Environmental quality standard certifications	0	11	4.36	2.4
Environmental management system certifications	0	1	0.81	0.39
GlobalGap certification	0	1	0.67	0.37
GRASP certification	0	1	0.49	0.42

and volume of certified hectares with GRASP.

3.2.2. Control variables

This study controlled for possible confounding effects by including three relevant variables: firm size, solvency rate and environmental regulation (Klomp and de Haan, 2008; Amin and Chin, 2019; Zhao et al., 2019). Firm size was measured by total number of employees (Huang and Li, 2015). Solvency rate assesses the company's ability to meet its liabilities with its cash flow (Diederen et al., 2002). Finally, environmental regulation includes one 5-point Likert scale item to indicate the regulatory and normative pressures implemented by the Spanish Government in order to reduce negative environmental company impact (Bocken et al., 2011; De Marchi, 2012).

3.3. Statistical analysis

A Partial Least Squares based-structural equation modelling method (PLS-SEM) is applied to test the research model and hypotheses proposed (Roldán and Sánchez-Franco, 2012). PLS-SEM method estimates complex cause-effect relationship models with latent variables or constructs. It is composed of two sub-models: the measurement model and the structural model. The first one represents the relationships between the observed data and the latent variables. The second takes into account the relationships between the latent variables. An iterative algorithm solves the structural equation model by estimating the latent variables using both sub-models in alternating steps. The measurement model estimates the latent variables as a weighted sum of its manifest variables. The structural model estimates the latent variables by means of linear regression between the latent variables estimated by the measurement model. This algorithm repeats itself until convergence is achieved (Hair et al., 2018). PLS-SEM is considered the most appropriate technique when structural models are complex, with formative and reflective indicators, as in this study (Hair et al., 2014). This method was preferred over covariance approaches since it is designed to predict relationships among variables in relatively small samples (although representative) with less sensitivity to normality assumption (Henseler et al., 2016). It was also applied because it accounts for measurement error and corrects for attenuation, thereby overcoming many of the problems associated with regression models (Jaccard and Wan, 1996). Moreover, due to the shape of the proposed model, PLS was chosen because it allows evaluation of a composite measurement model (Henseler et al, 2014; Sarstedt et al., 2016). As it is a structural model that includes a second order construct, a build-up approach was carried out (Aldás-Manzano, 2012).

As previous researchers have suggested that unusual patterns of scores can disproportionately influence the results (Tabachnick and Fidell, 2006), an outliers analysis was conducted with the aim of identifying and discarding them.

3.4. Common method variance (CMV)

CMV is addressed because the collected data were reported using a single informant from each of the companies and they were collected from the same questionnaire during the same period of time. Therefore, an exploratory factor analysis was conducted which included all the

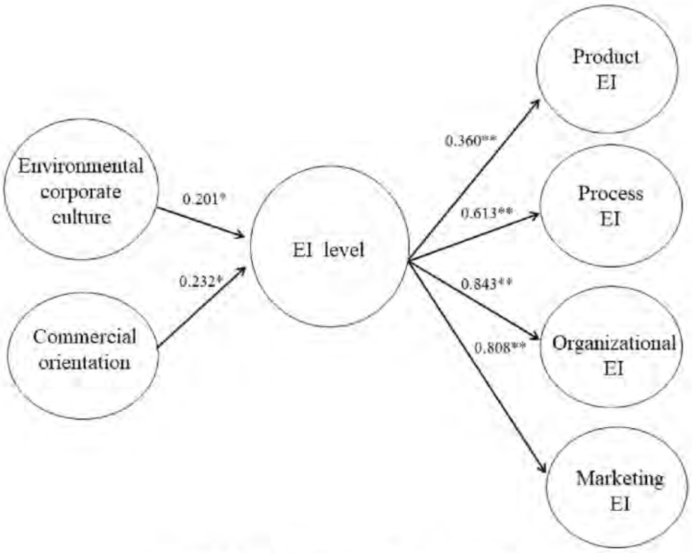

Fig. 2. EI model testing results. *p < .05; **p < .01.

measurement scales proposed in the model using SPSS. Similar methodological approaches have used CMV to assess the potential existence of common method variance (Cheng et al., 2014; Hojnik et al., 2018).

The results reveal that no single factor accounts for most of the variance and that the first factor captures only 24.97% of the variance, which demonstrates a low threat of common method variance.

4. Statistical results

4.1. Evaluation of measurement model

The evaluation of the measurement model is intended to assess the relationships between the indicators and the constructs. Due to the fact that the study uses both reflective and formative measurements, the measures of the variables were tested and validated in several ways. Two statistical tests were performed to evaluate the formative variables of the model in both steps of the build-up approach method: (i) multicollinearity analysis, and (ii) analysis of the weight-loading relationship of each indicator (Hair et al., 2014). The relative relevance of each formative indicator was supported by a comprehensive literature review, interviews with managers, and previous questionnaires pre-tests (as reported in Section 3.2). Based on the feedback and insights from the interviews with managers, the wording of some items was slightly modified to an acceptable level of significance.

As for another aspect, the existence of collinearity in formative constructs can cause erroneous results. In this line, Hair et al., (2011) defines Variance Inflation Factor (VIF) values below 5.00 for each item to avoid multicollinearity problems. As shown in Table 1A (Appendix A), all VIF values are under this value in the proposed model. Therefore, the existence of multicollinearity problems can be rejected, which validates the formative constructs for the model composition.

Likewise, the convergent and discriminant validity was examined to evaluate the reflective variables. Composite reliability is an indicator of shared variance among the set of observed variables used as indicators of a latent construct (Fornell and Larcker, 1981; Cheng et al., 2014). As shown in Tables 1B and 2B (Appendix B), the composite reliabilities of all constructs exceed the usual 0.60 benchmark in both steps of the build-up approach method (Bagozzi and Yi, 1988). The results provide the necessary evidence that all reflective constructs exhibit convergent validity. Moreover, all factor loadings are greater than 0.50 and the p-values are significant at the 0.05 level; thus, the convergent validity is assured (Fornell and Larcker, 1981; Hojnik et al., 2018). Discriminant validity was tested by comparing the average variance extracted (AVE) with the variance if each factor was shared with the other factors of the model (Cheng et al., 2014). All the diagonal elements representing the square root of the AVE are greater than the highest shared variance (the off-diagonal correlations).

4.2. Evaluation of structural model

Once the measurement model was assessed by testing the multicollinearity and the weight-loading relationship of the measurement scales for the formative indicators as well as the convergent and discriminant validity for the reflective indicators, partial least squares structural equation modelling (PLS-SEM) was used to test the hypothesized relationships between the latent variables. The steps suggested by Aldás-Manzano (2012) were followed as the proposed model is a second order construct and it is necessary to apply the build-up approach method. With this approach, firstly, the structural model is estimated ignoring the second order construct in order to calculate the residual value of the first order dimensions. Secondly, these residual values are included as indicators of the second order construct to estimate the model proposed. The evaluation of the structural model aims to determine the relationships between the constructs. Thus, three statistics were used: (i) structural model path coefficients, (ii) coefficients of determination R^2, and (iii) the predictive relevance Q^2.

Standardized betas (β) for the path coefficients measure the strength and direction of the significance of the structural model (Wijethilake et al., 2016). According to Chin (1998) and Hair et al. (2014), path coefficients must be above 0.20 in order to be

Table 3
Testing the EI model hypotheses

Hypotheses	Supported or rejected	Coefficient (related to path analysis)	p-value (related to path analysis)
H1. Environmental corporate culture is positively related to firms' EI level.	Supported	0.201	0.035*
H2. Commercial orientation is positively related to firms' EI level.	Supported	0.232	0.014*

* $p < 0.05$

meaningful predictors. The model presented all path coefficients above 0.20, demonstrating that the relationships maintained are significant. However, following Chin (1998) and Hair et al. (2014), a bootstrapping technique (5000 re-samples) is employed to generate standard errors and t-statistics that permit the evaluation of the statistical significance for the relationships hypothesized within the research model. Figure 2 shows the results. All correlations among latent variables are statistically significant.

Moreover, Table 3 reports that, as hypothesized, environmental corporate culture and commercial orientation have a positive relationship with EI level. Therefore, H1 and H2 are supported.

The Coefficient of Determination (R^2), which measures the predictive accuracy, is the central criterion for judging the quality of the partial least squares structural equation modeling (Chin, 1998; Wijethilake et al., 2016). The R^2 of the model is 0.43, which greatly exceeds the 0.1 minimum level proposed by Falk and Miller (1992), indicating that it is a good explanatory model. Concerning the cross-validated redundancy measure (Q^2), it assesses the model's predictive relevance, i.e., if the model has the ability to predict the reflective indicators of endogenous latent variables. Stone-Geisser's Q^2 value was calculated by referring to a blindfolding sample reuse technique with a data omission distance (D) equal to 6 (Wold, 1982). Q^2 values larger than zero for a particular endogenous construct indicate the path model's predictive relevance. The Q^2 value of the model is above zero (0.154), which indicates the satisfactory predictive relevance of the model.

5. Discussions and conclusions

Testing the structural model by means of PLS-SEM, the study offers a multidimensional measurement of EI level that previous studies fail to provide. The analysis of the relationship of environmental corporate culture and commercial orientation with EI level also provides evidence about important reasons that motivate companies to be environmentally friendly.

Firstly, the results shown in Figure 2 enhance the significance of contemplating product, process, organizational and marketing EI dimensions, as they are all important. Unlike several research studies that only analyze product and process EI types (Doran and Ryan, 2016; Castellacci and Lie, 2017; Rodríguez and Wiengarten, 2017), the explicative level of the other two dimensions (organizational and marketing) are stronger in the agri-food sector. Among all four, organizational EI is the most significant (β = .843), followed by marketing EI (β = .808). Product and process EI dimensions also display significance, though less than the other two (β = .360 and β = .613, respectively). These results call into question the effectiveness of measurements used in most previous EI investigations that do not consider all EI types. The findings also lend support to the defense of some authors (BID, 2007; García-Granero et al., 2018) who advocate the introduction of organizational and marketing EI practices to obtain an efficient analysis of the state of EI in any sector or country. Consequently, the results imply that any EI research should contemplate the four dimensions to offer an analysis which more closely resembles business reality.

Secondly, another interesting finding is the positive relationship that environmental corporate culture has with the EI level of agri-food firms. In line with the results of other investigations (Parr, 2009; Bossle et al., 2016; Dangelico, 2016), greater environmental awareness of the company is reflected in a higher predisposition to introduce more environmentally-friendly practices. In this context, the role of senior staff is a key factor in promoting green values throughout the company (Andriopoulos, 2001; Halbesleben et al., 2003; Rajala et al., 2016). Managers can have a great influence on assessing the conditions for a successful implementation of EI by their organizations.

Additionally, this investigation also found that commercial orientation is a significant driver that encourages firms to be more eco-innovative in the agri-food sector. Moreover, those firms that are more customer and competitor oriented are more open to implementing ecological practices with the aim of reaching environmental requirements and demands. According to Narver and Slater (1990), Deshpandé (1999) and Rkein et al. (2012), customer and competitor orientation are the two most important commercial orientation items, along with the motivation of results such as acquired competitive advantage or growth in markets (Salomon and Shaver, 2005; Weerawardena and O'Cass, 2004). Thus, organizations with commercial orientation might develop EI according to consumer preferences and changes in market conditions with the aim of pursuing reduction of costs, improvement of company reputation, and operational efficiency increase in terms of an output gained to run a business operation.

5.1. *Concluding remarks*

This study presents novel empirical research in this field, showing a multidimensional EI level measurement. The analysis argues that a better understanding of the complex relationship between EI and environmental corporate culture and commercial orientation in the agri-food sector is crucial to attain sustainable development.

Today, it is well-known that EI is necessary to achieve the transition towards 'greener' production process, distribution and consumption. However, although product, process, and organizational innovations are commonly taken into consideration in studies related to EI in several industrial sectors, the relationship between marketing practices and EI is scarcely contemplated. Unlike most studies, the present one focuses on highlighting the key role of each EI dimension in stimulating sustainable development. This is particularly relevant in the agri-food sector due to its capacity to generate socio-economic growth and its high capacity of adaptiveness to international market requirements.

The model developed in this study offers empirical evidence on the positive relationship between environmental corporate culture and commercial orientation and EI. A practical contribution for companies to implement EI involves two aspects. On one hand, regarding environmental corporate culture, acquiring more environmentally-friendly human capital is essential to promote more sustainable work habits that enhance EI. On the other hand, in order to improve EI level, this study provides a conceptual framework that explains which eco-practices should be implemented, while the adoption of EI represents an opportunity for achieving environmental standards and satisfying customers' needs. From a research perspective, this multidimensionality approach should be taken into account to properly study EI implementation in other sectors and/or regions. It suggests that environmental corporate culture and commercial orientation are connected to business decisions on implementing EI practices. What is more, it enhances the importance that marketing and organizational dimensions can have, the same as product and process types when analyzing business EI practices.

The presented study has several limitations which could encourage future works. For example, the analysis is focused on the Spanish agri-food export sector and the data are collected in one period, offering static results. Also, the measurement variables are limited, and other omitted factors may influence these complex relationships. Although the study's findings can be extended to other well-developed economies, it would be interesting for future research to replicate it in other countries and sectors with the aim of being able to compare different economies and business groups. Finally, exploring the EI level over an extensive period of time with the aim of analyzing the evolution of different green practices over the years is a worthwhile direction for future research.

CRediT authorship contribution statement

Eva M. García-Granero: Conceptualization, Methodology, Investigation, Formal analysis, Writing - original draft. **Laura Piedra-Muñoz:** Conceptualization, Methodology, Investigation, Writing - review & editing, Supervision, Funding acquisition. **Emilio Galdeano-Gómez:** Conceptualization, Methodology, Investigation, Writing - review & editing, Supervision, Funding acquisition.

Declaration of Competing Interest

The authors declare that they have no known competing financial interests or personal relationships that could have appeared to influence the work reported in this paper.

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Appendix A

Table 1A

Table 1A
Multicollinearity analysis

Measurement items	VIF Values
Commercial orientation	
Customer orientation	1.242
Achieve competitive advantage	1.741
Improve corporative image	1.619
Growth in market	1.482
Product EI	
Ecological/integrated production	1.207
Biodegradable packaging	1.041
Recycling packaging	1.163
Process EI	
Packaging control system implemented	1.016
Green technology investment	1.010
Green patent number	1.011
Recycling materials	1.014
Organizational EI	
Environmental advisory implemented	1.540
Environmental audit implemented	1.588
Cooperation with stakeholders	1.321
Environmental quality staff	1.306
Marketing EI	
Environmental quality standard certifications	1.416
Environmental management system certifications	1.131
GlobalGap certification	1.406
GRASP certification	1.142

Appendix B. Composite reliability (CR) analysis

Tables 1B and 2B

Table 1B
Step 1 build-up approach method

Measurement items	Factor loading	p-value
Environmental corporate culture (CR = .911)		
Degree of importance of implementing environmental plans and objectives	0.924	0.000
Degree of importance of achieving environmental objectives	0.909	0.000
Degree of importance of the company' staff being environmentally respectful	0.825	0.000
Degree of importance of the company' environmental initiatives investment	0.770	0.000
Degree of importance of the company' environmental impact	0.648	0.000

Table 2B
Step 2 build-up approach method

Measurement items	Factor loading	p-value
Environmental corporate culture (CR = .910)		
Degree of importance of implementing environmental plans and objectives	0.924	0.000
Degree of importance of achieving environmental objectives	0.909	0.000
Degree of importance of the company' staff being environmentally respectful	0.825	0.000
Degree of importance of the company' environmental initiatives investment	0.770	0.000
Degree of importance of the company' environmental impact	0.648	0.000
EI level (CR = .736)		
Product EI	0.512	0.002
Process EI	0.548	0.001
Organizational EI	0.748	0.000
Marketing EI	0.742	0.000

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