

# An Analytical Literature Review on Environmental Innovations Concepts

VASILE N. POPA

Universitatea Nationala de Aparare Carol I

LUMINITA I. POPA

Universitatea Transilvania din Brasov

Anca N. IUGA (BUTNARIU) (✉ [anca.iuga@unitbv.ro](mailto:anca.iuga@unitbv.ro))

Transilvania University of Brasov: Universitatea Transilvania din Brasov <https://orcid.org/0000-0001-5174-4307>

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## Review

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# Abstract

**Background:** The importance of environmental innovation concepts is growing in the private sector, in academia and at the level of government policies. The concept of environmental innovation is closely related to two other notions: eco-innovation and green innovation. The purpose of this paper is to contribute to a clarification of the concept of environmental innovation and to provide an overview of the existing scientific literature in this field, identifying the most active authors, countries, publishers and relevant publications.

**Results:** We created a matrix with a proposed eco-innovation model that is focused on the correlation between the measures related to the model application in the process of eco-innovation and the main areas of application.

**Conclusion:** This review draws from the resource-based theory and investigates the interrelationships between three types of innovation (environmental innovation, eco-innovation, green innovation) and their impact on firm's business performance using the proposed eco-innovation model. We found that the most active scholars are situated in US and Europe (i.e. USA, UK, Swiss, Germany, Singapore, Netherlands, Canada and France) and identified OECD as author of seven publications and Jens Horbach as author of six publications in the field of environmental innovations journals, leading the field.

## I. Introduction

The awareness of the business environment and companies in terms of applications and concepts of environmental innovation has fully reached the reality of current activity.

Governments, business, academia, consumers and private companies are also looking for alternatives to alleviate the pressing environmental requirements resulting from pollution, rising waste, population growth and continued economic development.

On the other hand, private companies face an increasingly competitive scenario on a daily basis, in which the application of sustainable eco-innovation models is considered an additional chance to survive in most markets in the world.

As far as we know, there is a lack of a recent and comprehensive review of a large number of publications in the field of environmental eco-innovation completed with a proposal to use a matrix with a new model of eco-innovation.

Thus, there is a lack of a matrix that determines the correlation between the measures related to the applications of the eco-innovation model in the eco-innovation process and the main areas of application.

In this context, this paper has two objectives:

1. 1. Aggregate findings of different publications on environmental innovation concepts through an interpretative framework of published literature on the topic, and
2. 2. Create a matrix with the proposed eco-innovation model and verify the hypothesis;

These objectives are achieved through a systematic review of the literature by studying 400 publications in the field (Annex 1) and proposing a new model of eco-innovation.

The structure of the paper is as follows: I. Introduction; II. Analytical literature review on environmental innovations concepts; III. Methods; IV. Results; V. Discussion, and VI. Conclusion.

The stages of the database analysis of publications addressing environmental innovations concepts are presented in figure 1.

Within the stage 1, we chosen the search terms and clarified the definitions of environmental innovations concepts. The quantitative stage 2, involved a survey by internet means of a number of 400 publications in the studied field using key words as so as to test and generalize a number of hypotheses developed in the exploratory and qualitative stage. The stage 3 was focused on the research refinement: every year since 1990 to 2019; reviewing books, articles, conference papers; reducing with 5% from the average of publication cumulative number of occurrence. The hypotheses referred to theoretical relationship between three types of innovation (Environmental Innovation, Eco-Innovation, and Green Innovation) and their implication on the Eco-Innovation Model (Figure 3). Within the stage 4, we used all the results for creating tables and representative graphics.

Finally, the conceptual eco-innovation model and literature review are used to analyse the data, verify the hypothesis and identify where future research is needed in this area. So, the stage 5 integrated the various results and discussed the future implications of the research done.

## **II. Analytical Literature Review On Environmental Innovations Concepts**

### 1. "Environmental innovation" concept (see Table 1)

Within our research, the Key Word "Environmental innovation" had an initial no. of occurrences of 1.030 from a total of 10.151 with a weight of 10.15%. After our research refinement, a 5% average reduction has done and the final no. of occurrences was 1.010 with a weight of 10.06%.

The publication with the most number of occurrences of the key word "Environmental innovation" identified in our analysis is authored by (Van Dijken & Prince, 2012), titled "Adoption of environmental innovations. Eco-efficiency in industry and science" published in Springer in 1999 (see Annex 1 and 2).

The publication with the second most number of occurrences of the key word "Environmental innovation" (119) identified in our analysis is authored by (Horbach, & Reif ,2018).

titled "New Developments in Eco-Innovation Research" published in Springer International Publishing in 2018 (see Annex 1 and 2).

The publication with the third most number of occurrences of the key word "Environmental innovation" (104) identified in our analysis is authored by (Vazquez-Brust & Sarkis,2012), Green Growth: Managing the Transition to a Sustainable Economy " published in Springer, 2012 (see Annex 1 and 2).

Defining environmental innovation concept, (Van Dijken & Prince, 2012) considered that it is purely based on a *technological assessment of their environmental impact*. According with (Rennings, K. 2000). environmental innovation has been defined as the *application or introduction of new products and processes contributing to the reduction of environmental burdens or to ecologically specified sustainability targets*. He also suggests that the non-punishment of producers and distributors for their environmentally harmful products and services will ultimately lead to distortions of competition between eco-innovation and non-environment. Emphasizing this point of view, (Beise & Rennings 2005), consider that this competition will continue to be distorted, unless markets reward substantial environmental improvements and punish harmful environmental impacts.

An interesting point of view has Jana Hojnik. She considers that environmental innovations can be defined as a *subset of all innovations in an economy, but did not mention the costs involved in supporting eco-innovation as a subset of world economy*. A different point of view, oriented towards financial costs had Ziegler et al., which considers that *the whole society exploits the benefits from an environmental innovation, while a single company carries all the costs by itself* (Hojnik, 2012).

(Vazquez-Brust, & Sarkis, 2012), pointed out that the concept of environmental innovation has a strong social character and began in Japan in response to the pollution problems brought by the rapid industrialization and economic growth of this country since the 1970s. Since then, the Japanese have believed that product design and process improvement need to be institutionalized to improve the respect for environment (eco-friendly concept).

According to Diego A, environmental innovations come from building the core of corporate social responsibility (CSR) that has evolved into corporate social performance (CSP) or corporate citizenship.

He points out that corporate social performance has been highlighted in the scientific literature as including charitable contributions, environmental management, performance, sustainability and until recently, environmental innovations. The Japanese Nakao (Nakano & Gemba 2007) first proposed environmental responsibility as a key tool for promoting environmental innovation.

Addressing the subject of environmental innovation (Horbach & Reif 2018) quoted on Rennings, (Rennings 2000), Bleischwitz and Jacob (Bleischwitz & Jacob 2011) who identified various barriers and

market failures to environmental innovations. Jens Horbach considers that the double externality of environmental innovation, the lack of information on how to allocate resources efficiently, the correct division of incentives in value chains, the blocking effects in resource-intensive technologies indicate the need for policies to correct the global market for environmental innovation.

Table 1  
Key Words for Environmental Innovations Concepts and their no. of occurrence

(Source: ANNEX 1)

Key words for Environmental Innovations Concepts	Initial no. of publications	Initial no. of occurrences	Initial no. of occurrences weight %	Initial average	Final no. of publications	No. of occurrences after 5% average reduction	Final no. of publications weight %	Final average
ENVIRONMENTAL INNOVATION	65	1.030	10.15	15.84	45	1.010	10.06	22.44
ECO-INNOVATION	74	8.503	83.77	114.90	36	8.430	83.99	234.16
GREEN INNOVATION	53	570	5.61	10.75	34	551	5.49	16.20
ECO-INNOVATION MODEL	4	48	0.47	12.00	2	46	0.46	23.00
TOTAL	196	10.151	100	-	117	10.037	100	-

## 2. "Eco-innovation" concept (see Table 1)

Within our research, the Key Word "Eco-innovation" had an initial number of occurrences of 8.503 from a total of 10.151 with a weight of 83.77%. After our research refinement, a 5% average reduction has done and the final no. of occurrence was 8.430 with a weight of 83.99%.

The publication with the most number of occurrences of the key word "Eco-innovation" (1583) identified in our analysis is authored by Jana Hojnik (Hojnik, 2012), titled "In Pursuit of Eco-innovation" published in University of Primorska Press in 2017 (see Annex 1 and 3).

The publication with the second most number of occurrences of the key word "Eco-innovation" (834) identified in our analysis is authored by Susana Garrido Azevedo (Azevedo, Brandenburg 2014) titled "Eco-Innovation and the Development of Business Models" published in Springer in 2014 (see Annex 1 and 3).

The publication with the third most number of occurrences of the key word "Eco-innovation" (760) identified in our analysis is authored by OECD (Publishing House, 2009) titled "Eco-Innovation in Industry" published in OECD Publishing House, 2009 (see Annex 1 and 3).

Defining the eco-innovation concept, Jana Hojnik (Hojnik, 2012) considered that this is a different type of innovation as it leads companies to reduce the environmental impact of economic activities, whether this effect is intentional or not. It is discussed in academia that the introduction of eco-innovation does not

necessarily depend on reducing environmental damage. Therefore, if the technology is less harmful to the environment than the conventional alternative (classical innovation), it can be defined as eco-innovation

Addressing the topic of classical innovation, Zongwei Luo (Luo, 2011) said that it can be seen as the replacement, improvement or renewal of existing ideas and practices to be understood, especially as a correspondence between new innovative technological ideas and their implementation.

In line with this concept, eco-innovation has generally been defined as the process of developing new ideas applied in technology, products and processes that contribute to reducing environmental burdens or achieving global environmental sustainability goals. (Rennings, 2000) .

It is necessary for companies, through eco-innovation, to try to turn constraints into opportunities, which can lead to reduced costs, gaining a good reputation and gaining new markets for the products obtained. The Eco-Innovation Observatory, a platform for collecting and analyzing a large amount of information on innovation, selected from across the European Union, proposed a new definition of eco-innovation (2010). Thus eco-innovation is defined as the introduction of any new or significantly improved product, which reduces the use of natural resources (fuel, materials, energy and water) and decreases the release of harmful substances immediately during its life cycle.

### 3." Green innovation" concept (see Table 1)

Within our research, the Key Word "Green-innovation" had an initial no. of occurrences of 570 from a total of 10.151 with a weight of 5.61%. After our research refinement, a 5% average reduction has done and the final no. of occurrence was 551 with a weight of 5.49%.

The publication with the most number of occurrences of the key word "Green-innovation" (Annex 6) identified in our analysis is authored by Francesco Calza (Calza, Parmentola & Tutore 2017). (Annex 6), titled "Types of Green Innovations: Ways of Implementation in a Non-Green Industry" published in MDPI Publishing House in 2017 (see Annex 1 and 4). The publication with the second most number of occurrences of the key word "Green-innovation" (O'Brien, & Saarinen, L. A. 2011), identified in our analysis is authored by Ruchika Singh Malyan, (Malyan & Duhan, 2000) (see Annex 1,4 and 6). The publication with the third most number of occurrences of the key word "Green-innovation" identified in our analysis is authored by Felicity Kelliher (Kelliher & Reinl 2014) titled "Green Innovation and future technology" published in Palgrave Macmillan, 2015 (see Annex 1 and 4).

Francesco Calza (Calza, Parmentola & Tutore 2017) [see no.386 Annex 6) considered that Green innovation can be defined as a innovation consisting of new or modified processes, practices, systems and products which benefit the environment and contribute to environmental sustainability.

The Green innovation can lead to the reduction of inefficient consumption in production processes and the rational use of natural resources, being an important source of cost reduction.

On the other hand, given the awareness of consumers about the environmental impact of the products purchased on the market, the environmental attributes of new products and services can be used to

differentiate producers in the market.

According with (Kelliher & Reini 2014), green innovation is the introduction of green-focused ideas, devices or methods relating to regional SMEs, while green innovativeness is defined as a “transformational innovative capability” within these firms.

(Luo, 2011). pointed out that the concept of being green does not always create value in the production and distribution chain as several factors will intervene in order to be successful.

The creation of economic value and the extent to which the businesses may integrate more environmental concerns in their activities may depend on these green innovations to meet customers and shareholder’s expectations or the capacity of the business to change these expectations and impact their management if the green innovation does not meet their short term criteria.

Some strategic environmental decisions are not only justified by the economic profitability of the company, as the implementation of green innovations can have positive long-term effects and can be an empirical justification for its implementation.

#### 4. “Eco-innovation model” concept (see Table 1)

Within our research, the Key Word “Eco-innovation model” had an initial no. of occurrences of 48 from a total of 10.151 with a weight of 0.47%. After our research refinement, a 5% average reduction has done and the final no. of occurrence was 46 with a weight of 0.469%.

The publication with the most number of occurrences of the key word “Eco-innovation model” (44) identified in our analysis is authored by Jana Hojnik (Hojnik, 2012), titled “In Pursuit of Eco-innovation” published in University of Primorska Press in 2017 (see Annex 1 and 5).

The publication with the second most number of occurrences of the key word “Eco-innovation model” (2) identified in our analysis is authored by Nancy Bocken (see no.227-Annex 6) (Bocken, Ritala & Verburg 2019) titled “Innovation for Sustainability” published in Springer Nature in 2019 (see Annex 1 and 5). Within proposed eco-innovation model, Jana Hojnik (Hojnik, 2012) used as determinants six descriptive elements: the command-and-control instrument, the economic incentive instrument, managerial environmental concern, customer demand, expected benefits and competitive pressure. Also she considered eco-innovation outcomes could be measured by five elements: company growth and company profitability, economic benefits, competitive benefits and internationalization.

## **lii. Methods**

Table 2  
Criteria and research filters used in our research

Criteria		Research key words and filter (5% average of occurrence)
Key words		Environmental innovation; Eco-innovation; Green innovation and Eco-innovation model
Databases	Academic	SPRINGER; PALGRAVE MACMILLAN; ROUTLEDGE; CRC PRESS; PHYSICA; MIT PRESS; TAYLOR & FRANCIS GROUP; JOHN WILEY & SONS; ELSEVIER; EDWARD ELGAR PUBLISHING; MCGRAW HILL COMPANIES; ROYAL SOCIETY OF CHEMISTRY; ICI GLOBAL; WAGENINGEN; CPI BOOKS GMBH; ISLAND PRESS.
	Non-academic	Web-pages and reports from lobby organizations, research organisations ( OECD; UNEP; ), and governmental agencies ( European Commission) through Google searches.
Language		English
Geographic scope		Worldwide
Publication years (age of material)		1997- 2019

The research method quantitative, descriptive and exploratory in nature and was performed on internet database using four key words. In this way, the goal of this study was to analyze the current state of research on environmental innovation using bibliometric tools that considered the main authors, publishers, publications years and countries using four keywords.

To achieve our objectives, a systematic literature review on environmental innovation concepts was conducted. The overview of article structure is shown in figure 2.

Based on the theoretical groundwork presented, Figure 3 shows our proposed Structural Model (SM) and the 6 hypotheses. In this SM, we observe the theoretical relationship between three types of innovation (Environmental Innovation, Eco-Innovation and Green Innovation) and the Eco-Innovation Model.

H1. There is a *positive and significant* relationship between Environmental Innovation and Eco-Innovation;

H2. There is a positive and significant relationship between Environmental Innovation and Green-Innovation;

H3. There is a positive and significant relationship between Environmental Innovation and Eco-Innovation Model;

H4. There is a positive and significant relationship between Eco-Innovation and Green-Innovation;

H5. There is a positive and significant relationship between Eco-Innovation and Eco-Innovation Model;

H6. There is a positive and significant relationship between Green-Innovation and Eco-Innovation Model

These research hypotheses make it possible to study the direct and indirect effects of environmental innovations on business performance using our proposed eco-innovation model (Table 5, figure 7).

The conceptual design adopted in our field of research is shown in figure 3

## **Iv. Results**

Reviewing a number of 389 scientific publications published between the years 1997- 2019, using the terms “environmental innovation”, “eco-innovation”, “green innovation”, and “eco-innovation model”, from a total of 196 selected publications, it was revealed that the term “eco-innovation” is used in 83,77% of the analyzed articles, followed by the term “environmental innovation” (10.15%), the term “green innovation” (5.61%) and finally “eco-innovation model” (0.47%). That was initial refinement of scientific publications. Within the second refinement it is used the 5% average reduction. In this case, from a total of 117 selected publications, it was revealed that the term “eco-innovation” is used in 83.99% of the analyzed articles, followed by the term “environmental innovation” (10.06%), the term “green innovation” (5.49%) and finally “eco-innovation model” (0.46%).

Our conclusion is that there were no major changes in the hierarchy of keywords used after the second refinement, or in the percentages allocated to them (Table 1).

### **Descriptive Results**

We started our search with a number of 400 publications. Eventually, 11 publications were excluded in the analysis of this paper published during the period 1997 - 2019, because of duplication of authors and title. Within the rest number (389 scientific publications) we were focusing on studying the determinant factors of our four selected key words. This total of 389 searched publications was covering 25 countries (Table 3, figure 4), 4 keywords (Table 1), 18 publishers (figure 5), 360 authors with a total 10.151 no of occurrences for 4 keywords.

#### *Publications authorship and authors countries (Table 3)*

There are a number of 360 authors for 389 publications. From a number of 360 authors, OECD and Jens Hornbach are prominent authors with 7 and 6 publications, respectively. They are followed by Dan Chiras from Canada with 3 publications. The fourth position belongs to a number of 16 authors with 2 publications. The rest of 341 of authors have a single publication. In terms of countries, the top 6 countries with most no. of occurrences of author country were: USA (94), followed by the UK (83), Swiss (68), Germany (34), Singapore (27) and Netherlands (24).

Table 3  
No. of occurrence of author country

Rank	Country	No. of occurrence of author country	Percentage of occurrences (%)	Cumulative percentage of occurrences (%)
1	USA	94	24.20	24.2
2	UK	83	21.35	45.55
3	Swiss	68	17.50	63.05
4	Germany	34	8.76	71.81
5	Singapore	27	6.95	78.76
6	Netherlands	24	6.17	84.93
7	Canada	15	3.88	88.81
8	France	12	3.10	91.91
9	India	5	1.30	93.21
10	Australia	4	1.03	94.24
12	Belgium	3	0.80	95.04
13	Romania	3	0.80	95.84
14	Moldova	2	0.52	96.36
15	Austria	2	0.52	96.88
16	Finland	2	0.52	97.4
17	Japan	2	0.52	97.92
18	Slovenia	1	0.26	98.18
19	Denmark	1	0.26	98.44
20	Spain	1	0.26	98.7
21	Pakistan	1	0.26	98.96
22	Turkey	1	0.26	99.22
23	China	1	0.26	99.48
24	Sweden	1	0.26	99.74
25	New Zealand	1	0.26	100
Total		389	100.0	100

From this table was removed a number of 11 publications (out of the number of 400 initially counted publications), identified as appearing twice. Frequency of occurrence of countries for a number of 389

publications is presented in figure 4.

The country with the most publications is USA (94 publications). It is noteworthy that USA has been proactive in implementing environmental eco-innovation concepts at all levels of economy and has become an experimental laboratory for entire world.

Frequency of occurrence of publishers for a number of 389 publications is presented in Figure 5.

The results clearly show the leadership of SPRINGER publishing house. This publisher has the most publications (158 publications). Publication year and number of occurrences is presented in Table 4 and figure 6.

Table 4  
Publication year and number of occurrences

<b>Publication year</b>	<b>Number of occurrences</b>
2004	6
2005	8
2006	18
2007	9
2008	16
2009	21
2010	23
2011	32
2012	26
2013	39
2014	17
2015	37
2016	48
2017	33
2018	37
2019	15

Figure 6 shows that there is a number of 6 publication in the first decade (1990- 1999), 84 publications in the second decade (2000-2009) and a number of 299 publications in the last decade (2010 -2019). So there is growing trend in the number of publications on eco-innovation concepts in the last 10 years, if we compare with the small number of publications in the first decade.

## **The proposed eco-innovation model**

Within our proposed eco-innovation model we had been focused on: measures related to the model application in the process of eco-innovation; eco-innovation carried out activities and the main areas of application (economy, environment, society and government- policies)

Taking in account the business and firm's internal factors, we started with a proposal for an analytical framework for exploring the determinants of our eco-innovation model (figure 7).

In figure 7, we can verify our research hypotheses (H1-H6) to study the direct and indirect effects of business environment on firm's business performance using our proposed eco-innovation model determinants. The product eco-innovation enables the firm to incorporate innovative organizational activities (eco-innovation carried out activities) in the development of new products and services.

The matrix with the proposed eco-innovation model is presented in Table 5.

Table 5  
The matrix with the proposed eco-innovation model

(source: our research).

Measures related to the model application in the process of eco-innovation:	No.	Eco-innovation carried out activities	Main areas of application			
			Economy	Environment	Society	Government policies
Market Request	1	Pricing tools to reduce material and energy costs	X	-	-	-
	2	Approaches based on ecological performance	-	X	-	-
	3	Ecological labelling and certification	-	X	-	-
Market Offer	4	Support for the marketing of organic products	X	-	-	-
	5	Pre-marketing support	X	-	-	-
	6	Support for business in the field of ecological research	X	-	-	-
Logistics	7	Green procurement (public and private)	-	X	-	-
	8	Ensuring infrastructure without pollution sources	-	X	-	-
	9	Safety and health at workplace	-	X	-	-
	10	Safety of handling used materials.	-	X	-	-
Technological manufacturing	11	Ecological and technological standards	-	-	-	X
	12	Eco-technological transfer	X	-	-	-
	13	Scientific research dedicated to eco-innovation	-	-	-	X
	14	Policies for innovation and stimulation of eco-friendly technologies	-	-	-	X

Measures related to the model application in the process of eco-innovation:	No.	Eco-innovation carried out activities	Main areas of application			
			Economy	Environment	Society	Government policies
	15	Compliance with technological requirements for improving biodiversity and ecosystems	-	-	-	X
Management/ Marketing	16	European legislative requirements on eco-innovation, climate change and sustainable management of natural resources	X	-	-	-
	17	Public research in the field of eco-innovation	-	-	X	-
	18	Network and partnerships	X	-	-	-
	19	Information services on increasing the quality of life	-	-	X	-
	20	Ecological education and training	-	X	-	-
	21	Market research tools on finding new business models on eco-innovation	X	-	-	-
	22	Creating new and sustainable jobs	-	-	X	-
	23	Research on finding new products, services and markets	X	-	-	-
	24	Fair distribution of resources	-	-	-	X
<b>TOTAL</b>		<b>24</b>	<b>9</b>	<b>7</b>	<b>3</b>	<b>5</b>
<b>Weight</b>		<b>100</b>	<b>37.5</b>	<b>29.17</b>	<b>12.5</b>	<b>20.83</b>

Based on Koos van Dijken and Rennings definitions of eco-innovation, with H1 hypothesis defending the assumption that there is a positive and significant relationship between Environmental Innovation and Eco-Innovation we consider that “Eco-innovation carried out activities for Technological manufacturing” (Table 5) confirmed this hypothesis.

Based on Francesco see no. 386, Annex 6), (Calza, Parmentola & Tutore 2017). definition of green innovation and “Eco-innovation carried out activities for Management and Marketing” (Table 5) we consider that our hypothesis H2 is confirmed.

Based on “Eco-innovation carried out activities for logistics” (Table 5) and our proposal for an analytical framework for exploring the determinants of our eco-innovation model (figure 7) we consider that our hypothesis H3 is confirmed. Based on Eco-innovation carried out activities for Market requests (Table 5) model we consider that our hypothesis H4 is confirmed. Based on Eco-innovation carried out activities for Market offer (Table 5) and our proposal for an analytical framework for exploring the determinants of our eco-innovation model (figure 7) we consider that our hypothesis H5 is confirmed.

Based on our matrix with the proposed eco-innovation model we consider that our hypothesis H6 is confirmed .

Analyzing our proposal for an analytical framework for exploring the determinants of our eco-innovation model and the matrix with the proposed eco-innovation model allows us to point to the testing of hypotheses.

As we can see in the matrix (Table 5), the item “Economy”, one of the main area of applications, has the highest weight (37.5%). On the second position (29.17%) is another main area, named “Environment”.

As we can see in the matrix (Table5), these two items are the basic parts of the “*Main areas of applications*” which are strongly influenced by the measures related to our proposed model application in the process of *eco-innovation*, having a very high cumulative score (66.67%).

Taking in consideration this very cumulative score (66.67%) we consider that these influencing measures over the entire process of eco-innovation are validating all our proposed Hypothesis H1-H6.

## V. Discussions

Considering that many pertinent papers in the literature use not only the concept of “environmental innovation” but also its synonyms, we have expanded the search by taking into account the following keywords: “eco-innovation”, “green innovation”, “eco-innovation model”. The objective of this paper was to contribute to a clarification of the concepts of environmental innovation and to provide an overview of the existing scientific literature in this field, identifying the most active authors, countries, publishers and relevant publications.

Then, following our second objective, a conceptual framework was proposed which aims to study the relationships between environmental eco-innovation concepts.

So, we created a matrix with our conceptual framework (a proposed eco-innovation model) that is focused on the correlation between the measures related to the model application in the process of eco-innovation and the main areas of application.

## Vi. Conclusions

This study draws from the resource-based theory and investigates the interrelationships between three types of innovation (environmental innovation, eco-innovation, green innovation) and their impact on firm's business performance using the proposed eco-innovation model.

However, there is still ample room for research in this area. The matrix with the proposed eco-innovation model is focused on the correlation between the measures related to the model application in the process of eco-innovation and the main areas of application (economy; environment; society and government policies). The firms' managers could be focused for applying the proposed model in the production processes for all main areas of applications: economy; environment; society and government policies (as a main area of application has the third position in our proposed matrix: 20.83%)

The field of research on environmental innovations concepts still has a long way to go in order to generate positive global, political, economic, scientific and social impacts.

For future research we suggest placing an emphasis on firm level first as described within our eco-innovation model (figure 7 and Table 5) to describe and analyze the influences of eco-innovation on this.

## Declarations

Professor Vasile N. POPA has no known competing financial interests or personal relationships that could have appeared to influence the work reported in the paper: *"An analytical literature review on environmental innovations concepts"*

Lecturer PhD Luminita I. POPA has no known competing financial interests or personal relationships that could have appeared to influence the work reported in the paper: *"An analytical literature review on environmental innovations concepts"*

Postdoctoral student PhD Anca N. IUGA (BUTNARIU) has no known competing financial interests or personal relationships that could have appeared to influence the work reported in the paper: *"An analytical literature review on environmental innovations concepts"*

### **Ethics approval and consent to participate**

Not applicable

### **Consent for publication**

Not applicable

### **Availability of data and material**

All data generated or analysed during this study are included in this published article and its supplementary information files.

## **Competing interests**

The authors declare that they have no competing interests

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## **Authors' contributions**

VP had made substantial contributions to the acquisition, analysis and interpretation of data;

LP had made substantial contributions to the conception and design of the work;

AI (B) had made substantial contributions to work calculation issues, had a major contributor in writing the manuscript, had drafted the work and substantively revised it.

All authors read and approved the final manuscript (and any substantially modified version that involves the author's contribution to the study);

All authors had agreed both to be personally accountable for the author's own contributions and to ensure that questions related to the accuracy or integrity of any part of the work, even ones in which the author was not personally involved, are appropriately investigated, resolved, and the resolution documented in the literature.

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## **Authors' information**

<sup>1</sup> Regional Department for Defense Resources Management Studies, Mihai Viteazul 130, Brasov, 500183, Romania

<sup>2</sup> Transilvania University of Brasov, Faculty of Electrical Engineering and Computer Science, Department of Automation and Information Technologies, str. Politehnicii nr. 1, Brasov, 500024, Romania

<sup>3</sup> Transilvania University of Braşov, Postdoctoral studies, B-dul Eroilor nr. 29, Brasov, 500036, Romania

\*Corresponding author, email: [anca.iuga@unitbv.ro](mailto:anca.iuga@unitbv.ro) ; Tel: +40 268 413000 ext. 237,131. Fax: +40 268 510052

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## Figures



Figure 1

The five stages of the database analysis of publications addressing environmental innovations concepts

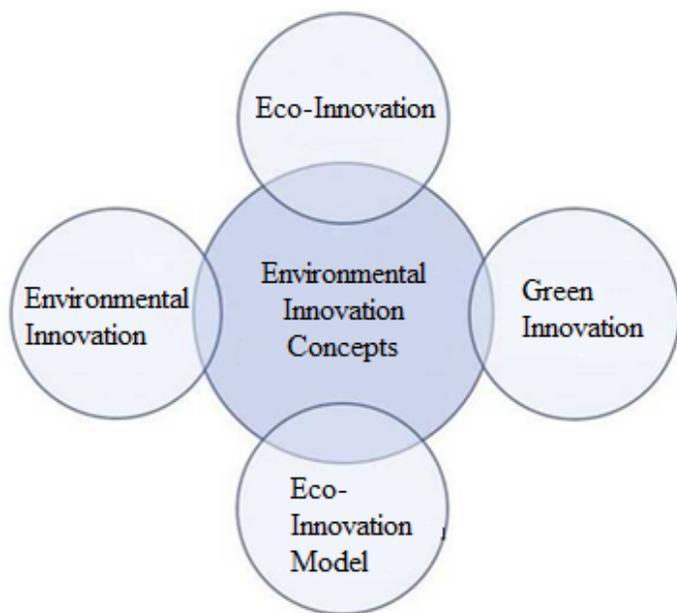
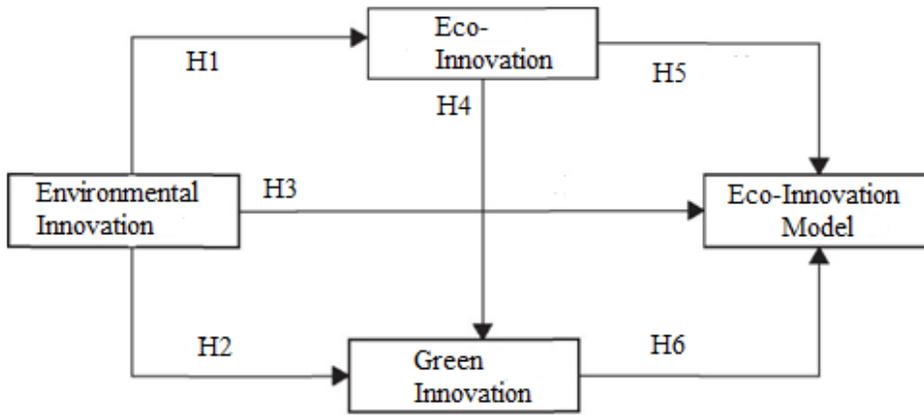


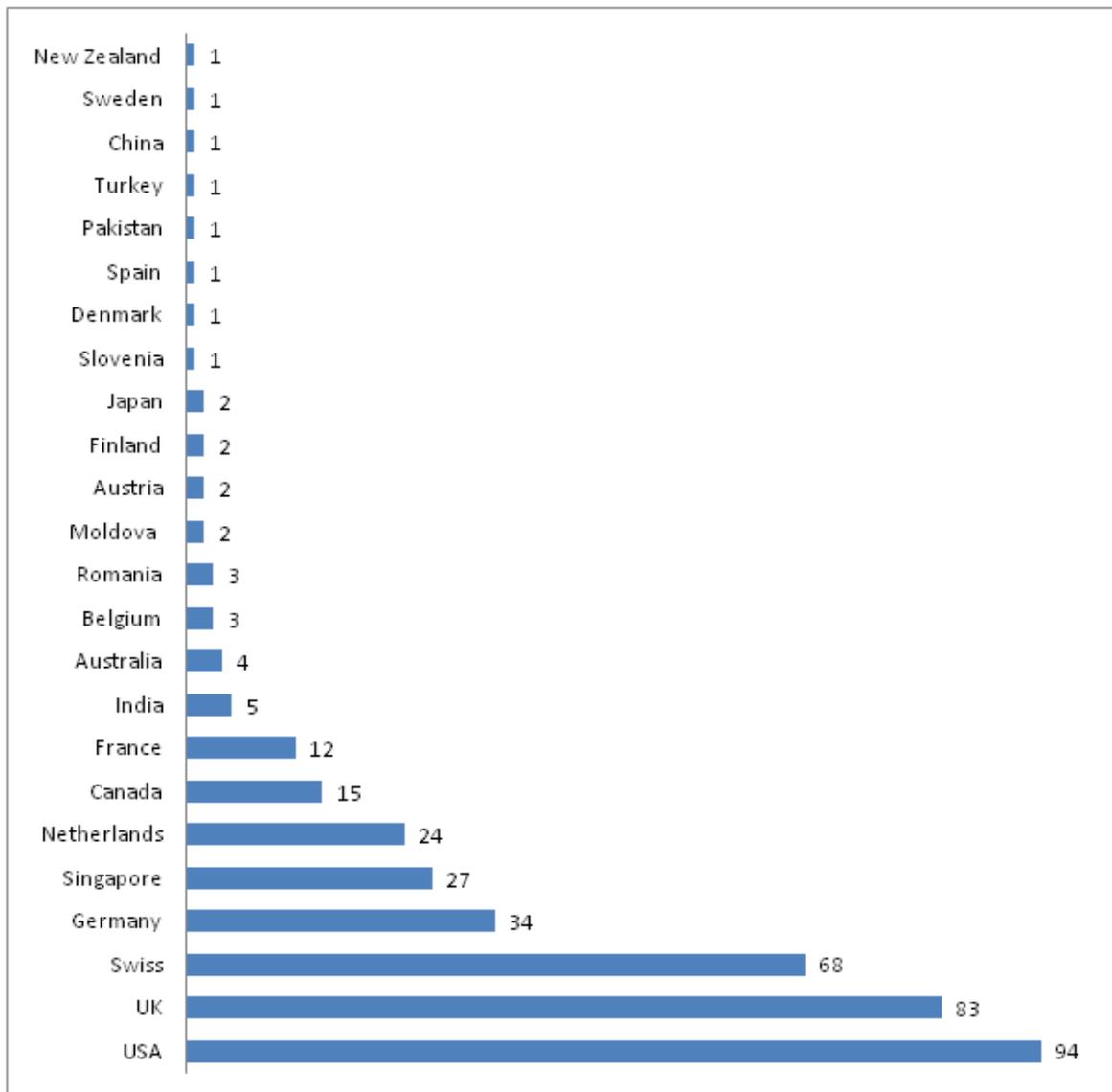
Figure 2

Overview of article structure



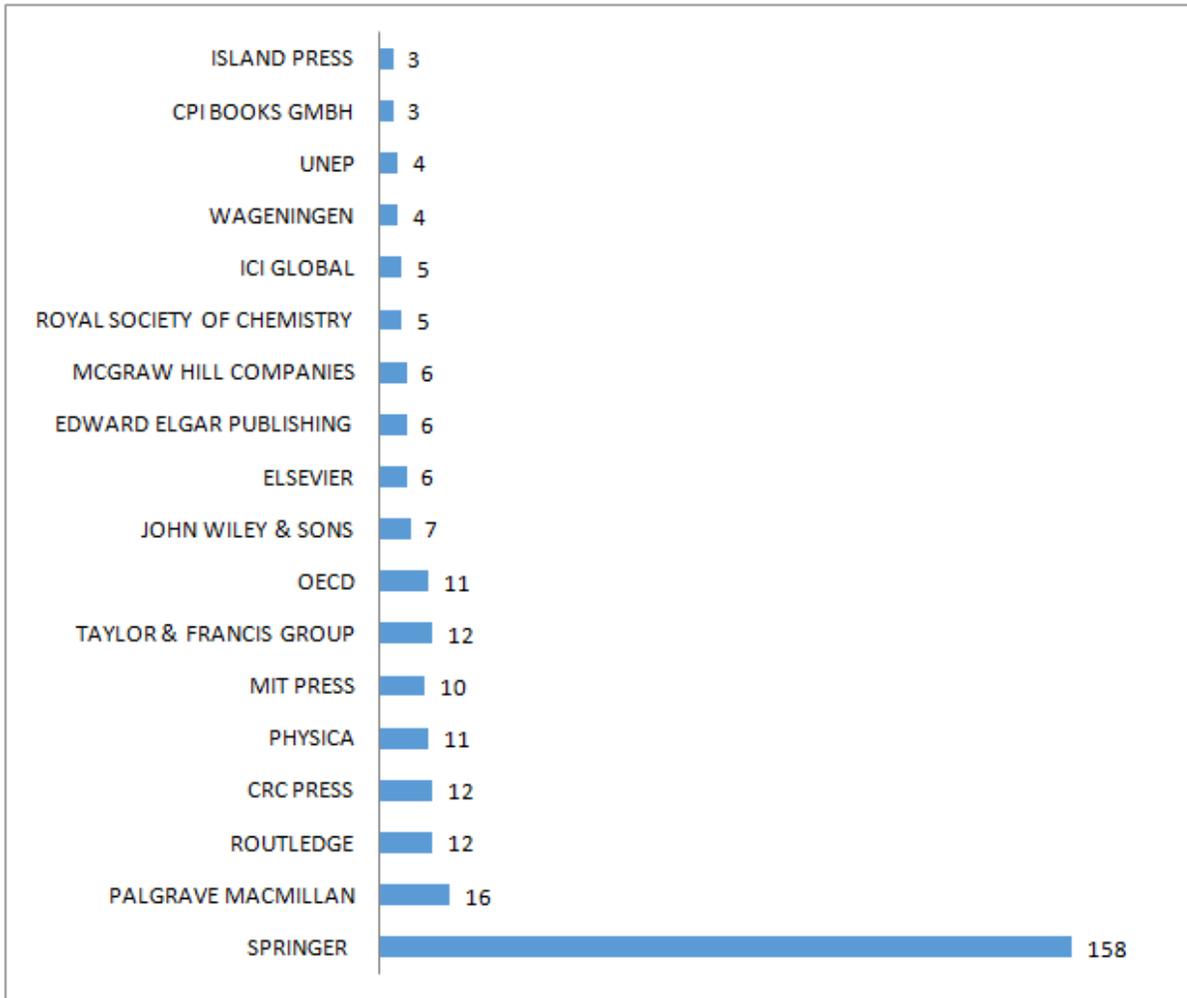
**Figure 3**

Conceptual design adopted in our of research



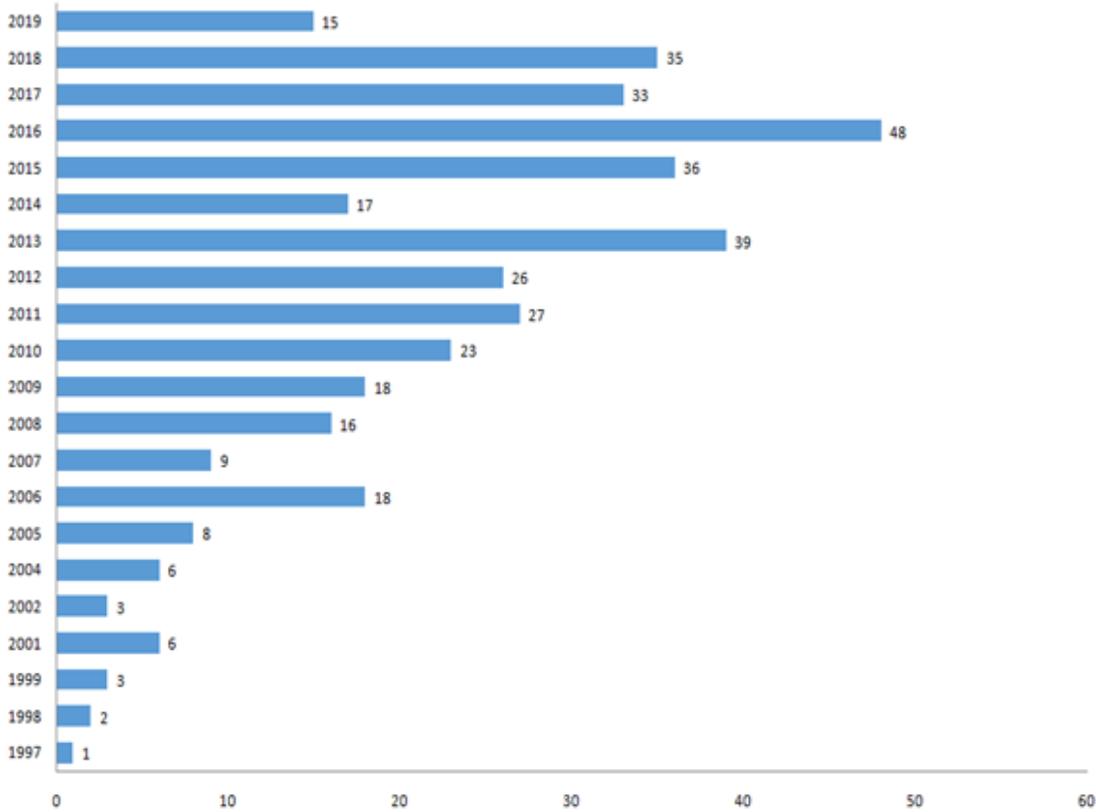
**Figure 4**

Frequency of occurrence of countries for a number of 389 publications



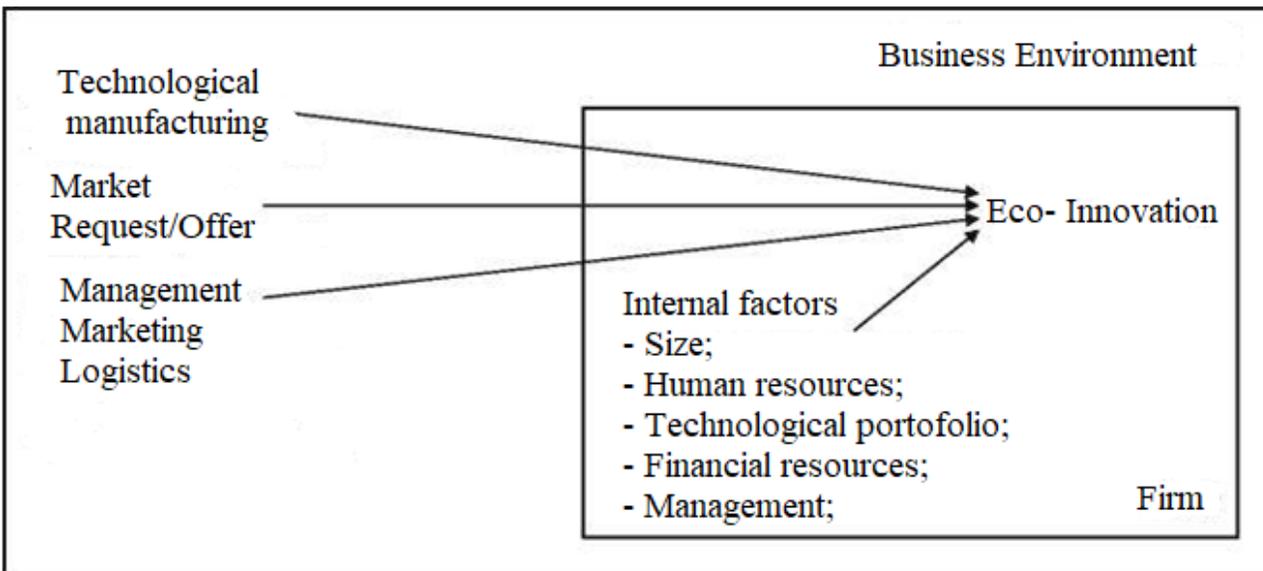
**Figure 5**

Frequency of occurrence of publishers for a number of 389 publications



**Figure 6**

Publication year and number of occurrences



**Figure 7**

The initial status of analytical framework for exploring the determinants of proposed eco-innovation model (source: our research).