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**Article**

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Article

# Eco-Innovation, Sustainability and Business Model Innovation by Open Innovation Dynamics

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**Abstract:** The paper aims to analyze the environmental aspects of innovation activity undertaken by companies and, in particular, to assess sustainable business leaders' propensity to generate eco-innovation. The research described in the paper was descriptive and, to some extent, diagnostic. It was based on a non-random sample and was conducted—using the Computer Assisted Telephone Interview (CATI) method—in 2019 among 54 of the most eco-innovative Polish companies. The results of the research indicate that they are more likely to generate radical rather than incremental changes. Moreover, the most eco-innovative companies are those developing technologies for biodiversity protection. The results further indicate that companies with more than 50 employees have a higher propensity to develop incremental and radical eco-innovation than smaller firms with relatively fewer resources. Finally, this study shows that adopting an open innovation strategy strengthens the propensity to generate eco-innovation, especially radical ones. Moreover, developing such changes is dominated by the adoption of strategic and operational forward supply chain collaboration, involving the absorption of knowledge and information streaming directly from the market. The results can provide a frame for developing new business models incorporating collaboration in eco-innovation activities, especially in the situation of a post-pandemic recovery of the economy.



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**Keywords:** sustainable business; environmental innovation; open innovation; open eco-innovation

## 1. Introduction

The modern world is facing multiple global crises, and problems resulting from them, with one of the key ones being the problem of an all-dimensional climate protection. This includes the economic dimension, which has significantly contributed to the current state of the environment with the onset of the Industrial Revolution. However, the uniqueness of the possible positive impact of economic activity on the environment is noteworthy. Usually, this impact is perceived in the dimension of passive (improvement) actions, as the introduction of solutions limiting the harmful environmental effects (e.g., limitation of pollution emission or natural resources consumption). However, in the economic dimension, there is also the possibility of implementing active solutions of a complex nature, limiting the harmful impact of economic activity on the environment and radically serving to restore its state before the industrial revolution. Such solutions undoubtedly include ecological innovation, especially radical eco-innovation.

Sustainable business, operated through the implementation of many ecological concepts (such as the Industrial Ecology, Ecological Modernization, Triple Bottom Line, or Cradle-to-Cradle design), is seen as a worldview in which business managers are economically incentivized to innovate towards sustainability [1]. However, it seems that economic motivation alone may not be sufficient, which is why A. Luqmani et al. [1] argue that if companies are to make a significant contribution to solving environmental problems within the prevailing sustainable business paradigm, there is an urgent need for managers

to understand better how to innovate effectively towards sustainability. It is also worth noting that an essential solution to complement this view is to extend sustainable business practices by actually promoting them, e.g., by creating open eco-innovation (under the Open Innovation concept [2–4]).

However, promoting sustainability goals often does not translate into taking practical sustainability measures, especially when they are expensive or disruptive. The literature abounds with negative examples of such attitudes, e.g., in the form of greenwashing [5]. Therefore, it seems crucial to focus on actions carried out by sustainable development leaders, i.e., companies that have significant and confirmed achievements in developing environmentally friendly solutions.

The paper aims to assess the propensity of sustainable business leaders to generate ecological innovation. In particular, the research problem concerns the verification of eco-innovative activity in Poland and identifying environmental activities undertaken by domestic companies. In this context, it will be valuable, given contemporary knowledge, to obtain answers to three fundamental research questions. The first is how developing eco-innovation is directed, and more specifically, are changes of an incremental rather than radical nature predominant? It is also complementary to determine the structure of environmental investments undertaken among the sustainable business leaders, i.e., to indicate which environmental technologies dominate. Secondly, is the propensity to generate incremental and radical eco-innovations in small and medium companies differentiated by employment size? Thirdly, what are the relations between cooperation with external partners and eco-innovation activities? In other words, do open innovation activities facilitate the development of eco-innovation among sustainable business leaders in Poland?

The realization of such an objective first requires an analysis of the literature on eco-innovation; then, discussing the research process and the results obtained. The paper ends with a discussion and conclusions stemming from the research.

## 2. Concept and Definitions of Eco-Innovation

The variety of definitions of eco-innovation manifests itself in heterogeneous terms and concepts. Environmental innovation, eco-innovation, green innovation, and sustainable innovation or sustainability-oriented innovation are just some of the terms used by researchers. The literature analysis shows that the first three terms have a similar meaning. However, sometimes ‘environmental innovation’ is taken very narrowly and is identified with environmental technologies (European Commission definition developed in 2004 [6]). The term ‘sustainable innovation’ refers to the concept of sustainable development defined by the World Commission on Environment and Development [7] (Brundtland Commission) as ‘development that meets the needs of the present without compromising the ability of future generations to meet their own needs’. The conceptualization of sustainable innovation as a tool for implementing sustainable development is shown in Figure 1.

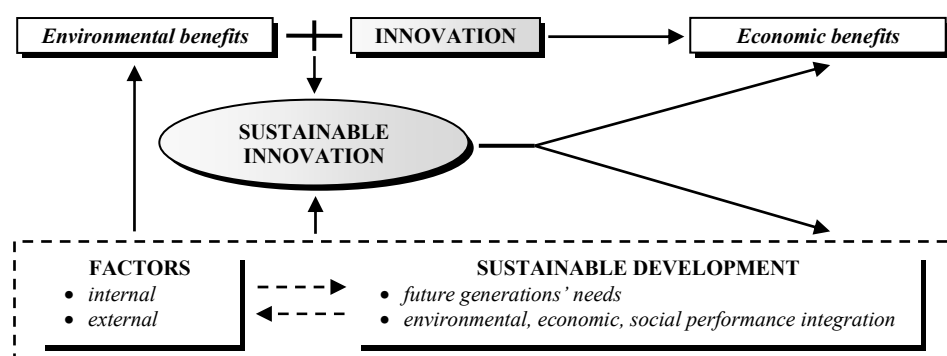


Figure 1. Conceptualization of sustainable innovation. Source: own study based on [8].

Both the conceptualization of sustainable innovation presented in Figure 1 and numerous definitions (e.g., by Charter and Clark [9] and de Medeiros et al. [10]) clearly emphasize the effectiveness of innovation activity, not only in the economic and environmental dimension, but also in the social one.

An important direction for conducting a comparative analysis of eco-innovation definitions can be detailing critical aspects of descriptions formed by Schiederig et al. [11], including: (1) Innovation object—product, process, service, and method; (2) Market orientation—satisfy consumer needs/be competitive on the market; (3) Environmental aspect—reduce negative impact (optimum = zero impact); (4) Phase—entire life cycle (for material flow reduction); (5) Impulse—economical or ecological; and (6) Level—setting an innovation/green standard to the firm. As noted by researchers [11], the first two aspects are characterized by high generality and apply to almost all eco-innovation definitions. Innovation can be a product, process, service, or method—e.g., a business model—and should meet the users' needs, affecting the competitiveness of companies—innovators on the market. Regarding the environmental aspect, the vast majority of definitions explicitly consider reducing negative environmental impacts through the implementation of eco-innovation, compared to the use of alternative solutions. Analysis of the definitions further indicates that the fourth aspect appears only in Kemp and Pearson's [12], Reid and Miedzinski's [13], and Eco-Innovation Observatory's [14] reports. The indicated approaches emphasize the necessity of considering the entire innovation life cycle, which firstly entails the analysis of all input and output factors in the innovation process, and secondly indicates the reduction of resources used. The fifth definitional aspect refers to the economic or ecological impulse for generating and implementing innovation (e.g., definitions by Carrillo-Hermosilla et al. [15] and Kammerer [16]). Finally, the last aspect is related to the perceived level of innovation novelty (in a company, on the market, in the sector, in the country, in the world), which emphasizes, e.g., definitions by Kemp and Pearson [12] and Melece [17].

Machiba [18] proposes to analyze and define eco-innovation in terms of their (1) target, (2) mechanism, and (3) impact. Regarding the first dimension, the target of eco-innovation can be products and services, processes, marketing methods, organizational changes, and institutional changes that transcend corporate boundaries (i.e., social norms or cultural values), as included in the definitions by Chan et al. [19], Organisation for Economic Co-operation and Development (OECD) [20] and Sarkar [21]. The purpose of eco-innovation can, therefore, be technological or non-technological. Product and process innovations are generally associated with technological changes, while marketing, organizational and institutional innovations are usually based on non-technological changes. The second dimension of defining eco-innovation, i.e., the mechanism, stems from the perceived level of their novelty. It can take the form of (1) small, progressive product and process adjustments; (2) significant changes in existing products, processes, and organizational structures; (3) alternatives, such as the introduction of a product that can fulfil the same functional need and operate as a substitute for other goods; and (4) generation and implementation of entirely new products, processes, procedures, and organizational and institutional changes [18]. This dimension is also included in the definitions by Horbach [22], OECD [20], and Oltra and Saint Jean [23]. The third dimension of defining eco-innovation is its impact on the environment and is conditioned by the other two dimensions. The more systemic the solutions generated (e.g., introducing alternatives or creating new products or processes), the greater the potential environmental benefits of implementing these changes [18].

It is worth noting that there is terminological diversity in the literature regarding eco-innovation. Most researchers use environmental innovation, green innovation, sustainable innovation, or sustainability-oriented innovation as synonyms of eco-innovation [17,24–27]. This is also the approach adopted in this study.

Focusing on eco-innovation, researchers [28] define it in two ways: by its environmental impact and the innovator's intention. Environmental motivation is more difficult to verify, although ecological effects may also prove challenging. The variety of defini-

tions of eco-innovation entails the need to systematize them. In this paper, the evolution of the eco-innovation concept over the period 2000–2021 is analyzed, followed by its conceptual scope.

One of the first definitions of eco-innovation proposed by Fussler and James [29] refers to eco-innovation as a new product or process that offers value to both the company and consumers, while significantly reducing harmful environmental impacts. Similarly, other definitions formulated in 1997–2000 (by Hemmelskamp [30], Kemp and Arundel [31] as well as Rennings [32]) primarily emphasize the mitigation of the effects of economic activity. Such an approach to eco-innovation refers to end-of-pipe technologies, enabling control or the neutralization of pollution generated in the production process. The application of these technologies does not reduce produced pollutants but limits their adverse environmental impact.

The definitions of eco-innovation developed in the following years (2001–2004) refer to the mitigation of environmental burdens and the economic aspect, which is the efficient use of resources. Researchers (e.g., authors of the VINNOVA study [33]) indicate that ecological innovation also includes clean or integrated technologies, which already at the source reduce the amount and change the quality of generated pollution to more environmentally friendly.

Further evolution of the eco-innovation concept capture definitions formulated in 2005–2009 (e.g., by Little et al. [34] and Hellstrom [35]), which consider eco-innovation much more broadly, as changes of not only environmental and economic but also social nature. Regarding innovation benefits, these definitions indicate that the generation and implementation of eco-innovation lead to the reduction of pollution (including the minimal release of toxic substances [13]), more efficient and responsible use of resources, the achievement of social benefits (through the design of green products or waste recycling [36]), and institutional benefits [20].

Finally, definitions developed in recent years capture eco-innovation in a strategic dimension, as they address the interrelationship between companies and their competitive environment and the dynamic interactions in the innovation process (e.g., definitions by Carrillo-Hermosilla et al. [15] and Forsman et al. [24]). Eco-innovation refers to solving environmental, economic, and social problems [17], encompassing technological changes (products and production processes) and non-technological changes (organizational, marketing, and institutional).

Another essential aspect in the analysis of the definitions is that they represent both a narrow (including definitions by Fussler and James [29], Kemp and Pearson [12] and Melece [17]) and broad (definitions by Rennings [32], Oltra and Saint Jean [23] or Xavier et al. [37]) framing of eco-innovation.

As Horbach et al. [38] point out, the narrow view of eco-innovation encloses eco-innovation activities within organizational boundaries, emphasizing three essential aspects. First, it is based on the subjective perception of eco-innovation (the innovation must be new at least to the firm). Second, it includes only innovations implemented (and not activities initiated to reduce environmental burdens). Third, it relates the reduction of harmful environmental impacts to state-of-the-art. The subjective view of eco-innovation is consistent with the Oslo Manual [39], which states that innovation does not require internal investment in R&D activities. Therefore, an innovation can be derived from its adoption of solutions developed by other firms (even those that have been on the market for some time) [15]. The second aspect of a narrow view of eco-innovation focuses on the actual environmental impact of these innovations (effects) rather than intentional actions (motivation). In such a context, it is irrelevant whether the environmental benefits are the primary purpose of eco-innovation or whether they are an unintended side effect [38]. Finally, a narrow view of eco-innovation assumes that it relates to state-of-the-art. It thus considers innovation whose use is less harmful to the environment than the use of alternatives (e.g., energy-efficient light bulbs versus conventional ones) [38].

A broad view of eco-innovation extends beyond organizational boundaries and includes changes in socio-cultural norms and institutional structures [15]. According to Cecere et al. [25], ecological innovations are least harmful to physical, biological, and cultural systems. Similarly, Oltra and Saint Jean [23] emphasize the impact of eco-innovation on sustainable development objectives. These objectives, broader than just the environmental ones, correspond to the institutional definition of eco-innovation adopted within the European Union. Rennings [32] also highlights such a perspective, as it captures eco-innovation in the context of sustainable development goals.

Eco-innovation is defined in this study as a new solution for a given company and leads to the avoidance or reduction of adverse environmental impacts. Such a definition is in line with the assumption that reducing adverse environmental impacts is the main distinguishing feature of eco-innovation. This approach to eco-innovation refers to the Oslo Manual [39] and emphasizes the organizational context of eco-innovation. As Carrillo-Hermosilla et al. [15] state, what is innovative for one company in a certain place and time may be quite common for another in a different place and time. Moreover, the proposed approach emphasizes only reducing negative environmental impacts, regardless of whether this effect is intended or not. Thus, the innovator's motivation remains a secondary issue, who avoids discussing whether the innovation was developed for strictly environmental reasons.

To conclude, the proposed definition of eco-innovation is characterized by a narrow view of it. Consequently, it departs from the institutional perception of it as a tool for achieving sustainable development targets. Another critical issue is the scope of changes defined in this way, including solutions with varying degrees of novelty. The proposed approach to eco-innovation is similar to the existing definitions of innovation in the literature (except that eco-innovations lead to the avoidance or reduction of adverse environmental impacts).

Eco-innovation can be classified according to the scale of environmental changes developed by companies. According to this perspective, incremental and radical eco-innovation can be distinguished. Incremental (evolutionary) eco-innovation refers to modifications in environmental products, services, and processes resulting from technological solutions that enhance, modify or extend the current environmental knowledge [40]. Radical eco-innovation represents—on the other hand—fundamental changes in environmental products, services, and processes, created by implementing new technological solutions that go beyond current environmental knowledge [40]. Radical eco-innovations are rarer than incremental ones (they often result from costly and long-term scientific research). They are also more original and more complex, which makes them more challenging and causes greater resistance in implementation [41–43].

Triguero et al. [44] relate this classification to end-of-pipe technology (incremental eco-innovation) and clean technology (radical eco-innovation). Both types of changes require significant expenditure. Still, only radical eco-innovation implies an increase in production processes' efficiency due to the rational use of materials and energy. As a result, it contributes to the competitive advantage. Del Río et al. [45] divide eco-innovations according to the originality of changes (into solutions new to the firm and unique to the market) and state that the first category characterizes by a lower degree of novelty; hence, they can be expected to be primarily incremental.

In conclusion, the conducted literature review indicates the importance of both radical and incremental eco-innovation. However, it is undeniable that the former is more valuable concerning key definitional aspects mentioned by Schiederig et al. [11] and the mechanism of eco-innovation proposed by Machiba [18]. In this context, it is crucial to identify the effects of eco-innovation activity undertaken by Polish companies considering the perceived level of their novelty (first research question). Moreover, del Río et al. [45] (p. 1) state that 'analyses of the relevance of different determinants to eco-innovation for distinct eco-innovator and eco-innovation types have largely been missing'. Concerning such a research gap, it is also important to determine whether the propensity to generate

incremental and radical eco-innovations in small and medium companies is differentiated by employment size (second research question).

An important premise arising from this classification is that radical eco-innovation can be perceived as creating new knowledge and combining existing knowledge in novel ways. In this context, the knowledge used in generating eco-innovation can be created within the organization or come from its environment. This assumption is in line with the concept of Open Innovation, seen as a critical paradigm in innovation management. This concept emphasizes the aspects of cooperation with external entities undertaken to generate innovation.

Open innovation, described by Chesbrough [2], refers to the processes of intentional (purposeful) inflows and outflows of knowledge, i.e., to all types of innovation activities that go beyond the organization's boundaries. Doran and Ryan [46] state that access to knowledge and information flowing from the market is particularly important in generating and implementing eco-innovation. Moreover, the results of studies conducted in the literature [47–49] confirm that eco-innovators are more likely to be collaborative than other innovators. Broadly defined, collaboration in generating eco-innovation includes interaction with customers and suppliers, research institutes and universities, and other firms.

Given the predominance of the paradigm of open innovation, as it fits the modern reality, it is essential to diagnose the relations between cooperation with external partners and the effects of eco-innovative activities (third research question). According to Triguero et al. [4], collaboration is one of the fastest, and sometimes easiest, ways to develop eco-innovations. Through collaboration, companies can gain access to new or complementary resources and expand business practices to include sustainability issues [50].

### 3. Materials and Methods

Assessing sustainable business leaders' propensity to generate eco-innovation required undertaking research among companies showing significant achievements in running eco-innovation activity. This research was conducted in Poland in 2019 on a targeted sample ( $N = 54$ ), including leaders in developing eco-innovative solutions. The gathered set of surveyed companies consisted of the winners of six editions of the GreenEvo program and eco-innovation leaders identified by the Specialist Observatory in Technologies for Environmental Protection.

Financed by the 'Polish National Fund for Environmental Protection and Water Management', the GreenEvo Program (Green Technology Accelerator) is aimed to promote the best innovative environmental technologies generated by Polish companies all over the world. As a result of the first six editions of the program, a list of the most eco-innovative Polish companies was created, and a total of 74 green technologies developed by GreenEvo winners were selected. The awarded technologies fall within the following broad technological areas: air protection, renewable energy sources, solutions supporting energy saving, waste management, water and sewage management, and biodiversity protection. It should be noticed that percentages do not add up because respondents could select more than one technological domain. The above-mentioned technical domains consist of the Polish National Smart Specializations (NSS), which are the areas of public support specified and described in the list of NSS developed by the Ministry of Entrepreneurship and Technology in 2019. The Specialist Observatory in Technologies for Environmental Protection, on the other hand, is part of the 'Network of Regional Specialist Observatories in the Entrepreneurial Discovery Process' project co-financed by the European Regional Development Fund and undertaken in Poland in 2017–2019.

The application of such a selection of research samples made it possible to examine 54 companies involved in developing new technological solutions, with the simultaneous limitation of companies declaring environmental activity. The research was conducted by the Marketing Research Center 'Indicator' using the CATI method (Computer Assisted Telephone Interview). Due to the considerable geographical dispersion of the compa-

nies included in the research sample, qualitative research was conducted based on a research questionnaire.

An additional substantive justification for the non-random sample selection is the inclusion of the propensity to create innovative solutions, which requires that the respondents' eco-innovation activities are not one-off and incidental but have—by definition—a long-term character. The purposeful selection of the research samples made it possible to include companies that, as eco-leaders (and sometimes multiple winners of the GreenEvo program), effectively generate technological eco-innovation over a relatively long time.

Three main research questions were formulated within the framework of the conducted research, which approximate the achievement of the stated purpose of the paper. The special interests of the authors are therefore directed at obtaining answers to the following questions:

**Q1:** How is the process of generating eco-innovation directed and, more specifically, do incremental or radical changes prevail? Is it also complementary to determine the structure of environmental investments undertaken among the sustainable business leaders, i.e., to indicate which environmental technologies dominate?

**Q2:** Is the propensity to generate incremental and radical eco-innovations in small and medium companies differentiated by employment size?

**Q3:** What are the relations between cooperation with external partners and the effects of eco-innovation activities undertaken by companies? In other words, do open innovation activities facilitate the development of eco-innovations among sustainable business leaders in Poland?

The first stage of empirical research was to construct a research tool, i.e., a questionnaire addressed to the management team members, especially on the top level. Due to the extensive nature of the research conducted, this paper discusses only part of the collected results. This part determines the purpose of this work, i.e., assessing the propensity to generate eco-innovations by Polish companies.

As part of the research, the internal consistency of the developed research tool was assessed, and the reliability and validity of the used scales were checked. The modification of the measurement scales involved evaluating the adequacy of their content through discussion with five experts working on innovation and the environmental implications of conducting innovation activity. The expert feedback helped improve several items to ensure that the respondents clearly and unambiguously understood them.

Eco-innovation was measured based on a modification of the measurement scales popular in the literature by Subramaniam and Youndt [43]. These scales refer to both incremental and radical changes. Adapting the original operationalization of innovation to the context of the conducted research, the questionnaire included six statements (three for each type of eco-innovation, respectively) regarding the development of changes characterized by varying levels of novelty. Regarding incremental changes, respondents were asked to determine whether the eco-innovation developed in their company: (1) makes a simple modification in current green products, services, or processes; (2) makes a slight change in current green products, services, or processes; (3) slightly enhances current environmental expertise or green technology. Regarding radical eco-innovation, respondents assessed whether the solution developed in their company: (1) makes a breakthrough in green products, services, or processes; (2) fundamentally changes green products, services, or processes; (3) departs from existing environmental expertise or green technology. The construction of the research tool was based on the achievements of other researchers to maintain the possibility of comparison of the results. Therefore, a modification of the original measurement scales by Chen et al. [40] was used.

The second part of the research questionnaire was descriptive and—to some extent—explanatory and predictive. The research was concluded with a metric that included control variables at the organizational level, particularly the age and size of the company (measured by the number of employees) and the technological domain of the eco-innovation activity. In measuring the variables included in the research, an interval scale of attitudes developed



by Likert was used. Respondents were asked to indicate their level of agreement (from 1—‘strongly disagree’ to 7—‘strongly agree’ with a given statement) to the statements in the questionnaire.

To assess the reliability of the measurement scales used, Cronbach’s alpha coefficient values were calculated. The obtained measurement values are based on correlations between items of a summary scale and indicate the degree of variance of that scale’s ‘true’ value. Low coefficients indicate the lack of reliability of the measurement scale and mean that its items generate the only random error. For questions concerning the generation of incremental eco-innovations, Cronbach’s alpha was 0.701. In contrast, for questions concerning the creation of radical eco-innovation, it reached 0.871, which confirmed the reliability of the research tool. Assuming—as a limiting value—the Cronbach’s alpha coefficient at a level of 0.7 [51,52], (which means that the values for the individual items are similar to each other, and therefore the whole scale is not random), both research scales display a satisfactory level of reliability. Cronbach’s alpha coefficient values are above the limiting level.

#### 4. Results

As a result of the conducted research, some interesting phenomena were observed, which allow the broadening of knowledge on the undertaken subject of the propensity to generate eco-innovation and, at the same time, sustainable development of the economy.

Performing a preliminary analysis of the activities undertaken by the surveyed companies in terms of environmental investments, it was noted that the scope of implementation of ecological functions varies. Still, the most common activities are those resulting from commonly available solutions for a sustainable business. It is worth noting that, of the 54 companies included in the research sample, 28% are involved in developing solutions supporting energy saving, and 37% are developing other environmentally friendly solutions related to renewable energy sources. One in five (20%) is active in the development of water and sewage management technologies, and almost one in ten (9%) in technologies supporting waste management and (9%) biodiversity protection. Only one in twenty (5.5%) is working on air protection technologies. It should be noticed that percentages do not add up because respondents could select more than one technological domain.

Sustainable business leaders’ propensity to generate eco-innovation was assessed based on the type and degree of novelty of environmental solutions declared by the respondents. Using a subjective tool for measuring the propensity to develop eco-innovation allows to partially eliminate the differences arising from the different levels of technological advancement of companies included in the study. According to the results, companies are more likely to generate radical changes—the average score given by respondents for this type of innovation is  $4.91 \pm 1.76$ . Companies also develop incremental eco-innovation—the average response for this type of change is  $4.17 \pm 1.54$ . However, the significant difference between the third quartile and the maximum score obtained indicates the presence in the sample of individual organizations declaring a very high level of generation of this solution.

It is also essential to determine in which technical area the surveyed companies develop the most eco-innovative changes. As seen from the results presented in Table 1, the most active—in the context of generating both incremental and radical eco-innovation—are companies creating advanced technological solutions in biodiversity protection (mean responses: 5.40 and 5.07). Moreover, companies developing water and sewage management technologies (mean: 5.30) and waste management solutions (mean: 5.00) have a relatively high propensity to create radical changes.

It is also worth noting that regarding incremental changes, the most eco-innovative are companies developing technologies supporting energy saving (mean: 4.56) and technologies that are increasing the efficiency of using renewable energy sources (mean: 4.15).

**Table 1.** Propensity to generate eco-innovation by the technological domain.

Technical Domain	Incremental Eco-Innovation			Radical Eco-Innovation		
	Simple Modification in Current Green Solutions	Slight Change in Current Green Solutions	Slightly Enhancing Current Environmental Expertise	Breakthrough in Current Green Solutions	Fundamentally Changes Green Solutions	Departing from Existing Environmental Expertise
Water and sewage management	4.18	4.64	3.36	5.18	5.64	5.09
		4.06			5.30	
Waste management	4.00	3.60	4.20	5.20	4.60	5.20
		3.93			5.00	
Energy saving	4.87	4.33	4.47	5.13	5.07	4.13
		4.56			4.78	
Air protection	4.00	2.00	2.00	4.00	4.00	3.33
		2.67			3.87	
Renewable energy sources	4.70	4.05	3.70	5.45	4.70	4.45
		4.15			4.87	
Biodiversity protection	6.00	5.20	4.00	5.40	5.40	5.40
		5.07			5.40	

All companies participating in the research belong to the sector of small and medium-sized enterprises (SMEs), which at the same time indicates that they are representatives of the critical sector in Poland as, in the Polish economy, it is this sector that has a 49.1% share in GDP creation (data from 2017) [53]. The SME sector employs as many as 68% of all workers in the Polish economy, and every fifth firm implements various innovations. However, while large enterprises (employing more than 250 people) see investments in environmental activities, the promotion of which often becomes a way to create competitive advantage, this ability seems to be limited in SMEs.

Regarding the structure of the surveyed enterprises, it should be noted that 74% of them are small companies (with less than 50 employees). In total, 26% are medium-sized enterprises with up to 250 employees. The average organization size in the sample is 54 employees, and the average existence on the market is 19 years.

Another aspect of the analysis was to illustrate the relationship between the propensity of companies to generate eco-innovations and their size (which, as it turns out, only slightly differentiates the research sample). Nevertheless, the results indicate that companies with more than 50 employees have a higher propensity to generate incremental and radical eco-innovation than small firms with relatively smaller financial, physical, and human resources. Moreover, as in the entire research sample, both small and medium-sized companies are more likely to develop radical eco-innovation (mean: 4.90 and 4.93, respectively) compared to generating incremental eco-innovation, which means are 4.05 and 4.50. Small firms are relatively most likely to develop eco-innovation that makes a breakthrough in green products, services, or processes (mean: 5.30). In contrast, the propensity of larger firms to generate eco-innovation is based equally on all three types of radical change (mean: 4.93).

The research sample was also divided according to their existence on the market. Of 54 firms, 9% are companies operating on the market for up to 5 years, 52% are companies between 6 and 20 years of existence, and finally 39% are companies operating for more than 20 years. The analysis shows that the most eco-innovative (in generating improvement changes) are companies existing for one generation (mean: 4.31), while in developing radical eco-innovation are the youngest companies (mean: 5.00).

It is also interesting to note that the youngest and the oldest companies most often develop solutions that fundamentally change green products, services, or processes (mean: 5.40 and 5.10). On the other hand, companies operating on the market for more than 5 years, but less than 21 years, usually generate solutions that make a breakthrough in green products, services, or processes (mean: 5.36).

Finally, to answer the question of the relationships between the directions of cooperation with external partners and the effects of eco-innovation activity, a descriptive analysis was carried out. First, the main directions of the conducted activities were identified, which include interaction with: (1) customers and (2) suppliers, (3) universities, research institutes, and agencies and (4) competitors. The research results indicate that 81% of the companies cooperate intensively with customers and 61% with suppliers. In turn, 72% of companies declare maintaining close public linkages (with research and development units, institutes, and universities), and only 11% declare horizontal linkages (with competitors). The analysis of the relationship between the directions of cooperation and the level of novelty generated eco-innovation presents in Table 2.

**Table 2.** Propensity to generate eco-innovation as a result of cooperation with external partners.

Collaboration with:	Incremental Eco-Innovation			Radical Eco-Innovation		
	Simple Modification in Current Green Solutions	Slight Change in Current Green Solutions	Slightly Enhancing Current Environmental Expertise	Breakthrough in Current Green Solutions	Fundamentally Changes Green Solutions	Departing from Existing Environmental Expertise
Customers	4.56	3.75	3.53	5.75	5.72	5.16
		3.95			5.54	
Suppliers	5.05	4.26	4.16	5.95	5.79	5.10
		4.49			5.61	
Univ *	4.97	3.90	3.87	5.57	5.27	5.77
		4.24			5.30	
Competitors	4.67	4.33	3.67	5.50	5.51	4.83
		4.22			5.28	

\* Univ—universities, research institutes, and agencies.

Not surprisingly, companies collaborating with external partners are much more likely to generate radical eco-innovations than incremental ones. Concerning collaboration with customers and suppliers, the highest scores were obtained for developing innovation that represents a breakthrough in current green solutions (mean: 5.75 and 5.95, respectively). Referring to collaboration with universities, research institutes, and agencies, it was found that through such activities, companies most often generated solutions that departed from existing environmental expertise. Finally, building horizontal linkages (with competitors) facilitates changes that fundamentally alter green solutions. However, it is worth noticing that these are declarations of managers, formulated in general terms, i.e., without a specific measurement or estimation tool.

### 5. Discussion

The described results have their connotations in the existing literature. Therefore, they will be discussed to formulate critical conclusions based on the answers to the research questions.

First, the companies participating in the study are more likely to generate radical eco-innovation than incremental ones. The scores obtained (on a scale of 1–7) exceed the value of four (with radical eco-innovation scoring 4.91 and incremental changes scoring 4.17). These values, especially for radical eco-innovation, should be considered significant in the overall business market. However, it is necessary to note that they are not representative of all businesses in Poland. This is due to the adopted research sample, which included the most innovative Polish companies developing internationally unique environmental technologies.

Nevertheless, it should be noted that companies also develop incremental eco-innovation. These changes are less original and less complex (compared to radical solutions). They are connected with lower risk; their creation requires fewer resources and less involvement in creating new knowledge and undertaking cooperation with external partners. Moreover, in the process of developing radically new solutions, their creators can be—as noted by

Carrillo-Hermosilla et al. [15]—‘functionally fixed’ in terms of the skills and knowledge they possess, and may therefore abandon the creation of further technological solutions. An important limitation of the generation of radical changes is that it is challenging to evaluate concepts and prototypes of such innovation (as no reference product exists) and high technological complexities, high anticipated costs, and uncertainty regarding their acceptance by consumers.

An essential aspect of the research was to determine in which technical domain companies generate the most eco-innovation. It turned out that the most active in developing both incremental and radical innovation are companies creating advanced technological solutions for biodiversity protection. Among the technologies developed in this area, we can point out, above all, technologies for reclaiming water reservoirs and innovative technical solutions for protecting water engineering objects. A relatively strong propensity to generate radical changes has also companies developing water and sewage management technologies. These solutions concern municipal and industrial wastewater treatment, technologies for water treatment and sewage waste drying, etc. Similar results were also obtained for technologies supporting waste management, such as the neutralization of hazardous and toxic waste, security of liquid fuel storage, biomass gasification, and processing of plastic waste into liquid fuels. Regarding improvement changes, the most eco-innovative are organizations working on energy-saving and renewable energy solutions. The fact that in these technical areas companies tend to focus on incremental changes (rather than radical ones) may be due to high relative investment costs in the energy sector, which imply the maintenance (rather than change) of existing technological paradigms [25,54].

Secondly, it is worth recalling that, according to the presented research results, three out of four companies were small firms employing up to 50 people, and only one in four was a medium-sized company. This distribution of the research sample is associated with several important substantive implications. First, in the literature [16,44,55,56] dominates the belief that larger companies—having a more extensive resource base and performing a larger scale of operations—are more likely to generate eco-innovative technological solutions. Despite the unquestionable advantage of large companies, the results of other studies [27,57] indicate that smaller companies also increasingly create environmental innovation. Moreover, Díaz-García et al. [28] noted that eco-innovation is an increasingly common practice among companies with less than 250 employees. This is also confirmed by the research described in this paper. In addition, small and medium-sized enterprises also have a greater ability to adapt to changes occurring in their environment, which significantly affects the undertaking of effective eco-innovation activities.

The most eco-innovative (in terms of generating incremental changes) are companies existing at least one generation, while concerning radical eco-innovation are the youngest companies. These results are generally consistent with the literature [28,45,58], stating that in the case of conventional changes, incremental eco-innovation is developed mainly by older organizations with an established position, higher turnover, and more employees. On the other hand, radical eco-innovation is more often generated by new market players who challenge dominant technological paradigms.

Third, the study results indicate that creating eco-innovation is dominated by strategic and operational upstream cooperation (with customers). Such results prove that in eco-innovation, the customers of new technological solutions are actively involved; thus, becoming real partners for surveyed companies. A significant percentage of respondents also declare intensive cooperation with suppliers, universities, research institutes, and agencies. Considering research context (companies characterized by a high eco-innovation potential), such results are not surprising. Moreover, they confirm the results of other analyses undertaken in the literature [59,60], which indicate the importance of creating a network of logistical and scientific connections for generating all types of eco-innovation by SMEs. Finally, it is noteworthy that companies which collaborate with external partners are much more likely to generate a radical eco-innovation than an incremental one. These results confirm other studies [61], indicating that increasing interdisciplinary collaboration in

developing new technologies is an important condition for developing such eco-innovation. This is because external partners have valuable knowledge resources that companies can use to complement internal innovation activities [62]. Moreover, creating eco-innovation requires developing new knowledge and, last but not least, sharing it within the organization. Pacheco et al. [59] refer to this factor as ‘technological advisory’. The obtained results also confirm such a conclusion. As indicated by the respondents, in 89% of companies, their members intensively exchange information and learn from each other.

It is also a significant inspiration to raise the importance of this process to the level of inter-organizational cooperation as part of developing open innovations, both in the context of offering unused technologies and acquiring innovations developed outside the enterprise [2,51,52]. It therefore seems important to combine eco-innovations and the concept of open innovation; thus, creating open eco-innovations. Such pro-ecological activities, especially in the area of offering open eco-innovations, can make a significant contribution to the development of global ecological solidarity, aiming at common sustainable goals by supporting and promoting Open Business Models [63–65] and Business Model Innovation [66–69].

## 6. Conclusions

The research results presented in the paper can be a substantive contribution to the still-developing stream of scientific literature devoted to environmental aspects of innovation activity undertaken by organizations. The most important scientific premise arising from this paper is assessing the propensity to generate incremental and radical changes by companies that undertake intensive environmental activities. Moreover, as Mousavi et al. [61] state, the complexity of eco-innovation and the accompanying uncertainty represents a challenge for the strategic management of firms that engage in its development. Moreover, this complexity of eco-innovation is precisely due to the need to consider the requirements of many different stakeholders. Therefore, the results of the conducted research can provide a framework for the development of new business models, including cooperation in eco-innovation activity with private and public partners.

The research results presented in the paper are not free from several limitations. The first, and most important, limitation is the small size of the sample. Hence, the direction of future research is to replicate them on other (larger) populations. In addition, existing differences between countries (e.g., environmental awareness of managers) may lead to ambiguous results. Therefore, it is necessary to conduct comparative studies and, as a result, to identify the actions undertaken by eco-innovators in different countries. Third, the study used subjective methods to measure variables. Therefore, future research should be based on objective indicators that could be verified a priori. Fourth, the data obtained are cross-sectional. Therefore, a necessary extension of the analyses is a longitudinal study that allows the assessment of long-term relationships between variables. An interesting direction for future research may also concern other types of eco-innovation that go beyond the technological domain.

A significant theoretical contribution is the confirmation—in the conditions of the Polish economy—of the usefulness of the applied measurement scales. Their reliability and good matching of variables to empirical data indicate that they can be used in further research. To sum up, the results of the analyses may serve as a basis for a further development of the theory and the design of future studies and their interpretation.

In summary, this research should not be treated as exhaustive and definitive, especially concerning such a complex issue as the creation of effective mechanisms supporting the generation of eco-innovation. They constitute only a tiny fragment of the still-developing knowledge and, within the designed scope, provide answers to the research questions raised in the introduction.

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