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The Implementation Environment for a Digital Technology Platform of Renewable Energy Sources

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Abstract: The study addressed broad aspects related to digital technology platforms and renewable energy sources, including the integration of these systems and concepts. The main objective was to identify the implementation environment for a digital technology platform of renewable energy sources (RES) based on business and consumer feedback. This gives an insight into whether there is a favourable environment for implementing a RES digital technology platform. The study was based on research carried out using computer-assisted telephone interview (CATI) and computer-assisted web interview (CAWI) methods. Additionally, an alternative model of attitudes towards digital technology platforms (DTPs) built using CATREG (categorical regression) analysis was also referred to. The study found that currently, there is a positive attitude among companies, including those which install RES systems, as well as among consumers towards the implementation of DTP-based RES projects. This attitude is driven by the many benefits that can be achieved by using these platforms. However, there are some obstacles to the implementation of a digital RES platform. These relate to cyber security concerns, including computer or internet failures. However, the obstacles are not crucial for the practical implementation of the discussed platform.

Keywords: renewable energy sources; digital technology platform; environment; attitudes; CATREG model

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1. Introduction

The topics discussed in this study have a broad context. Issues related to both digital technology platforms (DTPs) and renewable energy sources (RES) are intrinsically linked to such aspects as innovation [1–6], modern technologies [7–10] including information and communication technologies [11,12], and ecology [13–16]. In general, due to the drive for cost reductions or environmental protection, DTP- and RES-based solutions are widely promoted at the moment; therefore, the related topics are relatively often addressed in the scientific literature [17–19].

However, it has to be pointed out that so far, issues related to the opportunities DTPs offer in relation to RES equipment and systems have only been hinted at and have not been discussed extensively. The scientific discussion has focused either on DTPs or RES, but the possibility of integrating these two concepts or models has not been sufficiently addressed. Nevertheless, it is possible to point to some publications in which these issues were mentioned [20–24]. It is worth mentioning that a number of authors use terminology that indicates the integration of DTPs and RES. This is reflected in the terms used, e.g., digital energy platforms [25–28], electronic platforms of energy [22,29], IT platforms in the energy market [30], research and innovation (RRI) platforms for energy [31], and platforms for energy trading and risk management (abbreviated as ETRM) [32–34] which include solar energy trading platforms [35] or web platforms for water-energy monitoring and control [36]. However, none of the publications discusses the aspects related to the implementation environment for RES digital technology platforms in detail.

When referring to such an environment, it is first worth explaining the features and the functioning of the RES digital technology platform. In the scientific literature, DTPs are primarily defined as digital tools that create the basis for establishing and intensifying relationships among various market players, including businesses and consumers, and even administrative institutions (public administration bodies). Such relationships are made possible by the fact that DTPs enable these entities to make transactions and establish interactions, including business ones, as well as to communicate with each other using the internet. The essence of the digital platform ecosystem is the coexistence of a modular core and complementary elements that are interdependent and function on common principles and a comprehensive value proposition [37]. Due to the need for coordination among the many entities that make up the ecosystem of the digital platform, it seems possible to approach the platform ecosystem as a meta-organization: less formalized than a company but more so than markets [38,39].

The direct effect of DTPs is to link business partners and create business networks [40,41]. Another definition indicates that DTPs (in technical terms) are extensible code bases that enable the addition of further modules and functionalities at any time, as well as in socio-technical terms; a set of specified technical elements, including software and hardware, and related organisational processes and standards that enable the establishment of organisational ecosystems (i.e., networks of links between diverse entities) [42]. On the other hand, the author's definition of DTP is as follows: electronic (digital) tools that may take the form of services or content and which make it possible to develop the ground for establishing and intensifying contacts among different entities operating in the market; whereas a vital feature of these platforms is the possibility of their constant expansion with new modules or functionalities.

With regard to the concept of a digital technology platform in the context of RES or, more broadly, the energy market, a DTP should be referred to as a digital space where users can communicate with each other and establish various relationships and interactions related to the energy and RES market, as well as access specific energy products, services, and resources provided by other users or organisations [22]. Another approach points out that the RES digital technology platform is a new business model based on digital technology that offers pioneering and innovative solutions to various problems related to the functioning of the energy sector, including demand and supply coordination, grid management, data acquisitions and cost reductions [25,43].

Currently, there are examples of successful integration between DTP and RES. It can be seen in the increasing implementation of ETRM projects (i.e., platforms for energy trading and risk management). Platforms that are based on blockchain technology are undergoing particular development. Among other things, they enable energy trading without brokers or commodity exchanges, which leads to cost reductions [44,45]. DTPs are also widely used to manage digital wind farms [46,47] and hydropower plants [48,49], as well as for operating systems aiming at the digitalisation of energy consumption [50,51]. Examples of successful forms of integration between DTPs and RES constitute the underlying conditions for further development of technologies and solutions in this field.

The main objective of this study was to identify the implementation environment for the RES digital technology platform. The main goal of this study was to find out whether there are adequate attitudes and interest in the RES platform from both consumers and companies that install RES systems, which is undoubtedly one of the critical conditions for the success of the RES platform. It is worth emphasizing that the analyses contained in this study were based on an innovative methodological approach that uses, apart from CATI and CAWI methods, the CATREG model based on the measurement of attitudes towards DTPs.

2. Materials and Methods

This study was based on research carried out as a part of two research projects. The first of these is entitled 'Business Models Based on Digital Technology Platforms'. Here,

analyses were carried out using CATI and CATREG (categorical regression) methods. The second project, entitled 'Design and Customisation Platforms for Renewable Energy Installations', used CATI and CAWI methods.

The first research project focused on companies that received funding for the implementation and development of DTP, while the second project examined companies offering renewable energy generation systems and individual consumers who had the opportunity to install RES in their buildings. In both projects, the survey was conducted with the managers of these companies and randomly selected individual RES users. A study designed in this way allows for comprehensive identification of the implementation environment of the RES digital technology platform based on the opinions of three groups of respondents: companies offering RES systems (producers and distributors), companies that have implemented and develop them, and individual users of RES systems.

The CATI method, which is one of the varieties of standardised questionnaire interviews, is used in all sectors of the survey industry [52]. This method, based on obtaining quantitative data through telephone interviews, is very useful in social research [53]. First of all, it allows one to efficiently survey a relatively large part of the population and generalise the results to the entire population. It also provides the possibility of immediately recording respondents' answers and ensures a high degree of control over the course of interviews, which leads to minimisation of errors when recording the data [54,55]. Compared with face-to-face interviews or mailed questionnaires, CATI usually ensures a higher participation rate and generates lower costs [56]. Importantly, the high usefulness of the CATI method has also been confirmed in relation to research conducted within sectors traditionally associated with innovation and modern technologies, including the energy sector [57–59] or logistics [60,61]. This also applies to environmental innovation (eco-innovation), including the RES sector [62–64].

In the first of the projects mentioned above, the CATI method was used in telephone interviews that were carried out between 18 and 28 February 2019. This method was based on a specially constructed interview questionnaire containing 23 questions. The sample was randomly selected. Interviews were conducted with representatives of the management staff of enterprises that were granted funding for the implementation and development of DTPs under the Innovative Economy Operational Programme implemented by the Polish Agency for Enterprise Development (PARP). The final sample consisted of $N = 320$ records, out of which effective interviews were conducted with $N = 121$ entities.

In the second project, carried out between 9 and 13 November 2020, the CATI method was used to survey companies offering energy generation systems from renewable sources. The use of CATI and CAWI methods in the second project aimed to show two perspectives: from the side of the company implementing RES (CATI) and from the point of view of the end user (CAWI). The sampling frame (CATI) was the 'Bisnode Poland' database, which contains up-to-date contact and financial data of companies which operate in Poland. Here, $N = 328$ companies from all over Poland meeting the selection conditions were drawn, from which $N = 120$ effective interviews were conducted. The randomisation algorithm incorporated into the telephone survey software ensured that each record in the database had an equal chance of being included in the sample. The *response rate* was 0.74.

CATREG (categorical regression) analysis is one of the regression methods classified as optimal scaling. Scaling is a method of predicting the value of a selected variable based on the values adopted by other variables, which are also indicated by the researcher. It is important to note that optimal scaling allows variables to be included in the analysis at each level of measurement: nominal, ordinal, interval, and quotient. This is a significant advantage of this method. This method can be considered a kind of 'first choice' in social sciences as, generally, the variables are measured at a qualitative level. The purpose of using this method is to quantify the relationship between multiple independent variables and a single dependent variable. This is 'categorical regression' and examines the combined interaction of the variables (interaction means the 'product' of the individual variables) [65]. The concept of optimal scaling originates from different sources (correspondence analy-

sis [66] and multidimensional scaling (MDS) [67,68]) and is considered to be the successor of these methods. It is more statistically correct and rigorous [69].

Optimal scaling is a technique that ensures multidimensional exploration of the data: 200 predictors are permitted, although only one independent variable can be predicted. However, it is reasonable to limit the number of variables. At the same time, each variable should have a minimum of 10 and, preferably, 20 units of analysis; otherwise, it may result in unstable regression lines. This means that in the present analysis, where the set is $N = 121$, a maximum of 12 independent variables could be used and, optimally, no more than six [70].

CATREG enables the development of various models. Their construction follows strictly defined stages. The stages include (1) including a set of variables in the model that, in the opinion of the researcher, influence the dependent variable; (2) manipulating the order of variables to achieve the highest score; (3) forming and evaluating the model; (4) reducing the number of variables by the weakest predictor; (5) forming a reduced model; and (6) comparing the two models. The model of measuring the attitudes towards DTPs was constructed as a part of the research. In this study, an alternative model was analysed. It was based on synthetic indicators (indices, scales). In this case, the independent variables were synthetic values obtained from two or more direct indicators (questionnaire questions). A direct advantage of this approach was that it reduced the number of independent variables, which made it possible to reduce the distance between the R^2 and the adjusted R^2. As a result, it was possible to obtain a model that explained the variation of the dependent variable to a more considerable degree. An unquestionable advantage of this approach can be its transparency as a result of ordering and structuring the individual factors into groups.

The data were synthesised through a simple, arbitrary summation and subsequent averaging of sets of indicators. In terms of methodology, these are the so-called 'reflective indicators' (i.e., those that are not related to a common cause but, according to the researcher's assumptions, classified in a more general category).

The following five synthetic indices were distinguished: cybersecurity (represented by one factor), economic (one factor), human (eight sub-factors), structural (four factors) and structural-demographic (two sub-factors). These factors are shown in Table 1.

The analyses conducted for the purpose of this study were also based on the CAWI method. This is, similar to CATI, a method of questionnaire-based research, but unlike CATI, CAWI is conducted online (i.e., by means of websites where a research questionnaire containing questions to be answered by the respondents is uploaded). The questions are standardised, and their wording and sequence are determined by the researcher. Importantly, the CAWI survey, in each case, takes place without the participation of the researcher, which is one of the most important differences between this method and CATI [71,72].

A few advantages of using the CAWI method can be pointed out. These include, in particular, the relatively low cost, the possibility of including a variety of graphical and multimedia elements, which increases the attractiveness of the interview for the respondents, elimination of the potential impact of the interviewer on the research results, a significant reduction of the researcher's error potential, and, in relation to data acquisition, quick access to the acquired data and exporting them to statistical analysis software, including SPSS, as well as the possibility of conducting research virtually anywhere there is access to the internet and mobile devices [73–76]. These advantages allow the CAWI method to be widely used in numerous scientific studies, including those concerning broadly understood innovation and modern technologies [77–79]. This also includes issues related to renewable energy sources [80–82].

The research using CAWI included a group of individual respondents. The prerequisite for the respondent to be included in the sample was the feasibility of installing renewable energy sources (the respondent needed to live in a building that enables the installation of such devices). The sample for the CAWI survey was randomly selected. The sampling frame was the *inetpanel.pl* database, which contains data on active panellists and comprises almost 20,000 adult Poles. In total, $N = 500$ effective interviews were conducted. The sample

was representative concerning socio-demographic variables such as gender, age, size of the town of residence, and voivodeship.

Table 1. Classification of factors of the entrepreneurs' attitudes towards the digital technology platforms.

Index	Questionnaire Question	Level of Variable Measurement
Cybersecurity	Question 8. Please specify: Has the implementation of DTPs in the company where you carry out your professional duties resulted in the following negative cybersecurity incidents and risks directly resulting from the use of these platforms?	Nominal (multiple choice question), transformed into a quotient variable; counting the number of answers
Economic	Question 11. Please specify: What key benefits are generated due to using DTPs in your business?	Nominal (not subject to factor analysis, for example)
Human	Question 1. Does your company use DTPs (i.e., tools that allow you to link trade partners and provide a ground to intensify their contacts and carry out transactions with them)?	Ordinal
	Question 5. Please specify: What is the attitude of the management staff in your company towards the implementation and use of DTPs?	Ordinal
	Question 16. Please specify your gender.	Nominal (not subject to factor analysis, for example)
	Question 17. Please specify your age.	Interval
	Question 18. Please specify your level of education.	Interval
	Question 19. Please specify your length of service in the company where you currently perform your professional duties.	Interval
	Question 20. Please specify: How long has the company where you perform your professional duties operated in the market?	Interval
	Question 21. Please specify: What type of position do you hold in the company in which you currently perform your professional duties?	Nominal (not subject to factor analysis, for example)
Structural	Question 4. Please specify: Which type of DTPs are used or will be used (in the case of implementation plans) in your company? (Please check all possible answers)	Nominal (multiple choice question), transformed into a quotient variable; counting the number of answers
	Question 10. In which areas of your business operations are DTPs used or will be used (in the case of implementation plans)? (Please check all possible answers)	Nominal (multiple choice question), transformed into a quotient variable; counting the number of answers
	Question 12. Do you agree with the statement that DTPs enable the establishment and development of innovative business models?	Ordinal
	Question 14. Has the implementation of DTPs in the company where you perform your professional duties forced, or will it force, specific changes to its organisational structure?	Ordinal
Structural (socio-demographic)	Question 22. Please specify: In which type of company, in terms of the headcount, do you carry out your professional duties?	Interval
	Question 23. What industry does your company operate in?	Nominal (not subject to factor analysis, for example)

3. Results

In the analysis of the implementation environment for the RES digital technology platform, including the attitudes towards and relations with the DTPs of both people who use DTPs professionally and consumers, the results of the 2019 CATI survey are considered first. During this research, respondents were asked about the attitudes of management staff towards DTPs. The analysis of the respective answers is presented in Table 2.

Table 2. The attitude of the management staff of surveyed companies towards DTPs.

Please Specify: What is the Attitude of the Management Staff in Your Company towards the Implementation and Use of DTPs?	Frequency	Percentage
Strongly positive	43	35.5
Somewhat positive	60	49.6
Neither positive nor negative	8	6.6
Somewhat negative	2	1.7
I have no opinion on that subject	8	6.6
Total	**121**	**100.0**

The vast majority of respondents (85.1%) declared that the management staff of their companies had a positive attitude towards DTPs, of which 35.5% declared a strongly positive attitude and 49.6% declared a somewhat positive attitude towards DTPs. Only 1.7% of respondents had a contrary opinion. On the other hand, 6.6% of people considered their attitude towards DTPs to be neither positive nor negative, and 6.6% had no opinion on that subject.

During the survey, the respondents were asked to indicate how the positive and negative attitudes of the management staff towards DTPs were expressed. The analysis of the respondents' declarations in this regard is presented in Table 3.

Table 3. Indications of positive and negative attitudes towards DTPs expressed by the management staff of surveyed companies.

Indications of Positive Attitude	Frequency	Percentage
Strong involvement in tasks related to the implementation and use of DTPs	83	17.8
Strong, unsolicited willingness to participate in training on this subject	63	13.5
Active in generating new ideas resulting from the use of DTPs	76	16.3
Giving consent to any changes resulting from the implementation of DTPs, including those relating to organisational structure	88	18.8
Significant readiness to change own professional duties	81	17.3
Interest in further investments related to the implementation of DTPs	76	16.3
Total	**467**	**100.0**
Indications of negative attitude		
Strong resistance to the DTP implementation phase, resulting from possible changes in the organisational and employment structure of the company	2	40.0
Numerous concerns resulting from economic factors (high implementation costs and possible cost reductions in other areas of the company's operations)	1	20.0
Expressing numerous concerns related to cybersecurity	2	40.0
Total	**5**	**100.0**

Among the indications of a positive attitude, the respondents mentioned the willingness of the management staff to implement changes resulting from the use of DTPs (18.8%), their high involvement in processes related to the implementation of these platforms (17.8%), their readiness to make changes in their own professional duties (17.3%), as well as their involvement in developing new ideas related to DTPs and their interest in further investments related to these platforms (16.3% for each answer). The negative attitude of company management staff, on the other hand, mainly resulted from strong resistance to organisational or employment changes and concerns about cybersecurity (40.0% for each answer).

As part of the CATI survey, the respondents were also asked to indicate whether any specific cybersecurity risks had become apparent in relation to the implementation of the DTPs. The analysis of the respondents' answers in this regard is presented in Table 4.

Table 4. Negative incidents and risks related to DTP implementation.

	Frequency	Percentage
Computer hardware failure	65	36.1
Internet network failure resulting from overload due to the use of DTPs, for example	43	23.9
Leaking of company, employee or contractor data	6	3.3
Leaking of customer data	6	3.3
Phishing (i.e., fraudulent impersonation of a trusted source via a website)	12	6.7
Pharming (i.e., redirection to fake websites and web servers)	10	5.6
Financial losses	6	3.3
Internet spying	3	1.7
No negative incidents occurred	28	15.6
Total	**180**	**100.0**

Among the negative incidents and risks associated with the implementation of DTPs, respondents mainly pointed to hardware failures (36.1%) and computer network failures (23.9%). They gave much less importance to cybersecurity threats such as phishing (6.7%), pharming (5.6%) or leakage of company and employee data (3.3%).

As part of the research project 'Business Models Based on Digital Technology Platforms', the respondents were also asked to respond to specific statements related to the implications of DTP implementation in companies. The analysis of their respective declarations is presented in Table 5.

Table 5. Implications of DTP implementation.

	Implementation of DTPs Entails Excessive Costs Which Do Not Correspond to the Benefits of Using Them		**Ongoing Use of DTPs is an Excessive Financial Burden for the Company**		**Employees Consider Using DTPs to be Economically Inefficient**	
	Frequency	**Percentage**	**Frequency**	**Percentage**	**Frequency**	**Percentage**
Strongly agree	7	5.8	3	2.5	1	0.8
Somewhat agree	5	4.1	9	7.4	12	9.9
Somewhat disagree	49	40.5	61	50.4	36	29.8
Strongly disagree	60	49.6	48	39.7	72	59.5
Total	**121**	**100.0**	**121**	**100.0**	**121**	**100.0**

In general, the respondents did not indicate that implementing DTPs would generate high costs and be an excessive financial burden for the company. Not only the management staff of the surveyed companies (90.1%) had such an opinion, but also the employees of these companies (89.3%).

At this point, it is also worth analysing the survey results concerning the benefits perceived by respondents in relation to the implementation of DTPs. These benefits are highlighted in Table 6.

Table 6. The benefits resulting from the implementation of DTPs. Reprinted with permission; 2021, MDPI.

	Frequency	**Percentage**
Profit increase	56	46.3
Increase in competitiveness level	19	15.7
Expansion of the product range	13	10.7
Increase in market share	3	2.5
Increase in the innovation level	6	5.0
Increase in the customer count	2	1.7
Improvement of customer service and increase in consumer satisfaction levels	3	2.5
Increase in the number of markets in which the company operates	2	1.7
Expanding the number of business partners, including those operating in a virtual environment only	1	0.8
Optimisation of various business processes, including customer service	11	9.1
Building digital supply chains	1	0.8
Increase in the overall efficiency of the company's operations	3	2.5
The possibility of being actively involved in the implementation of programmes initiated in the virtual environment, aimed at expanding the range of products or the customer base	1	0.8
Total	**121**	**100.0**

The respondents mainly indicated the following benefits of implementing DTPs: an increase in profits (46.3%), an increase in the level of competitiveness of the company (15.7%) and the possibility for the company to expand its product range (10.7%).

During the survey, participants were also asked to indicate whether DTPs are a factor contributing to the establishment and development of innovative business models. The analysis of the respondents' declarations in this regard is presented in Table 7.

Table 7. The impact the DTPs have on the establishment and development of innovative business models.

Do You Agree with the Statement That Digital Technology Platforms Enable the Establishment and Development of Innovative Business Models?	Frequency	Percentage
Strongly agree	63	52.1
Somewhat agree	45	37.2
Neither agree nor disagree	12	9.9
Somewhat disagree	1	0.8
Total	**121**	**100.0**

The majority of respondents (89.3%) declared that DTPs enable the establishment and development of innovative business models, whereas 52.1% strongly agreed and 37.2% somewhat agreed that such a correlation exists. The opposite opinion was expressed by only 0.8% of the survey participants, and 9.9% could not clearly say whether DTPs have any impact on the establishment and development of innovative business models.

The respondents were also asked to what extent, in their opinion, DTPs influence the relationships established by the company with its stakeholders, mainly suppliers, contractors, distributors, or customers. The analysis of their answers to this question is presented in Table 8.

Table 8. The impact that DTPs have on relations with stakeholders Reprinted with permission; 2021, MDPI.

To What Extent Do DTPs Increase the Quality and Intensity of the Relationships Established by the Company in Which You Perform Your Professional Duties with All Stakeholders, Including Mainly Suppliers, Contractors, Distributors, or Customers?	Frequency	Percentage
To a very large degree	44	36.4
To a large degree	47	38.8
Neither to a large nor a small degree	11	9.1
To a small degree	2	1.7
To a very small degree	6	5.0
I have no opinion on that subject	11	9.1
Total	**121**	**100.0**

The majority of the respondents (75.2%) stated that DTPs increase the quality and intensity of relations between companies and their business partners, with 36.4% stating that the impact is 'very high' and 38.8% stating that the impact is 'high'. The opposite opinion was expressed by 6.7% of people.

As already mentioned, based on the CATREG analysis, a model was constructed to measure attitudes towards DTPs. Tables 9 and 10 present the results in relation to the alternative model.

Table 9. Summary of coefficients of the optimal scaling model obtained by the descending method.

Multivariate R	0.361
R^2	0.131
Adjusted R^2	0.052

Table 10. ANOVA (analysis of variance) for the optimal scaling model obtained by the descending method.

	Sum of Squares	Number of Degrees of Freedom (df)	Mean Square	F	Significance
Regression	15.805	10	1.580	1.653	$p \leq 0.1$
Residual	105.195	110	0.956		
Total	**121.000**	**120**			

In the social sciences, the results of calculations in inductive reasoning statistics which show a *p*-value (*probability value*) above 0.05 are considered to be statistically insignificant.

Sometimes an exception is made to this rule, and test results that show $0.05 < p < 0.1$ are presented. There is a high (about 10%) risk of making a Type I error here, but such a result should be noted in the margin.

In the alternative model, the most significant factor, explaining more than a quarter (25.4%) of the independent variable's variance, is a structural (socio-demographic) factor, namely the size and industry of the company.

During systematic analysis of variables, the correlation mentioned above was confirmed at the level of single indices of inductive reasoning statistics by Pearson's chi-square method. The results are presented in Tables 11 and 12.

Table 11. Structural (socio-demographic) index: chi-square test of a correlation's significance.

	To What Extent Do DTPs Increase the Quality and Intensity of the Company's Business Relationships?													
	To a Very Large Degree		**To a Large Degree**		**Neither to a Large nor a Small Degree**		**To a Small Degree**		**To a Very Small Degree**		**I Have No Opinion**		**Total**	
	N	**%**	***N***	**%**	***N***	**%**	***N***	**%**	***N***	**%**	***N***	**%**	***N***	**%**
0–25	4	30.8	6	46.2	2	15.4	0	0.0	0	0.0	1	7.7	13	100.0
26–50	10	35.7	11	39.3	3	10.7	2	7.1	0	0.0	2	7.1	28	100.0
51–75	15	36.6	16	39.0	5	12.2	0	0.0	5	12.2	0	0.0	41	100.0
76–100	15	38.5	14	35.9	1	2.6%	0	0.0	1	2.6	8	20.5	39	100.0
Kruskal–Wallis H intergroup comparison test									n.i.					
Test of a correlation's significance between the Pearson's chi-square test variables and Cramér's V									χ^2 (15, N = 121) = 26.27; $p \leq 0.05$, V = 0.269					

Table 12. Components of the optimal scaling model obtained by the descending method.

Description of Model Component (Factor)	**Beta Coefficient**	**Number of Degrees of Freedom (df)**	**F**	**Significance**	**Zero-Order Correlation**
Structural (socio-demographic)	0.261	0.201	1	10.682	0.197
Structural	0.147	0.163	3	0.816	0.488
Human	0.141	0.163	2	0.749	0.475
Economic	0.070	0.207	3	0.114	0.952
Cybersecurity	−0.138	0.159	1	0.756	0.386
	Partial correlation	**Semi-partial correlation**	**Validity**	**Tolerance after transformation**	**Tolerance before transformation**
Structural (socio-demographic)	0.274	0.262	0.254	0.547	0.944
Structural	0.140	0.154	0.145	0.157	0.975
Human	0.145	0.148	0.139	0.157	0.972
Economic	0.105	0.072	0.067	0.056	0.932
Cybersecurity	−0.078	−0.141	−0.133	0.083	0.928

Proceeding to the results of the research carried out as a part of the project 'Design and Customisation Platforms for Renewable Energy Installations', first of all, it is possible to present the data concerning individual respondents (i.e., those obtained on the basis of CAWI). These data relate primarily to the level of consumer interest in the RES platform. The respective data are presented in Table 13.

Individual respondents are interested in the RES digital internet platform. This opinion was expressed by 88.4% of them.

The respondents' interest in the RES platform results undoubtedly from their plans to install equipment that produces electricity from renewable energy sources. Data related to these plans are presented in Table 14.

Table 13. The interest of consumers in the RES digital technology platform.

Would You Be Interested in Using a Free Online Platform That Would Match the Appropriate Size of RES Installations—Mainly Photovoltaics, Solar Collectors and Heat Pumps—for a Specific Household or Business, on the Basis of Demand, Annual Consumption, and Location?	Frequency	Percentage
Yes, I am planning to install and/or interested in installing RES	141	28.2
Yes, mainly to find out what the potential of the site is and the possible options, cost, and potential benefits	301	60.2
No, I am planning to install and/or interested in installing RES, but my knowledge is sufficient	9	1.8
No, at the moment, I do not plan to install these, but I do not exclude such an investment in the future	25	5.0
No, I am not interested at all in RES	24	4.8
Total	**500**	**100.0**

Table 14. Respondents' plans to install equipment producing electricity from renewable energy sources.

Have You Considered Investing in the Installation of Equipment That Produces Electricity from Renewable Sources Such as Photovoltaic Panels, Heat Pumps, Solar Collectors, etc.?	Frequency	Percentage
Yes	373	74.6
No	103	20.6
Yes, we have such a system	24	4.8
Total	**500**	**100.0**

Here, 74.6% of individual respondents had considered investing in RES, while 20.6% of respondents had the opposite opinion.

The level of consumers' interest in investments in RES can be implied by the possible scope of benefits that can result from using the RES systems. This issue was also addressed when surveying individual respondents; the results are presented in Table 15.

Table 15. Respondents' opinions on the impact of RES systems on reducing expenses related to the purchase of electricity.

Do You Think That RES Devices Can Contribute Significantly to Savings and Reducing Expenses Related to the Purchase of Energy?	Frequency	Percentage
Strongly agree	91	18.2
Somewhat agree	384	76.8
Neither agree nor disagree	25	5.0
Total	**500**	**100.0**

In total, 93.0% of respondents stated that RES equipment can contribute to savings and reducing expenses for the purchase of electricity, whereas 18.2% of them stated that they definitely could, and 76.8% of them said that it is somewhat possible. None of the respondents had the opposite opinion, while 5.0% of respondents had an ambiguous position on this issue.

It is also worth pointing out the factors which discourage respondents from installing RES equipment. These factors are highlighted in Table 16.

With regard to their plans to install RES equipment, respondents are mainly afraid of the high prices of such installations (35.8%); apart from that, they are discouraged from investing in such systems because they lack reliable knowledge about co-financing possibilities (22.4%) and lack time to search for an appropriate installation company (17.5%).

Table 16. Factors discouraging respondents from the installation of RES systems.

	Frequency	Percentage
No need for such investment; energy bills are at a satisfactory level	9	1.6
No need for such investment; I do not consider that the installation of RES equipment could bring any noticeable benefits	3	0.5
I am interested in RES installation, but I am discouraged because I lack knowledge about RES equipment and whether this is a solution for me/my company	41	7.4
I am interested in RES installation, but I am discouraged because I lack knowledge about the possible benefits	57	10.3
I am interested in RES installation, but I am afraid of the high cost of such an investment	198	35.8
I am interested in RES installation, but I am discouraged because I lack knowledge about the possibilities of co-financing such an investment	124	22.4
I am interested in RES installation, but I am discouraged because I do not have time to search for an installation company	97	17.5
We already have such equipment	24	4.3
Total	**553**	**100.0**

As far as the CATI survey of companies that install RES systems is concerned, the respondents were also asked about their interest in using the RES platform. The respective data are presented in Table 17.

Table 17. Interest of entrepreneurs in the RES digital technology platform.

Would You Be Interested in Using a Free Online Platform That Would Match the Appropriate Size of RES Installations—Mainly Photovoltaics, Solar Collectors and HEAT Pumps—for a Specific Household or Business, on the Basis of Demand, Annual Consumption, and Location?	**Frequency**	**Percentage**
Yes	88	73.3
No	32	26.7

The majority of surveyed entrepreneurs (73.3%) were interested in the RES digital technology platform.

As a part of the survey, they were asked about key aspects of using such a platform. These aspects are shown in Table 18.

Table 18. Elements of a RES digital technology platform that are important for entrepreneurs.

What Would Be Important to You in Such a Tool?	**Frequency**	**Percentage**
The possibility of placing an advertisement there	20	10.8
A tool that would prepare a simulation related to the potential of the site and estimations of electricity and/or heat production, CO_2 emission savings, and energy bill savings per year (daily, quarterly, monthly)	77	41.4
Information on the possible co-financing of RES systems	30	16.1
The possibility of placing your company in the company database on the platform. On the basis of recommendations, customers could choose it as a contractor/service provider. This way, you would gain new customers	27	14.5
Not applicable; not interested in the platform	32	17.2
Total	**186**	**100.0**

For the surveyed entrepreneurs, the most important thing when using a RES digital platform would be the possibility of using a simulation related to the site's potential and estimations of electricity production (41.4%). Furthermore, access to information regarding possible co-financing of RES installations (16.1%) and the possibility of placing one's company in the database of companies on the platform (14.5%) were all indicated by the respondents.

4. Discussion

The main objective of the study was to identify the implementation environment of the RES digital technology platform, understood as a particular ecosystem of a digital platform consisting of many elements. Among these, an important role is played by companies implementing digital RES platforms as well as individual consumers: the users of RES platforms. The success of the implementation and operation of the RES platform depends on their attitude and interest in the RES platform. As a result of our research, we were able to prove that currently, there are favourable conditions for the implementation of a digital technology platform. Above all, it is important to note that the management staff and employees of companies have a positive attitude towards the implementation of a DTP, which is expressed by their readiness for the changes that this process entails (including organisational changes) and their involvement in the implementation of related activities. This is undoubtedly implied by the extensive range of benefits offered by DTPs. According to our own research, these benefits include increased profits and competitiveness, expanding the product range, establishing and developing modern business models, and extending the relations established by companies with all the stakeholders. These conclusions have been confirmed in the literature. The literature indicates the high willingness of companies to use DTPs, which is because such platforms can significantly contribute to the development of a digital organisational culture, the establishment of a multi-level system of interactions with customers, or the widespread promotion of innovations [83]. In addition, it is also due to the co-creation of goods and values by all market participants, including the consumers, who are becoming prosumers [84–87], and the implementation of completely new solutions tailored to market requirements (DTPs operate in an open-source environment that enables it to be complemented with new modules and functionalities) [88]. It is also important that DTPs generate demand for completely new goods, promote a positive image of companies in the market, and lead to increased trust between suppliers and producers on one hand, and consumers on the other, as well as expanding the scope of cooperation and coordination between companies, including the sphere of production and marketing of information [89–91].

It is worth adding that attitudes towards DTPs, as shown by the alternative CATREG model, are explained to the largest degree by the structural factor of company size and sector of operations. The literature indicates that it is the largest companies with adequate funds, as well as those operating in sectors with a strong focus on innovation, particularly trade, transport and logistics, finance, or energy, that focus on the implementation of DTPs [92,93], including for the purpose of using RES [4,27,32,94,95].

Both consumers interested in RES and companies that provide installation of RES systems expressed their willingness to be involved in the activities of the proposed RES platform. This is an important factor for the success that such a platform may bring and shows that the environment and surroundings are currently favourable for implementing such a platform. However, it should be borne in mind that there are certain obstacles that may discourage some entities from participating in such a platform, including cybersecurity concerns, including hardware and internet network failures. Given that DTPs operate in a digital environment, the risk of such failures exists, which has also been recognised in the literature [96]. However, it seems that cybersecurity concerns are the only barriers that can hinder the implementation of a RES digital technology platform. In general, the environment, including both businesses and consumers, is favourable to the emergence and development of this type of platform. It is worth adding that the analyses carried out in this study may, in the course of further research, be complemented by issues related to the impact of policies, including energy market regulatory policies, on the implementation of the RES digital technology platforms.

The rapid development of digital technology platforms creates new application possibilities in the implementation environment of RES platforms. The results obtained in this research project have a significant practical and application value both for companies implementing digital RES platforms and for the national and regional authorities responsible

for the development of renewable energy sources. Based on the results obtained, entities involved in the development and implementation of digital technology platforms can focus their activities on deepening the positive attitudes of both institutional and individual consumers, increasing financial support and creating a positive atmosphere in the business environment in order to strengthen the implementation environment of the RES digital technology platform.

5. Research Limitations

One of the research limitations is the test sample in the "Business Models Based on DTPs" project. This sample included enterprises that applied for and received co-funding under the Innovative Economy Operational Programme for investments related to the implementation and development of DTPs. Therefore, representatives of these enterprises may have positive attitudes towards such platforms, which may have significantly influenced their declarations regarding the implementation and use of DTPs. Therefore, to confirm the results obtained, further research will have to be carried out including those companies that did not obtain or did not apply for the abovementioned funds. It should also be noted that the obtained results concern the attitudes of the managers of Polish companies and, due to cultural and social differences and business conditions, they should not be blindly analysed in the context of the situation in other countries.

It is necessary to also distinguish the limitations related to the CATREG optimal scaling. One of such limitation is related to the permissible number of predictors or independent variables, which amounts to 200 (in the case of the CATI survey results, this condition is irrelevant, as the number of predictors rarely exceeds 100). At the same time, each variable should have a minimum of 10 and, preferably, 20 units of analysis. Optimal scaling is therefore not advisable in the case of small sample sizes. Failure to take this condition into account results in unstable regression lines. Another limitation is the inherent defect of all regression methods, which provide information on the existence or absence of relations between variables but do not provide any knowledge about the cause-and-effect relationship of such relations. An important reservation also concerns the fact that, depending on the type and number of variables included in the model, different results can be obtained, and it is difficult to decide which of the constructed models is best. The choice was made by the researcher, taking the structure of the obtained results into account.

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