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ASSESSMENT OF THE RELATIONSHIP BETWEEN THE OCCURRENCE OF CSR INSTRUMENTS AND INDUSTRY 4.0 PILLARS IN MANUFACTURING COMPANIES IN POLAND

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Purpose: The purpose of this article is to assess the relationship between the CSR (Corporate Social Responsibility) instruments used and the implemented pillars of Industry 4.0 in manufacturing companies in Poland.
Design/methodology/approach: Literature review, survey questionnaire research, correlation analysis.
Findings: The article describes the correlations between the CSR instruments used and the implemented Pillars of Industry 4.0 in manufacturing companies in Poland, based on the research conducted using a survey questionnaire. Subjecting the results of the questionnaires, to correlation analysis, made it possible to isolate the most strongly correlated pairs of variables, juxtaposing CSR Instruments and Industry 4.0 Pillars. The overall level of correlation is not at a very high level, which may indicate a moderate or differentiated relationship between CSR and Industry 4.0 Pillars. Despite such results, it was possible to observe distinctive pairs of variables that significantly stand out from the others. These include pairs such as Socially Engaged - Incremental Manufacturing, Investment in Ecology - Cybersecurity and Eco-labeling - Big Data. Despite the existing limitations, the area of research presented in the paper can inspire further research to identify the relationship between CSR and Industry 4.0.
Originality/value: An assessment of the relationship between the CSR (Corporate Social Responsibility) instruments used and the implemented pillars of Industry 4.0 in manufacturing companies in Poland, which may inspire further research in this area.
Keywords: Industry 4.0, Pillars of Industry 4.0, CSR, Sustainability, Correlation.
Category of the paper: Research paper.

Introduction

In an era of increasing globalization and rapid development of technology, manufacturing companies face the challenge of not only operational efficiency, but also sustainability and social responsibility (Orbaninigsih, 2021; Chen, Jin, 2023). In Poland, as a country that is intensively developing its industrial sector, there is a unique opportunity to examine how the implementation of Corporate Social Responsibility (CSR) strategies correlates with the adaptation and use of the Pillars of Industry 4.0.

The purpose of this article is to accurately assess and analyze the relationship between the CSR (Corporate Social Responsibility) instruments used and the implemented Pillars of Industry 4.0 in manufacturing companies in Poland. The analysis includes the identification of positive (synergistic) and negative (conflicting) relationships between pairs of variables - CSR Instruments and Pillars of Industry 4.0. Consideration of such relationships is crucial for understanding how modern technologies and innovations affect the socio-economic aspects of enterprises' activities.

The research methodology is based on a case study of manufacturing companies in Poland that have implemented elements of Industry 4.0 while actively pursuing CSR strategies.

The article contributes to the literature on the subject by providing valuable information for managers and entrepreneurs interested in the harmonious implementation of technological innovations while maintaining high standards of corporate social responsibility.

Pillars of Industry 4.0

The changing business environment, combined with greater technological capabilities and rising customer expectations, has led to the concept of Industry 4.0, a reference to the fourth industrial revolution (Davies, 2015; Bendkowski, 2017).

Industry 4.0 is characterized by the key features of a digital manufacturing plant, which relies on the full automation of production processes, effective collaboration between people and autonomous machines that are essential for optimal operation, and their harmonious integration with supply chain systems (Gabor, 2021).

Research on Industry 4.0 shows a variety of approaches to classifying its main elements. These classifications often include common pillar categories, such as: Autonomous Robots, Augmented Reality, Simulations, Incremental Manufacturing, Integration of Information Systems, Cybersecurity, Internet of Things, Cloud Computing, Big Data, Artificial Intelligence (Erboz, 2017; Tay et al., 2018; Trzop, 2020; Dubey et al., 2022). Table 1 shows the definitions, advantages and disadvantages of each of the listed pillars of Industry 4.0.

Table 1.
Definitions, advantages, disadvantages and examples of applications of each pillar of Industry 4.0

Pillar	Definition	Adventages	Disadventages
Automated Robotics	Devices programmed to perform tasks without human intervention.	Efficiency, precision, 24/7 availability	High maintenance costs, job displacement, limited functionality
Augmented Reality	Technology superimposing virtual objects onto the real world in real time.	Mobility, enhances training, improves interaction	High maintenance costs, requires specialized hardware, technical limitations
Simulations	Process of modeling real systems for analysis or testing.	Safe testing, resource savings, rapid analysis	Requires specialized knowledge, time-consuming, costly
Incremental Manufacturing	Creating 3D objects by layering material based on a digital model.	Rapid prototyping, local manufacturing	High initial costs, limited materials
Integration of Information Systems	Linking disparate systems into a functional whole.	Data management, increased efficiency	High complexity, error risk
Cybersecurity	Protecting computer systems, networks, and data from digital threats.	Data security, increased trust	High costs, continuous updating
Internet of Things (IoT)	Network of physical objects with sensors exchanging data over the Internet.	Task automation, data collection, remote monitoring	Privacy risks, complexity
Cloud Computing	Delivering computer resources over the Internet.	Resource availability, scalability	Lack of data control, dependence on providers
Big Data	Large and complex data sets analyzed for insights.	Deep analysis, decision support	Requires advanced tools, high costs
Artificial Intelligence	Creating algorithms for human-like tasks.	Automation, precise data analysis	Ethical concerns, high costs, limited contextual understanding

Source: Own elaboration based on: Sojak et al., 2009; Jeffrey, Neidecker, 2010; Zaskórski, 2012; Sasimowski, 2015; Głuchy et al., 2015; Jabez et al., 2015; Negandhi et al., 2015; Wielki, 2016; Romero et al., 2016; Rusek et al., 2016; Erboz, 2017; Krok, 2017; Kaczmarek et al., 2017; Pniewski et al., 2017; Tay et al., 2018; Malucha, 2018; Szajna et al., 2018; Chong et al., 2018; Mantravadi et al., 2018; Zaskórski, Ogórek, 2019; Surma et al., 2019; Orłowski, 2019; Gaku et al., 2019; Trzop, 2020; Vinitha et al., 2020; Kolny et al., 2020; Grabińska et al., 2020; Dubey et al., 2022; Skórnóg, 2023; Wolniak, 2023.

Despite the use of many innovative solutions in Industry 4.0, it faces significant environmental challenges, which are very often the result of rapid technological change (Aquilani et al., 2020). A study by Banyai et al. (2019) describing the optimization of municipal waste collection in cities highlighted Industry 4.0, which increases cost efficiency, as one of the challenges. Despite the many benefits of Industry 4.0, environmental and sustainability challenges must be faced at the same time. Rapid technological change requires equally rapid adaptation to new environmental realities, which is key to a long-term sustainable future (Banyai et al., 2019; Aquilani et al., 2020).

Corporate sustainability

In an era of dynamic technological change, the goal is to achieve a balance between development and environmental protection, the concept of sustainable development was developed. This concept, is to shape human activity in such a way as to meet the needs of current generations without compromising the ability to meet the needs of future generations (Atisa et al., 2021; Densmaa et al., 2022). At the UN Conference on Environment and Development, which took place in 1992, two documents were adopted (the Rio Declaration and Agenda 21), the general thrust of which was to achieve three basic goals of sustainable development (Sielicka, Choma, 2019):

- Ecological goal - by reducing environmental degradation and removing potential threats to the environment;
- Economic goal - to meet the basic material needs of man, while avoiding environmental degradation;
- Humanitarian and social purpose - to meet basic human needs.

When describing sustainability, it is also worth noting a related term, CSR. CSR is defined as the responsibility of companies for their impact on society, taking into account economic, environmental and social issues (Kaźmierczyk, Kamińska, 2017). Today, there are a number of corporate social responsibility instruments that, when properly implemented, can provide a source of competitive advantage in the market. Table 2 shows the instruments of corporate social responsibility, which include: Social Campaigns, Ethics Program for Employees, Employee Volunteerism, Eco-labeling, Investment in Ecology, Socially Engaged Marketing, Corporate Governance, Social Reports, Socially Responsible Investment (Leoński, 2016).

Table 2.
CSR Instruments

Instrument Name	Description
Social Campaigns	Social campaigns in CSR aim to change public attitudes and behavior, often by raising awareness of important social issues.
Ethics Program for Employees	Workplace ethics programs aim to promote ethical behavior among employees, often through training and codes of conduct.
Employee Volunteerism	Employee volunteering is an initiative in which employees engage in social activities, often supported by employers.
Eco-labeling	Eco-labeling is the process of certifying products and services that meet certain environmental standards.
Investment in Ecology	Green investments include financing projects and initiatives aimed at environmental protection and sustainable development.
Socially Engaged Marketing	Socially engaged marketing is marketing strategies that take into account the social and environmental aspects of a company's operations.
Corporate Governance	Corporate governance refers to a company's governance structures and processes to ensure accountability and transparency.

Cont. table 2.

Social Reports	Social reports are documents published by companies that report on their activities and impact on society and the environment.
Socially Responsible Investment	Socially responsible investments are investments that incorporate environmental, social and governance (ESG) criteria into the investment process.

Source: Own elaboration based on: Schleifer, Vishny, 1997; Haniffa, Cooke, 2005; Dobson, 2020; Kirschstein et al., 2022; Dempsey-Breach, Schantz, 2022; Okun, Ayalon, 2022; Kim, 2023; Kolwas, Domański, 2023; Shahid et al., 2023).

The instruments used in corporate social responsibility, shown in Table 1, indicate a variety of methods that aim not only to improve the image of companies, but also to engage employees and the public for a better future. This includes supervision and activities that are key to transparency and business responsibility.

Methods

The purpose of this article is to assess the relationship between the CSR Instruments used and the implemented pillars of Industry 4.0 in manufacturing companies in Poland. In order to thoroughly analyze and verify the research objective set, the research question "How are the various CSR instruments related to the selected pillars of Industry 4.0?" was formulated. In order to find an answer to the research question, an auxiliary question was formulated, "What are the differences in the application of CSR instruments in enterprises of different sizes, measured by the number of employees?”.

To find an answer to the research question, a survey was conducted using a questionnaire based on a five-point Likert scale on a sample of 137 enterprises in the manufacturing sector. The questionnaire was aimed at administrative employees, managers and directors of enterprises.

The survey included 7 manufacturing companies with up to 10 employees [5%], 11-50 employees, 40 companies [29%], 51-250 employees, 57 companies [57%], and 33 companies [24%] with more than 250 employees.

Respondents were subjected to 19 variables, nine of which relate to the degree of use of CSR instruments, such as: Social Campaigns, Ethics Program for Employees, Employee Volunteerism, Eco-labeling, Investment in Ecology, Socially Engaged Marketing, Corporate Governance, Social Reports, Socially Responsible Investment (Leoński, 2016). While 10 more refer to the pillars of Industry 4.0 used in the company, such as: Autonomous Robots, Augmented Reality, Simulations, Incremental Manufacturing, Integration of Information Systems, Cybersecurity, Internet of Things, Cloud Computing, Big Data, Artificial Intelligence (Erboz, 2017; Tay et al., 2018; Trzop, 2020; Dubey et al., 2022).

In order to achieve the research objective, the results of the surveys were subjected to correlation analysis, in order to assess the dependencies and relationships between the various variables.

Results

Survey results for two groups of variables (CSR Instruments and Industry 4.0 Pillars) were subjected to Pearson correlation analysis, as shown in Table 3.

Table 3.
Correlation analysis of CSR Instruments and Pillars of Industry 4.0

	Automated Robotics	Augmented Reality	Simulations	Incremental Manufacturing	Integration of Information Systems	Cybersecurity	Internet of Things (IoT)	Cloud Computing	Big Data	Artificial Intelligence
Social Campaigns	-0.0354	0.0507	0.0689	-0.0752	0.1053	-0.0302	-0.0231	-0.0315	-0.0383	0.0506
Ethics Program for Employees	-0.0183	0.0814	-0.0935	-0.0766	-0.0215	0.0463	-0.0811	-0.0235	-0.0440	0.0605
Employee Volunteerism	0.0028	-0.0832	-0.1021	-0.1513	-0.0849	-0.0542	0.1265	-0.1876	0.0646	-0.0493
Eco-labeling	0.0218	-0.1789	-0.1038	0.0188	0.0834	-0.0025	-0.0317	-0.1202	0.1656	-0.0317
Investment in Ecology	-0.0127	-0.0605	-0.1130	0.0187	0.0577	0.2150	0.0285	-0.0859	0.0651	0.1376
Socially Engaged Marketing	-0.1026	-0.0593	-0.0004	0.2408	0.0343	-0.0202	-0.0484	0.0117	0.0933	0.0036
Corporate Governance	-0.1317	-0.0127	0.0753	0.0811	-0.0433	-0.0834	-0.0311	-0.0780	0.1003	-0.0466
Social Reports	-0.0168	-0.1055	-0.0650	0.0830	0.0739	-0.0881	0.0172	0.0000	0.0363	-0.0953
Socially Responsible Investment	-0.0564	-0.0868	0.0627	-0.0860	0.0942	-0.0113	0.0567	0.1254	-0.0436	-0.1213

Source: Own elaboration based on survey results.

Correlation analysis shows values from -1 to 1, where -1 indicates a strong negative correlation, 0 no correlation, and 1 a strong positive correlation. Correlations close to zero indicate no relationship, negative values indicate an opposite relationship (one factor increases while the other decreases), and positive values indicate a commensurate relationship (both factors increase or decrease together).

Social Campaigns have the highest positive correlation with Integration of Information Systems and the highest negative correlation with Incremental Manufacturing. This may suggest that CSR initiatives are better perceived in the context of Integration of Information Systems, but less associated with Incremental Manufacturing.

Ethics Program for Employees shows stronger positive relationships with Augmented Reality and Cybersecurity, which may indicate that ethics programs are more valued in companies that invest in modern technology and care about data security.

Employee Volunteerism shows a strong positive correlation with Internet of Things (IoT), which could mean that employees of high-tech companies are more likely to engage in social activities.

Eco-labeling has a strong positive correlation with Big Data, suggesting that companies using big data may be more likely to promote green activities.

Investment in Ecology has a positive correlation with Cybersecurity and Artificial Intelligence, indicating that investment in ecology may be more common in companies involved in these technology areas.

Socially Engaged Marketing shows the highest positive correlation with Incremental Manufacturing, suggesting that socially engaged marketing may be more effective in companies using incremental manufacturing.

Corporate Governance has a positive correlation with Incremental Manufacturing, which may suggest that good governance practices can support modern production methods.

Social Reports have a positive correlation with Incremental Manufacturing and Integration of Information Systems, which may indicate that CSR transparency and communication are important to companies investing in these technologies.

Socially Responsible Investment shows the highest positive correlation with Cloud Computing and the highest negative correlation with Artificial Intelligence, which may mean that investors prefer companies using cloud computing technologies, but may have some ethical reservations about companies investing heavily in AI.

In general, the correlation values are not very high, suggesting that the relationship between CSR and the pillars of Industry 4.0 is moderate or varied. This could be due to a number of factors, including differences in industries, company strategies, and the varying impact of technology on aspects of CSR.

Discussion

The article describes the correlations between the CSR instruments used and the implemented pillars of Industry 4.0 in manufacturing companies in Poland. In the correlation analysis presented, the highest positive correlation between Social Campaigns and Integration of Information Systems suggests the importance of CSR initiatives in a technological context. Bag and Pretorius (2022) emphasized the importance of intelligent systems in sustainable manufacturing, which may complement the observed pattern, indicating that integrating CSR with technology is beneficial to companies (Bag, Pretorius, 2022).

The strong positive correlation of the Ethics Program for Employees with Augmented Reality and Cybersecurity is reflected in the work of Alkaraan et al. (2022), where it was noted that investments in technology and attention to data security are associated with advanced CSR practices (Alkaraan et al., 2022).

The positive correlation of Employee Volunteerism with the Internet of Things is consistent with the findings of Jayashree et al. (2021), who found that technology companies often promote social engagement among employees by using advanced technologies to support social causes (Jayashree et al., 2021).

Similarly, the strong correlation of Eco-labeling with Big Data can be supported by a study by Vrchota et al. (2020), which suggests that companies using big data can effectively monitor and communicate their environmental activities (Vrchota et al., 2020).

In summary, while the correlations in my study are not very high, they suggest a moderate relationship between CSR and the pillars of Industry 4.0, which is consistent with the literature indicating the complexity of the relationship between high-tech and responsible business. The discrepancies may be due to the diversity of industries and the specific activities of companies, which is a valuable area for further research.

Conclusion

This study focused on assessing the relationship between the CSR Instruments used and the implemented pillars of Industry 4.0 in manufacturing companies in Poland. The literature review enabled the identification of Industry 4.0 pillars such as: Autonomous Robots, Augmented Reality, Simulations, Incremental Manufacturing, Integration of Information Systems, Cybersecurity, Internet of Things, Cloud Computing, Big Data, Artificial Intelligence, and CSR instruments: Social Campaigns, Ethics Program for Employees, Employee Volunteerism, Eco-labeling, Investment in Ecology, Socially Engaged Marketing, Corporate Governance, Social Reports, Socially Responsible Investment. Based on the information gathered during the literature review, a questionnaire was developed and sent to companies in the manufacturing sector.

Realization of the research objective of assessing the relationship between the CSR Instruments used and the implemented pillars of Industry 4.0 was made possible by conducting a correlation analysis.

The results showed the strongest positive correlations between pairs of variables such as Socially Engaged - Incremental Manufacturing, Investment in Ecology - Cybersecurity, and Eco-labeling - Big Data. The correlation between Socially Engaged and Incremental Manufacturing suggests that companies that place importance on social responsibility can simultaneously invest in modern, efficient and flexible production methods. The link between investment in eco-labeling and cybersecurity suggests that companies that care about the environment often use advanced technologies that require robust digital protection. The link between eco-labeling and Big Data underscores how important it is in today's business world to manage and analyze large data sets, especially in the context of monitoring and reporting on the environmental impact of products. These correlations reflect the trend of combining sustainability with technological innovation, which is increasingly important in modern business. The correlations are not high, indicating a moderate to varied relationship between CSR and the pillars of Industry 4.0. These differences may be due to a number of factors, such as industry specifics, company strategies and the diverse impact of technology on aspects of CSR.

The study conducted has its limitations, which may affect the generality of the conclusions. One limitation is that the study is based on correlation analysis, which can indicate relationships between variables, but cannot determine whether one variable causes changes in another. Another limitation is the ongoing development of industry technology and CSR practices, so the results can quickly become outdated. Despite the careful selection of variables based on academic articles, there is a risk that some key studies or results were missed, which could affect the completeness of the research. There is therefore a need for further research, which should be conducted on larger samples of the population.

Despite the existing limitations, the work is an important step to understand the relationship between CSR and Industry 4.0, which may prompt researchers to conduct further research in this area.

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