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Satisfaction with the Implementation of Industry 4.0 Among Manufacturing Companies in Poland

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Abstract:

Purpose: *To analyze the problem, a systematic literature review on industry 4.0 was carried out. The article aims to analyze and evaluate the effectiveness of the implementation and satisfaction with the activities carried out in enterprises in Poland in this area.*
Design/Methodology/Approach: *The study was conducted using the CAWI diagnostic opinion questionnaire, based on which the Kano model was developed. The survey was conducted among 670 respondents from enterprises located in various regions of Poland.*
Findings: *Entrepreneurs indicate their benefits and their fears. Low social awareness of what industry 4.0 is the reason why it is not understood and implemented in a limited way. In his satisfaction survey, thanks to the Kano model, it indicated the necessary and conditioning attributes and those without which the company can do, which reduces implementation costs.*
Practical Implications: *The study provides knowledge for industry 4.0 regarding the behavior of entrepreneurs and employees, which significantly affects the effectiveness of the implementation of managerial solutions. The proposed Kano method is an effective tool for the assessment of the rightness of the actions taken. Employees and customers must be aware of the company's innovation and commitment to development.*
Originality/Value: *The study also showed that the implementation, dependent on the understanding of the problem from the employee's perspective and not just the company's customer, allows for faster and more efficient implementation of new solutions. The results of this article may form the basis of future research.*

Keywords: *Industry 4.0, technology, company, management engineering.*

JEL Classifications: *O33, O35, O39.*

Research type: *Case study.*

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1. Introduction

Industry 4.0 relates to all fields of life, founded on nine technology pillars (Matt, Modrak, Zsifkovits, 2020), which are already applied on the shop floor and in business practice. They include the Internet of Things, artificial intelligence, robotics, automated machinery, big data, data analytics, mobile services, 3D printing, cloud technologies, virtual and augmented reality, and cybersecurity solutions. Industry 4.0 is part of a more significant megatrend which is a digital transformation affecting several industries.

The Fourth Industrial Revolution introduced a new paradigm for digital control, independent and decentralized industrialization of manufacturing systems. Industry 4.0 has two goals: to ensure maximum uptime throughout the production chain and increase productivity while reducing production costs. With the development of a data-driven economy, companies have begun to use big data technologies to achieve these goals (Souza and de Costa, *et al.,* 2020). Also, Industry 4.0 includes the introduction of new technologies in the industrial field, this is done by changing the technological level of the old industry, and it is through the introduction of specialized equipment that controls the old equipment or the creation of new equipment and machines that are managed through robots and programs. There may be industries where updates can only be made by completely replacing them.

Industry 4.0 is represented by several new concepts in industrial processes, using technologies such as the Internet of Things (IoT), Cyber-Physical Systems (CPS), Cloud computing, Reference Architectural Model Industry 4.0 (RAMI), Cyber-Physical Production Systems (CPPS) (Asif, 2020). This concept aims to improve the productivity and performance of the intelligent factory through the application of advanced production systems and strategies; Smart manufacturing allows the integration of devices, equipment, and technologies to improve factories, reduce risks, maximize profits, and increase the quality of products (Beier *et al.*, 2020). Industry 4.0 brought the possibility of having adaptive systems to automatically adjust production tasks, which contributes to the availability of self-decision-making processes and real-time control of high-precision machines, predictability of business problems before they occur, enhancing the resilience of manufacturing resources to increase productivity (Li, Dai, and Kim, 2020).

Industry 4.0 was defined as increasing digitization, automating the manufacturing scenario, and creating digital value chains to make products, the environment, and business partners communicate with each other. Industry technology 4.0 is heterogeneous and thus will have a multiplier effect on stakeholders. The workforce feels threatened by robots and artificial intelligence. Considering the above, the impact of new technologies on human resources has become more necessary and strategic (Culot *et al.,* 2020). Industry 4.0 requires high levels of independence to ensure manufacturing processes achieve production goals. Therefore, high levels of coordination and cooperation are needed to communicate and interact with actors in the manufacturing process. It is expected to bring various benefits to the business, such as product allocation, efficiency, productivity, and quality. In addition to the principles of Industry 4.0 are compatibility, virtualization, decentralization, ability to perform tasks within real-time, service orientation, and modularity. Industry 4.0 requires placing the right person in the right place. In this sense, compatibility allows for greater flexibility in manufacturing systems and their ability to adapt (Cancino, La Paz, and Ramaprasad, 2019).

The successful development of such systems is vital to creating a competitive advantage between manufacturing firms and national economies. Within Europe, the most established company is "Industry 4.0," and the purpose of Industry 4.0 was to support national growth by promoting industrial development. The objectives of Industry 4.0 are to provide comprehensive customization of IT products; To make automatic and flexible adjustments of the production chain; To track parts and products; To facilitate communication between components, products, and machines; To apply human-machine interaction models (HMI); To achieve Internet of things-based production improvement in smart factories; And to provide new types of services and business models to interact in the value chain" (CasteloBranco *et al.*, 2019). Through a literature review, most of them confirm that Industry 4.0 is one of the catalysts that strongly influence the adoption of sustainability (Miśkiewicz, 2019). Technology and information, adopting supportive environmental attitudes, attention to the administrative and economic issues of the organization to activate sustainability, managing the supply chain, adopting organizational and social attitudes supporting sustainability (Paccchini, *et al.,* 2019).

In addition, Industry 4.0 contributes to improving the digital supply chain and achieving sustainability, and the organization can overcome the challenges facing Industry 4.0 (German, Lucas, and Dalenogare, 2019). Industry 4.0 is an intelligent approach based on industrialization and sustainability. It searches for the most appropriate path for technological progress and structural change to promote economic growth and successful transformation towards a circular economy (CE). China has adopted this to achieve sustainable development by integrating the circular economy with industry 4.0 (Leung, Wue, and Wen, 2019). Industry 4.0 is not a radical innovation but a reassembly of existing or recently introduced technologies based on cyber-physical integration. Industry 4.0 is essential for several reasons, including It, was launched in the international industrial debate and policymaking on a German initiative, and is a mix between the technologies that originated in the ICT model and the more traditional techniques in mechanical engineering, creating an intersection between different technological systems (Goecks, Santos, and Korzeniowski, 2010).

The concept of Industry 4.0 is still in the pre-model stage, where there are no primarily approved standards and no dominant design (Cicculo *et al.*, 2019). Industry 4.0 can be considered a convergence of many emerging concepts and new technologies, such as radio frequency identification.

The advanced technologies involved in Industry 4.0 restructure the entire production system by converting analog and central workflows into digital and decentralized production processes. These advanced technologies have high capabilities to increase production productivity significantly. Industrial sector 4.0 also benefits from the manufacturing industry through three different methods. The first is vertical integration, horizontal integration, and end-to-end comprehensive engineering that integrate people, machines, and data, creating more supply chains Flexibility and responsiveness (Coccia, 2009). The transition to Industry 4.0 is critical for manufacturing companies to maintain competitive advantage, seize new opportunities, and achieve economic wealth for industrialized countries in the long run. Industry 4.0 has been known to be "moving towards digitization and automation of manufacturing" and represents a new stage or new industrial production model (Dalenogare, Lucas, and Santos, 2018).

There are a set of factors that contribute to enabling industry 4.0. Technology does not usually provide ready solutions, and significant productivity gains cannot be expected unless business processes and business practices must be implemented jointly. As for the additional organizational factors, the corporate design must follow higher links between the divisions within the organization, the organizational structures must be flattened to comply with the decision-making process, and there should be Flexibility in administrative practices because there will be a need for digital and strategic capabilities at all levels within the organization (Nosalka *et al.*, 2019). The business world is constantly changing. Dynamic environments filled with uncertainty, complexity, and mystery require quicker and more confident decisions (Manda, Ben Dhaou, 2019). To compete in this environment, so Industry 4.0 appears as a primary alternative. In this context, manufacturing reliability is an essential aspect for companies to make successful decisions (Souza *et al.*, 2020).

2. Literature Review

Despite extensive economic growth and improving the quality of life, industrialization has significant adverse effects on the natural environment. These effects reduce the vitality and the sustainability of economic systems (Muller, 2019). The concept of a knowledge-based economy reflects the vision of achieving economic growth through the high-tech sector, which requires investment in innovation and a highly skilled workforce. Some authors (Franceschelli, Santoro, and Candelo, 2018) address several trends that can be considered drivers of sustainability-related business model innovation. These include the circular economy (Man, Man, 2019), corporate social responsibility (Gunsekaran, Subramaniam, and Ngai, 2019), shared economy (Geissinger *et al.*, 2019; Leung *et al.*, 2019). 2019), technological innovation (Coccia, 2009), lean manufacturing (Wichaisri and Sopadang, 2018). The development of sustainable business model innovations is significant (Franceschelli *et al.*, 2018), as this sector is inherently linked to respect for nature and its resources.

Innovation, technological opportunities, changing consumer preferences, and sustainability concerns have become the economy's main drivers (Todeschini *et al.*, 2017). According to Zilberman *et al.* (2013), von Braun (2018), technological progress requires constant public investment in research and innovation and the creation of a regulatory framework and financial incentives that would lead to the commercialization of new products. One of the biggest challenges is developing a regulatory framework that would control possible externalities from new products without restricting the innovative process.

3. Research Methodology

The analysis of many reports and available literature shows that Industry 4.0 has great potential and importance for the development of enterprises, in particular in the field of production technology development and implementation of new business models. Technologically supported, Smart factories allow us to meet customer requirements (Horvath and Szabo, 2019). The effectiveness of Industry 4.0 is also determined by the more efficient use of resources and energy. Industry 4.0 in Poland can be analyzed in terms of the following indicators, developed by the World Economic Forum, the European Commission to monitor digitization. The attributes of the Kano model were set based on these indicators. According to various indicators, in 2016, Poland ranked 42 out of 139; according to another hand, in 2018, Poland ranked 24 out of 31, and according to another indicator in 2017, Poland ranked 23 out of 28.

Despite the visible continuous improvement, Poland still in no category exceeds the average for countries in the European Union (Sony and Naik, 2019). The relatively best-rated types in Poland are ICT infrastructure and human capital. The biggest challenges are categories such as the use of the Internet by companies, the integration of digital technology, and digital public services.

The study was conducted using the CAWI (Computer Assisted Web Interview) diagnostic opinion questionnaire. The study was conducted in 5 production companies among 670 white-collar workers related to technology or supporting technologies for Industry 4.0. companies are in various regions of Poland, all of which represent the manufacturing industry. The study was dominated by men (63%) with higher education (78%), aged 40-50 years (24%), with work experience of 21-25 years (23%). The study was conducted from January to June 2020. The research novelty is analyzing the employees' satisfaction with the implementation and the ability to navigate in a new area. Such a disconnection reflects the level of awareness of employees in the studied area, and for this, the Kano model was used. The limitation and difficulty of the study was the low level of employees' knowledge of industry 4.0. Even companies using these solutions have not provided adequate expertise to their employees, making it challenging to navigate this topic efficiently**.**

This research stage is primarily a questionnaire describing the potential attributes that should characterize the image in social media, the media itself, and the threats it carries

(Nosratabadi *et al*., 2019). The respondents were asked to rate the attributes when they occur (positive points) and when they do not happen (negative traits). Based on the responses, it was possible to indicate features that must be included and those that affect overall customer satisfaction (one-dimensional). The list of positives from the Kano questionnaire is presented in Table 1. The assessment of these features (answers to these questions) was based on the following scale: (a) "I like it," (b) "It must be like this," (c) "I don't mind it," (d) "I can take it," (e) "I don't like it."

4. Results

The analysis of the results was based on the individual types of attributes included in the questionnaire, using the comparisons presented in Table 2. Then it was checked which type of feature was indicated most often.

Table 1. *Kano model attributes*

Attribute Number	*Attributes (Positive Attributes)*
1	*A company implementing industry 4.0 should treat it as a revolution.*
2	*The company should have credible sources of change.*
3	*Information about changes should be complete and reliable.*
4	*The implementation requires the use of intelligent machines.*
5	*the disappearance of man / machine barriers should be logical.*
6	*personalization of activities should be accessible and understandable.*
7	*Social networks should contain a detailed description of process integration.*
8	*Digitization should be secure and protect user and enterprise data.*
9	*The customer should be able to choose between different payment methods.*
10	*IT systems should be based on the integration of systems and not their single activity.*
11	*The employee should be able to easily contact technical support, among others via chat to get additional information about systems, processes.*
12	*The employee should be able to easily contact the service of the digitization process in order to clarify any doubts.*
13	*The employee should be able to influence the elements of the process that are subject to automation.*
14	*Industry 4.0 is primarily an organizational culture and its individual features.*
15	*The action strategy should be clearly defined and understood by employees.*
16	*High variability of factors should not affect the quality of the processes.*
17	*Managers are expected to be able to translate processes into digital.*
18	*The manager must have technical and social skills.*
19	*The modularity of enterprises is a necessary condition for the functioning of industry 4.0*
20	*Knowledge of industry 4.0 solutions facilitates implementation.*
21	*Quality is of great importance in the implementation.*

22	*Full personalization of solutions improves the functioning of industry 4.0.*
23	*Managing employees' knowledge in the field of industry 4.0 facilitates the creation of an organizational culture favorable to this solution.*

Source: *Own creation.*

Table 2. *Types of attributes in the Kano method.*

		Negative				
Positive	I like it	Q	A	A	A	O
	That is the way it has to be	R	I	I	I	M
	I do not mind	R	I	I	I	M
	I can put up with it	R	I	I	I	M
	I do not like it	R	R	R	R	Q
	Negative					

Notes: *A—attractive; O—one-dimensional; M—must-have; I—customer was indierent to the attribute; R—customer did not like the attribute; Q—there was a contradiction: customers both wanted the attribute to occur and not to occur.*

Source: *Own creation.*

Table 3. *Interpretation method.*

Distribution of Response	XY Pair	Location of the Point on the Graph
All attractive	0 1	Top left corner
All one-dimensional	1 1	Top right corner
Evenly split between attractive and one-dimensional	0,5 1	Middle of the top, halfway between attractive and one-dimensional—point A
All must-have	1 0	Bottom right corner
Evenly split between one-dimensional and must-have	1 0,5	Middle of right edge, halfway between one-dimensional and must-have—point B
All indierent	0 0	Bottom left corner
Evenly split between must-have and indierent	0,5 0	Middle of bottom edge, halfway between must-have and indierent—point C
Evenly split between indi_erent and attractive	0 0,5	Middle of left edge, halfway between indierent and attractive—point D
Evenly split among attractive, one-dimensional, must-have, and indierent	0,5 0,5	Exact middle of graph—point E
Evenly split between attractive and must-have	0,5 0,5	Exact middle of graph, halfway between attractive and must-have, without an influence of one-dimensional or indierent—point E
Evenly split among attractive, one-dimensional, and must-have	0,67 0,67	Equally spaced between attractive and must-have, but influenced by one-dimensional—point F

Source: *Own creation.*

The rating given by customers in the Kano questionnaire can calculate the customer satisfaction and dissatisfaction rates. The satisfaction index was in the range (0, 1). If the value was close to 1, customer satisfaction was very high. If the value was close to 0, customer dissatisfaction was very high. Indexes can be interpreted graphically.

For this purpose, a two-dimensional matrix was created. The X-axis indicated dissatisfaction with individual attributes into absolute ones, and the Y-axis was an indicator of satisfaction. The results were presented based on Table 3.

The responses of individual respondents obtained during the research were compared in pairs (positive and negative attributes) by the assumptions presented in Table 3. The type of feature that occurred most often and the demonstrated indicators of satisfaction and dissatisfaction for the individual were calculated. Attribute numbers corresponding to the numbers and names of the attributes from Table 1. The comparison of the results obtained with the Kano model is presented in Table 4.

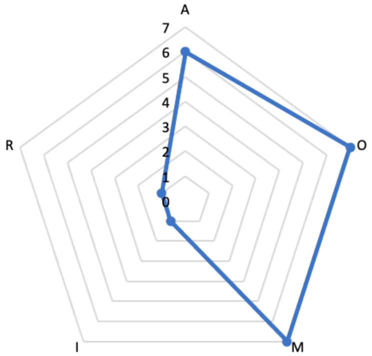
Table 4. *Kano questionnaire results.*

Attribute Number	*Assessment of the Attribute*	*Satisfaction Index*	*Dissatisfaction index*
1	M	0.82	−0.31
2	A	0.65	−0.75
3	M	0.25	−0.85
4	M	0.57	−0.89
5	O	0.67	−0.85
6	O	0.76	−0.78
7	A	0.66	−0.50
8	A	0.68	−0.59
9	M	0.34	−0.84
10	O	0.40	-0,80
11	I	0.31	−0.93
12	A	0.20	−0.92
13	A	0.32	−0.53
14	O	0.89	−0.68
15	R	0.46	−0.65
16	M	0.11	−0.96
17	M	0.29	−0.93
18	M	0.36	−0.55
19	O	0.23	−0.30
20	O	0.62	−0.70
21	O	0.12	−0.78
22	A	0.20	-0,88
23	A	0,17	-0,57

Source: *Own creation.*

The figure presents a graphical presentation of the results obtained in Table 4.

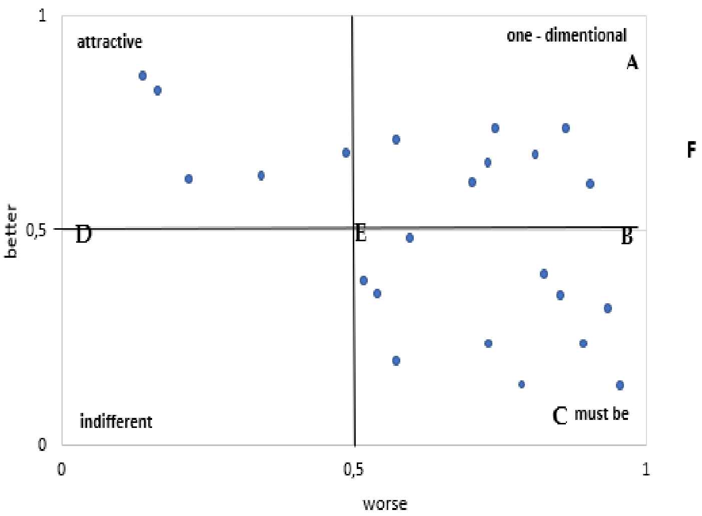
Figure 1. *List of attribute types, where: A—attractive; O—one-dimensional; M—must-have; I—indierent; and R—reverse [own study].*



Source: *Own study.*

Satisfaction and dissatisfaction indicators for individual attributes allowed us to create a map of features and indicate the details more precisely. This map helped identify the necessary qualities and other types of points. The map of the attributes of this research venture is shown in Figure 3.

Figure 2. *Map of attributes according to the Kano questionnaire.*



Source: *Own creation.*

5. Conclusions

Industry 4.0 solutions determine the development of a significant degree of economic growth of enterprises, as well as, consequently, the development of the country. The aim of the article was to present knowledge about industry 4.0, the behavior of entrepreneurs and employees, which significantly affects the effectiveness of the implementation of such solutions. The Kano method allowed for the assessment of the rightness of the actions taken. Employees and customers must be aware of the company's innovation and commitment to development.

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