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

Submitted 11/05/21, 1st revision 14/06/21, 2nd revision 22/07/21, accepted 25/08/21

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Abstract:

Purpose: The aim of this article is to analyze the problem of satisfaction with the implementation of industry 4.0 with a systematic literature review. To analyze and evaluate the effectiveness of the implementation and satisfaction with the activities carried out in enterprises in Poland in the manufacturing sector.

Design/Methodology/Approach: The study was conducted using the CAWI diagnostic opinion questionnaire, on the basis of which the Kano model was developed. The survey was conducted among 670 respondents from enterprises located in various regions of Poland.

Findings: Entrepreneurs clearly 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 the satisfaction survey, thanks to the Kano model, it was indicated the necessary and conditioning attributes as well as those without which the company can do, which allows to reduce the implementation costs.

Originality/Value: The study also showed that the implementation dependent on the understanding of the problem from the perspective of the employee 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.

Paper 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, and Zsifkovits, 2020), which are already applied on the shop-floor and in business practice. They include, internet of things, artificial intelligence, robotics, and automated machinery, big data and data analytics, mobile services, 3D printing, cloud technologies, virtual and augmented reality, and cybersecurity solutions. Industry 4.0 is part of a larger megatrend which is a digital transformation affecting several industries.

The Fourth Industrial Revolution introduces 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 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 technological equipment that controls the old equipment or the creation of new equipment and machines that are controlled 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 smart 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 Ullrich, *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 and automating the manufacturing scenario and creating digital value chains to make products, the environment, and business partners able to 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, in light of the above that the impact of new technologies on human resources has become more necessary and strategic (Culot, Nassimbeni, Orzes, and Sartor, 2020). Industry 4.0 requires high levels of independence to ensure manufacturing processes to achieve production goals.

Therefore, high levels of coordination and cooperation are needed, so that actors in the manufacturing process can communicate and interact. It is expected to bring a variety of 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 adjustment of the production chain; To track parts and products; To facilitate communication between parts, 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 " (Castelo Branco, Crus-Jesus, and Olivera, 2019). Through a review of literature, 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 environmental supportive attitudes, attention to the administrative and economic issues of the organization in order to activate sustainability, managing the supply chain, adopting organizational and social attitudes supporting sustainability (Pacchini, Lucato, Faccini, and Mummulo, 2019).

In addition, Industry 4.0 contributes to improving the digital supply chain and achieving sustainability and the organization has the ability to overcome the challenges facing Industry 4.0 (German, Lucas, and Dalenogare, 2019). Industry 4.0 is a smart approach based on industrialization and sustainability, and 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). This is what China has adopted 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 important for a number of reasons, including: It was launched in the international industrial debate and policy-making 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 largely approved standards and no dominant design (Ciccullo, Pero, Caridi, Gosling, and Purvis, 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 systems by converting analog and central workflows into digital and decentralized production processes. These advanced technologies have high capabilities to increase production productivity significantly. The industrial sector 4.0 also benefits from the manufacturing sector 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 model of industrial production (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 large productivity gains cannot be expected unless changes are made to business processes and business practices that must be implemented jointly. As for the organizational auxiliary factors, the organizational 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, Sledziowska, Włoch, and Grace, 2019). The business world is constantly changing. Dynamic environments filled with uncertainty, complexity, and mystery requires quicker and more confident decisions (Manda and Ben Dhaou, 2019). To compete in this environment so Industry 4.0 appears as a primary alternative. In this context, the reliability of manufacturing is an essential aspect for companies to make successful decisions (Souza Costa *et al.*, 2020).

2. The Level of Enterprises' Readiness to Implement Industry 4.0 – Literature Review

Despite extensive economic growth and improving the quality of life, it is clear that industrialization has significant adverse effects on the natural environment and that these effects reduce not only the vitality but also 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 a number of trends that can be considered as drivers of sustainability-related business model innovation. These include, in particular, the circular economy (Man and Man, 2019), corporate social responsibility (Gunsekaran, Subramaniam, and Ngai, 2019), shared economy (Geissing *et al.*, 2019; Leung *et al.*, 2019), technological innovation (Coccia,

2009), lean manufacturing (Wichaisri and Sopadang, 2018). The development of sustainable business model innovations is important (Franceschelli *et al.*, 2018), as this sector is inherently linked to respect for nature and its resources.

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

3. Materials and Methods

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 the implementation 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 the level of digitization. The attributes of the Kano model were developed on the basis of these indicators. According to various indicators, in 2016 Poland ranks 42 out of 139, according to another indicator in 2018, Poland ranks 24 out of 31, and according to another indicator in 2017, Poland ranks 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 categories 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 located in various regions of Poland, all of them 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 the analysis of 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 knowledge among their employees, which makes it difficult to navigate this topic efficiently.

4. Results

This stage of research 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 attributes) and when they do not occur (negative attributes). Based on the responses, it was possible to indicate features that must be included, but also those features that affect the 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."

Table 1. Kano model attributes

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

Source: Own study.

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

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

Notes: A—attractive; O—one-dimensional; M—must-have; I—customer was indifferent 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 study.

The rating given by customers in the Kano questionnaire can be used to calculate 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 in which the X axis was an indicator of dissatisfaction with individual attributes into absolute ones, and the Y axis was an indicator of satisfaction. The results were presented on the basis of Table 3. The responses of individual respondents obtained during the research were compared in pairs (positive and negative attributes) in accordance with 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 corresponded 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. Figure 1 presents a graphical presentation of the results obtained in Table 4.

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 indifferent	0 0	Bottom left corner
Evenly split between must-have and indifferent	0,5 0	Middle of bottom edge, halfway between must-have and indifferent—point C
Evenly split between indifferent and attractive	0 0,5	Middle of left edge, halfway between indifferent and attractive—point D
Evenly split among attractive, one-dimensional, must-have, and indifferent	0,5 0,5	Exact middle of graph—point E
Evenly split between attractive and must-	0,5 0,5	Exact middle of graph, halfway between

have	attractive and must-have, without an influence of one-dimensional or indierent—point E
Evenly split among attractive, one-dimensional, and must-have	Equally spaced between attractive and must-have, but influenced by one-dimensional—point F

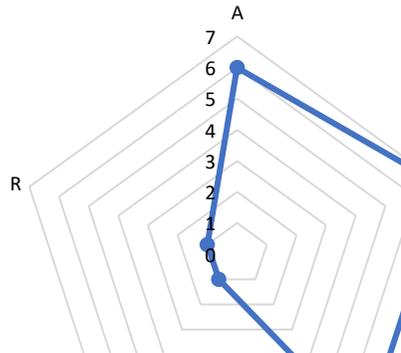
Source: Own study.

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 study.

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

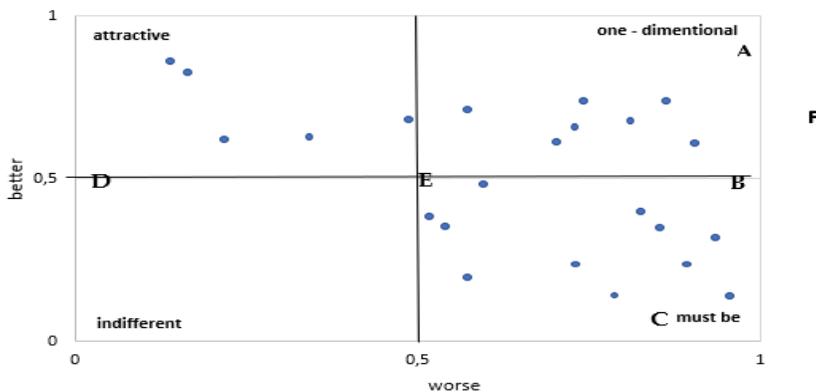


Source: Own study.

5. Discussion

Satisfaction and dissatisfaction indicators for individual attributes allowed us to create a map of attributes and indicate the type of attributes more precisely. This map helped identify the necessary attributes and other types of attributes. The map of the attributes of this research venture is shown in Figure 2.

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



Source: Own study.

6. 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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