FACTORS SHAPING ORGANIZATIONAL LEADERSHIP IN INDUSTRY 4.0 CONDITIONS

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Purpose: The main objective of the study is to identify the factors shaping organizational leadership in Industry 4.0 conditions.

Design/methodology/approach: The research is conducted based on an extensive and thorough analysis of literature from open-access platforms such as Google Scholar, ResearchGate, Scopus, and Sciencedirect. The literature search primarily involved using keywords such as "Leadership", "Leadership 4.0", and "Industry 4.0".

Findings: The article discusses the factors shaping organizational leadership in the context of Industry 4.0. The lack of a unified and precise definition of leadership has led to various interpretations in scientific literature, resulting in subjectivity among researchers and discrepancies in understanding the concept. Conducting an in-depth literature review allowed for the identification of four areas that shape organizational leadership in Industry 4.0, namely the pillars of Industry 4.0, leader attributes, leadership styles, and leader functions. Breaking down these areas into smaller elements provides a foundation for further research, enabling the exploration of correlations between individual factors and their impact on Leadership 4.0.

Originality/value: Identification of factors shaping organizational leadership in the context of Industry 4.0, which can serve as a foundation for conducting further research.

Keywords: Industry 4.0. Leadership 4.0, Digital Transformation, Technology in Business.

Category of the paper: Literature Review.

1. Introduction

Leadership in organizations is a complex and significant issue, occupying a crucial place in the field of contemporary organizational science and management (Mrówka, 2009). Despite intensive research, a complete description of this concept and phenomenon remains incomplete, opening perspectives for further research, interpretations, and the creation of new theories and models (Dartey-Baah, 2009; Tokar, 2010; Mrówka, 2010; 2021; Podgórska, 2014; Mazurkiewicz, 2015; Soliński, 2023; Dębicka, 2023). Leadership is a multidimensional

phenomenon, encompassing various psychological, social, and organizational aspects (Pichlak, 2011; Malinowski, 2013). Effectively understood and utilized leadership can play a crucial role in shaping an organization's success. In Industry 4.0, where innovations and technological transformations are key to success, organizational leadership plays a vital role in achieving strategic goals and maintaining a competitive market position. Factors shaping leadership in these modern conditions are immensely important for ensuring smooth organizational functioning and effective management strategies implementation.

The main objective of this study is to identify the factors shaping organizational leadership in Industry 4.0 conditions based on a literature review in the fields of leadership, Industry 4.0, and Leadership 4.0. Such an approach will help pinpoint the key factors influencing effective organizational management in the era of Industry 4.0, which is crucial for ensuring their smooth functioning and achieving strategic goals while maintaining a competitive market position.

2. Definition of leadership

Reviewing the literature, it is impossible to find one specific definition of leadership (Dartey-Baah, 2009; Tokar, 2010; Mrówka, 2010; 2021; Podgórska, 2014; Mazurkiewicz, 2015; Soliński, 2023; Dębicka, 2023). This is evidenced by research conducted by J.C. Rost, who, while reviewing literature from 1900 to 1990, found 200 different definitions of leadership, confirming the multitude of interpretations of such a statement (Rost, 1991; Northouse, 2021). Table 1 presents examples of several leadership definitions from the 20th and 21st centuries in chronological order.

Table 1.
Definitions of leadership in the 20th and 21st centuries

Definition	Year
Leadership is the ability to impress the will of the leader upon those who are led and evoke obedience, respect, loyalty, and cooperation.	1927
Leadership is any activity that influences the attitude of a group.	1959
Power means every opportunity that someone's will, even despite resistance, will be enforced within a social relationship, regardless of what this chance concerns.	1972
Leadership is the ability to take certain actions or generate ideas within a specific group (organization, society) that attract and focus the members of that group over the long term.	1987
Leadership is the ability to influence or wield power within social communities.	1988
Leadership involves using influence without resorting to coercive means.	1989
Leadership is the power of one or several individuals to influence a group and shape its own policies.	1993
Leadership is the perceived willingness by other members of the organization to exert or self-exert influence on the thoughts, feelings, and actions of its members in line with the organization's goals.	1996
Leadership is the process of influencing a group to achieve common goals through motivation, inspiration, and mobilization.	2002

Cont. table 1.

Leadership is the process of influencing a group to achieve common goals through coordination, motivation, and mobilization.	2009
Leadership is skillfully influencing individuals by tapping into their potential, enabling them to strive for greater good.	2021

Source: Own elaboration based on: (Moore, 1927; Morris, 1959; Weber, 1972; Gleick, 1987; Abercrombie, 1988; Yukl, 1989; Bogdanor, 1993; Smith, 1996; Yukl, 2002; Adair, 2009; Mrówka, 2010; Blanchard, 2021).

Definicja The definition of leadership largely depends on the point of view, leading to the development of various theoretical concepts (Karwowski, 2009). The most popular concept of leadership posits the existence of four leadership styles: autocratic, participative, democratic, and laissez-faire (Bucurean, 2016; Żuchowski, 2018).

- An autocratic leader is an individual who exercises power in an absolute manner and concentrates immense authority in their hands. This type of leadership is characterized by the leader making decisions independently without consulting the group. The leader employs strict control and supervision methods, demanding obedience and execution of orders without discussion. Such a leader prioritizes efficiency and achieving results, but it may lead to a loss of engagement, motivation, and innovation within the team (Kwiatkowski, 2011; Żuchowski, 2018; Chukwusa, 2018);

- A participative leader is someone who emphasizes collaboration, engages employees, and considers their opinions in the decision-making process. Such a leader creates an atmosphere of trust and openness, encouraging team members to share ideas, suggestions, and constructive criticism. The participative leader actively listens, appreciates diverse perspectives, and facilitates collective reflection on issues and solutions (Brahim, 2015; Wang, 2022; Khassawneh, 2022);

- A democratic leader in an organization is an individual who emphasizes a balance between employee participation and decision-making. Such a leader involves team members in the decision-making process, listens to their opinions, and considers diverse perspectives. The democratic leader promotes open communication, collaboration, and knowledge sharing, enabling team members to participate in making key organizational decisions. This approach contributes to a greater sense of engagement, motivation, and trust among employees (Gastil, 1994; Sharma, 2012);

- A laissez-faire leader in an organization is an individual who exhibits minimal intervention in the daily operations and decisions of their team. Such a leader delegates responsibility to team members, giving them freedom in decision-making and task execution. The laissez-faire leader creates an environment in which employees have autonomy and independence in their actions, while the leader plays a supportive role and provides necessary resources. In such an environment, team members can develop their skills, creativity, and initiative (Chaudhry, 2012; Robert, 2021; Iqbal, 2021).

Other styles into which leadership can be decomposed are transactional and transformational (Birasnav, 2014; Deichmann, 2015; Klein, 2023; Abbas, 2023).

- Transactional leadership in an organization refers to a leadership style where the leader focuses on exchanging rewards and punishments in return for the completion of specific tasks by subordinates. It is based on the principle of transactions between the leader and team members, where rewards are offered for achieving goals, and punishments are applied in case of non-compliance with expectations;
- Transformational leadership in an organization is a leadership style that focuses on creating profound and lasting changes through inspiration, motivation, and the development of team members. The transformational leader aims to transform both themselves and others by creating a vision, strengthening commitment, and mobilizing collective efforts to achieve higher goals together.

To gain a better understanding of the essence of leadership, it is worth familiarizing oneself with the functions that a leader fulfills. By delving into these functions, it will be possible to grasp the full scope of responsibility and role that leadership plays in effectively guiding a group or organization. Conducting a literature review, the functions of a leader can be decomposed as follows (Steele, 2022):

- Performance assessment and providing feedback;
- Planning, coordinating, and monitoring;
- Challenging assumptions;
- Distributing rewards and recognizing achievements;
- Developing team members;
- Scanning and sensing the environment;
- Setting and clarifying goals;
- Securing and allocating resources;
- Providing autonomy;
- Managing social relationships.

Table 2 presents the assigned statements to specific leadership functions.

Table 2.
The functions of the leader in the development of specific statements

Group	Statement
Performance assessment and providing feedback	The leader gives feedback comments to employees after a task is completed.
	The leader performs inspections according to the relevant inspection procedures.
	The leader informs employees about performance standards.
	The leader monitors the team's performance.
	The leader identifies performance gaps.

Cont. table 2.

Planning, coordinating, and monitoring	The leader defines the balance of needs.
	The leader makes cyclical observations of progress toward goals.
	The leader acts according to a program to achieve specific goals.
	The leader formulates the organization's strategy.
	The leader coordinates activities so that they are the next steps in the strategy.
	The leader shapes the image and the right attitudes toward the organization.
	The leader imposes a strategy for change in the organization.
	The leader periodically controls the adopted management system of the organization.
	The leader plans activities that are included in the organization's mission.
	The leader focuses on improving the organization's operations.
	The leader synchronizes the activities of all levels of the organization.
	The leader skillfully manages time.
	The leader implements actions to improve performance.
	The leader chooses appropriate methods to achieve goals.
	The leader chooses the fundamental direction of the organization.
	The leader uses interactive visual aids of the planning process.
	The leader sets performance standards.
Challenging assumptions	The leader challenges assumptions made by members of the organization.
	The leader encourages open debate among employees.
	The leader stimulates employees' intellectual curiosity.
	The leader challenges assumptions in a way that respects employees.
	The leader is open to different perspectives.
Distributing rewards and recognizing achievements	The leader tailors the incentive system to the needs and requirements of employees.
	The leader gets to know the individual needs and expectations of the employees.
	The leader makes demands on the employee tailored to him.
	The leader has implemented a system to motivate employees for well and poorly performed tasks.
	The leader positively influences employees' loyalty and integrity to the organization.
Developing team members	The leader voluntarily communicates his knowledge.
	The leader makes open communication.
	The leader inspires and stimulates action.
	The leader is a role model.
	The leader gives direction to accelerate the adaptation of new employees.
	The leader helps members of the organization reach a common understanding.
	The leader stimulates employees for personal development.
	The leader supports employees in pursuing career paths.
	The leader encourages employees to be creative.
	The leader encourages employees to develop.
	The leader provides employees with expertise.
	The leader provides employees with training to develop competencies.
Scanning and sensing the environment	The leader analyzes potential threats.
	The leader analyzes regional and global relationships.
	The leader identifies opportunities and threats to the organization.
	The leader is a creator of creative ideas.
	The leader focuses on the organization's environment.
	The leader creates the future.
	The leader monitors opportunities and threats arising in the organization.
	The leader observes macroeconomic changes.
	The leader forecasts potential losses.
	The leader makes changes faster to be implemented and accepted by employees.

Cont. table 2.

Setting and clarifying goals	The leader creates an appropriate vision for the organization.
	The leader gives the organization direction.
	The leader sets specific goals for the organization.
	The leader leads the company to achieve success.
	The leader communicates and clarifies goals to the various levels of the organization.
	The leader stimulates employees to perform actions that are in line with the organization's goals.
	The leader establishes a course of action.
	The leader aligns activities to achieve the goal.
	The leader sets tasks in accordance with the law.
Securing and allocating resources	The leader creates conditions for effective work.
	The leader provides employees with appropriate equipment.
	The leader provides employees with adequate information.
Providing autonomy	A leader empowers employees to take action freely.
	The leader delegates authority.
	The leader allows employees to undertake risky ventures.
	A leader disseminates a vision of development to the organization.
Managing social relationships	The leader involves all employees of the organization.
	The leader takes into account the opinion of employees.
	The leader ensures a positive work atmosphere.
	The leader aligns the organization's activities with others to achieve goals that are impossible to achieve individually.
	The leader is an authority for other employees.
	The leader carries out activities aimed at uniting social groups.
	The leader creates positive relationships among employees.
	The leader manages the flows and dependencies between activities.
	The leader meets the needs of the group.

Source: Own elaboration based on: (Jeżak, 1990; Malone, 1994; Grant, 1996; Ziębicki, 2000; Peters, 2001; Sitkin, 2005; Antoszkiewicz, 2007; Karaszewski, 2008; Oleksyn, 2008; Gołębiewski, 2009; Lumpkin, 2009; Williams, 2009; Olausson, 2010; Penc, 2010; Kisielnicki, 2012; Janasz, 2013; Skoczylas, 2013; Carnall, 2014; Hysa, 2014; Mesjasz, 2014; Kania, 2015; Smolarek, 2015; Karpacz, 2016; Łużniak, 2016; Karna, 2017; Verburg, 2017; Sienkiewicz, 2018; Zheng, 2019; Steele, 2022).

This division of leadership functions encompasses both management and team development aspects. The leader is responsible for formulating strategies, motivating team members, maintaining harmonious relationships, and ensuring that resources are well-managed. The leader should also challenge existing assumptions, be aware of the environment, and anticipate changes to make appropriate decisions. Developing team members is crucial for ensuring long-term success and organizational growth.

3. Leadership in Industry 4.0

The dynamics of the context, rapid technological transformations, and intense global competition compel organizations to continually search for new strategic solutions that will enable them to gain a competitive advantage (Rogozińska-Pawełczyk, 2022). This has led to the emergence of the term Industry 4.0, referring to the fourth industrial revolution (Davies, 2015; Bendkowski, 2017; Skórnóg, 2023), which is a result of the development of information

technology and robotics (Cellary, 2019). Industry 4.0 promotes production efficiency through intelligent data aggregation, making sound decisions, and their reliable implementation. The use of cutting-edge technologies allows simplifying the processes of data collection and interpretation. Interoperability serves as a strategic bridge, enabling the establishment of a reliable production environment within Industry 4.0 (Qin, 2016; Rupp, 2021). Based on the concepts of Tay (2018) and Vinitha (2020), a literature review decomposed Industry 4.0 into the following pillars:

- Big Data - a collection of complex data that cannot be processed using conventional applications. The main idea behind this concept is to enable real-time data analysis. This task is not easy as data often have an unstructured format, which, combined with a large influx of data, leads to an increased demand for computational power. To avoid constant investments in better machines, horizontal scaling has been introduced, which involves adding more machines (Racka, 2016; Wang, 2023; Jahani, 2023);

- Simulations - a method of analyzing processes or systems using real-time data to support decision-making. It enables forecasting outcomes and optimizing machine settings in a virtual environment. This shortens machine configuration time and improves quality. A modern approach involves modeling production systems using virtual factories (Rodič, 2017; Moraes, 2023; Cimino, 2023);

- Internet of Services - plays a crucial role as an essential element in the automotive industry. Processes are initiated through data transfer in information technology, aiming to provide daily mobility in a safe, simpler, and enjoyable manner. It enables the delivery of on-demand services through the internet based on various types of digital services (Buxmann, 2009; Khodadadi, 2017; Reis, 2018; Anrijs, 2023);

- Augmented Reality - is a technology that blurs the boundaries between the virtual and real world. It enables the implementation of new capabilities and efficiencies in processes. This technology supports work by reducing the time needed for its execution and minimizing the chance of potential errors using goggles that provide the operator with necessary information in real-time (Carmigniani, 2011; Bottani, 2019; Jayawardena, 2023; Yin, 2023);

- Cyber-Physical System - This term refers to the new generation of systems that combine integrated capabilities and computational power, enabling interaction with humans through computation, communication, and control. It is a key factor facilitating future technological advancements (Krogh, 2008; Baheti, 2011; Lee, 2015);

- Additive Manufacturing, also known as 3D printing, is a production process based on layer-by-layer deposition of material to create three-dimensional objects. This method utilizes various techniques such as sintering, bonding, or curing to gradually build the object's structure. Additive manufacturing is characterized by several benefits, including the ability to create custom shapes, reduce production time, and minimize waste

generation. It finds applications in various fields, including prototyping, spare part production, medicine, and architecture. In the context of Industry 4.0, additive manufacturing plays a key role, contributing to the flexibility, customization, and efficiency of production processes (Siemiński, 2015; Dilberoglu, 2017; Dodziuk, 2019; Calignano, 2023);

- Internet of Things (IoT) - a concept in which objects are interconnected in a communication network. IoT devices collect, process, and share data. It enables monitoring, control, and process optimization. Integrating IoT with Industry 4.0 supports dynamic response and efficient information exchange while generating vast amounts of data that, with proper analysis, can support decision-making processes (Mukhopadhyay, 2014; Rose, 2015; Kosik, 2019; Balicka, 2023; Zdun, 2023; Nalajala, 2023);

- Cloud Computing - is a component that enables smooth digital transformation. Through the network, it allows the delivery of computing resources such as servers, databases, applications, or storage. These resources are provided on-demand based on central management by the cloud service provider. This technology enables remote access and resource sharing efficiently and flexibly. It is characterized by scalability, reliability, and fault tolerance through the distribution of resources across multiple physical servers (Krok, 2017; Srivastava, 2018; Abdullayeva, 2023; Al-Jumaili, 2023);

- Autonomous Robots - are robots capable of performing tasks and making decisions independently, without the need for constant human supervision. They are equipped with sensors such as cameras, touch sensors, or navigation systems that enable them to gather information about their surroundings. Using this data, autonomous robots analyze and interpret the environment, taking appropriate actions. They can autonomously plan routes, avoid obstacles, manipulate objects, or collaborate with other robots. Autonomous robots find applications in various fields, performing complex tasks efficiently and independently from humans (Fahimi, 2009; Ardito, 2012; Gajdzik, 2019; Goel, 2020; Rose, 2023).

The increasing aspirations of organizations to pursue development determine a growing demand for employees who possess competencies enabling the organization to be directed towards success (Gajdzik, 2021; Rogozińska-Pawełczyk, 2022). This process has led to the emergence of the first concepts of Leadership 4.0. In Industry 4.0, leadership plays a significant role due to the need for making decisions on an organizational scale (Kasapoglu, 2018). Leadership in Industry 4.0 is defined as *the ability to quickly adapt and engage empowered, networked teams with clarity of goals and solutions focused on their achievement* (Rogozińska-Pawełczyk, 2022). A leader should possess the appropriate knowledge, digital skills, vision, understanding of customers, risk-taking ability, and collaborate with others (Bawany, 2019; Dabic, 2023). The literature does not describe the attributes of Leadership 4.0 in a fully specified manner (Kim, 2005; Mdluli, 2017; Bolte, 2018; Oberer, 2018; Kelly, 2018;

Rogozińska-Pawełczyk, 2022). One concept decomposes leadership for the blue ocean attributes such as vision, courage, passion, strategic thinking, planning, focus, collaboration, innovation, readiness for change, and communication (Rogozińska-Pawełczyk, 2022). Another division includes attributes such as responsibility, systemic leadership, adaptive leadership, and shaping society (Rogozińska-Pawełczyk, 2022). Meanwhile, F. Herder-Wynne identified seven attributes of leadership: engagement capability, trust, authenticity, networked team, fast adaptation, transparency, and agility (Herder-Wynne, 2017; Rogozińska-Pawełczyk, 2022). All of the mentioned attributes are necessary predispositions that enable a person to fulfill the role of a leader within Industry 4.0.

4. Factors shaping organizational leadership in Industry 4.0

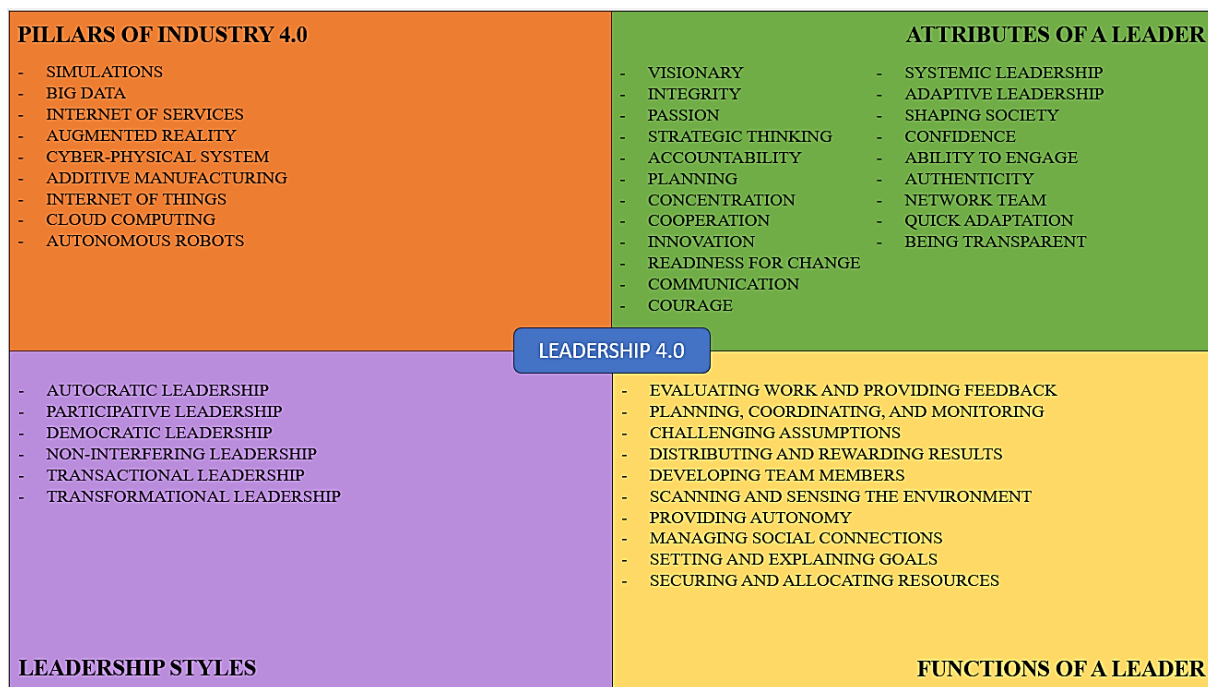Based on the literature review described in earlier chapters, a model was developed, as shown in Figure 1.

Figure 1. Factors shaping Leadership 4.0.

Source: Own elaboration.

Leadership in the context of Industry 4.0 is a complex process shaped by various factors. Figure 1 illustrates four groups of factors influencing Leadership 4.0. These include the pillars of Industry 4.0, leader attributes, leader functions, and leadership styles.

The first group is "Pillars of Industry 4.0," which includes key technologies and elements characteristic of this industrial revolution. Among them, we can include simulations, big data, Internet of services, augmented reality, cyber-physical systems, additive manufacturing,

Internet of things, cloud computing, and autonomous robots. Implementing the pillars of Industry 4.0 implies diverse requirements placed on the leader, arising from the individual characteristics of each pillar.

The second group is "Leader Attributes," which are crucial for effective leadership in Industry 4.0. Among these characteristics are vision, agility (the ability to respond flexibly to changes), passion, strategic thinking, responsibility, planning, focus, collaboration skills, innovation, adaptability, effective communication, courage, systemic leadership, the ability to shape society, building trust, engagement, authenticity, and the ability to create networked teams.

The third group is "Leadership Styles," which differ in their approach to managing and motivating teams. In the context of Industry 4.0, several leadership styles are distinguished: autocratic leadership, where decisions are made centrally; participative leadership, which involves employees in the decision-making process; democratic leadership, which is based on cooperation and consensus; laissez-faire leadership, which provides employees with autonomy; transactional leadership, which is based on rewards and punishments; and transformational leadership, which focuses on motivating and inspiring the team towards achieving higher goals.

The fourth group is "Leader Functions," which determine the various tasks and roles that a leader must fulfill in the Industry 4.0 environment. These functions include performance evaluation and providing feedback, planning, coordinating, and monitoring actions, challenging assumptions, distributing and rewarding outcomes, developing team members, analyzing the environment and taking appropriate actions, ensuring autonomy in work, managing social relationships, setting and clarifying goals, and effectively managing and allocating resources.

5. Conclusion

This study focused on the multi-faceted nature of leadership and its evolution in the context of technological advancements, particularly in the Industry 4.0 era. The analysis of the literature review allowed for the identification of key factors shaping organizational leadership in the Industry 4.0 environment.

The research results showed that a significant aspect of leadership is its impact on the group. Valuable insights were also derived from the identification of four main groups of factors influencing leadership in Industry 4.0: the pillars of Industry 4.0, leader attributes, leader functions, and leadership styles.

Decomposing these areas into smaller elements provides a basis for further research, which can explore the correlations between individual factors and their impact on Leadership 4.0. Such research can contribute to a deeper understanding of the complex nature of leadership in

the Industry 4.0 era and may provide guidance for organizations in effectively managing and achieving strategic goals.

The study conducted based on the literature review has its limitations, which may affect the generalization of the conclusions. Primarily, due to the nature of the literature review, there is no possibility to conduct personal measurements and observations on a live sample. This limitation may impact the completeness and accuracy of available data and the ability to detect hidden dependencies. Despite the careful selection of articles for analysis, there is a risk that some key studies or results may have been overlooked, which could affect the completeness of the analysis. Therefore, there is a need for further research, which should be conducted on larger population samples, considering empirical studies to expand the findings. Research using empirical data would allow for a more precise understanding of the relationship between factors shaping leadership in Industry 4.0 and actual behaviors and outcomes in organizations.

Despite the limitations, this work represents a significant step towards understanding and defining leadership in the Industry 4.0 era, which could positively impact the effectiveness of managing organizations in the modern industrial environment.

References

1. Abbas, M. (2023). Transformational versus transactional leadership styles and project success: A meta-analytic review. *European Management Journal, Vol. 41, Iss. 1*.
2. Abdullayeva, F. (2023). Cyber resilience and cyber security issues of intelligent cloud computing systems. *Results in Control and Optimization*.
3. Abercrombie, N., Hill, S., Turner, B.S. (1988). *The Penguin dictionary of sociology.* Penguin Books.
4. Adair, J. (2009). *Effective Leadership: How to Be a Successful Leader*. Pan Macmillan.
5. Al-Jumaili, A.H.A., Muniyandi, R.C., Hasan, M.K., Paw, J.K.S., Singh, M.J. (2023). Big Data Analytics Using Cloud Computing Based Frameworks for Power Management Systems: Status, Constraints, and Future Recommendations. *Sensors, 23(6),* 2952.
6. Anrijs, S., Marien, I., De Mares, L., Ponnet, K. (2023). Excluded from essential internet services: Examining associations between digital exclusion, socio-economic resources and internet resources. *Technology in Society. Vol. 73*.
7. Antoszkiewicz, J. (2007). *Metody zarządzania*. Warszawa: POLTEXT.
8. Ardito, S., Lazarevs, D., Vasiliniuc, B., Vukic, Z., Masabayashi, K., Caccia, M. (2012). Cooperative Autonomous Robotic Towing system: definition of requirements and operating scenarios. *IFAC Proceedings Volumes, Vol. 45, Iss. 27*.
9. Baheti, R., Gill, H. (2011). Cyber-physical systems. *The impact of control technology, 12(1),* 161-166.

10. Balicka, H. (2023). Internet rzeczy i modele uczenia głębokiego w zrównoważonym rozwoju inteligentnych miast. *Współczesna Gospodarka, 16(1(40))*.

11. Bawany, S. (2019). *Transforming the Next Generation Leaders: Developing Future Leaders for a Disruptive, Digital-Driven Era of the Fourth Industrial Revolution (Industry 4.0).* New York: Business Expert Press.

12. Bendkowski, J. (2017). Zmiany w pracy produkcyjnej w perspektywie koncepcji. Przemysł 4.0. *Zeszyty Naukowe Politechniki Śląskiej, Organizacja i Zarządzanie, 112,* 21-33.

13. Birasnav, M. (2014). Knowledge management and organizational performance in the service industry: The role of transformational leadership beyond the effects of transactional leadership. *Journal of Business Research, Vol. 67, Iss. 8.*

14. Blanchard, K. (2021). *Przywództwo wyższego stopnia*. Warszawa: PWN.

15. Bogdanor, V. (ed.) (1993). *The Blackwell Encyclopedia of Political Science.* Oxford, Cambridge: Blackwell Publishers.

16. Bolte, S., Dehmer, J., Niemann, J. (2018). Digital Leadership 4.0. *Acta Technica Napocensis-Series: Applied Mathematics, Mechanics, And Engineering, 61(4)*.

17. Bottani, E., Vignali, G. (2019). *Augmented reality technology in the manufacturing industry: A review of the last decade.* IIE Transactions.

18. Brahim, A.B., Riđić, O., Jukić, T. (2015). The Effect of Transactional Leadership on Employees Performance – Case Study of 5 Algerian Banking Institutions. *Economic Review – Journal of Economics and Business, Vol. XIII, Iss. 2*, pp. 7-20.

19. Bucurean, M. (2016). Comparative Analysis between the Managerial Style of Upper and Lower Level Managers. *Annals of the University of Oradea. Economic Science Series*.

20. Buxmann, P., Hess, T., Rugabber, R. (2009). Internet of Services. *Business & Information Systems Engineering, 5(2)*.

21. Calignano, F., Mercurio, V. (2023). An overview of the impact of additive manufacturing on supply chain, reshoring, and sustainability. *Cleaner Logistics and Supply Chain, Vol. 7.*

22. Carmigniani, J., Furht, B. (2011). *Augmented reality: an overview. Handbook of augmented reality,* 3-46.

23. Carnall, C. (2014). *Managing change in organizations*. Preentice Hall.

24. Cellary, W. (2019). Przemysł 4.0 i Gospodarka 4.0. *Biuletyn PTE, 3(86),* 48-52.

25. Chaudhry, A.Q., Javed, H. (2012). Impact of Transactional and Laissez Faire Leadership Style on Motivation. *International Journal of Business and Social Science, Vol. 3, No. 7,* pp. 258-264.

26. Chukwusa, J. (2018). *Autocratic Leadership Style: Obstacle to Success in Academic Libraries*.

27. Cimino, A., Gnoni, M.G., Longo, F., Barone, G., Fedele, M., Le Piane, D. (2023). Modeling & Simulation as Industry 4.0 enabling technology to support manufacturing process design: a real industrial application. *Procedia Computer Science, Vol. 217*, pp. 1877-1866.

28. Dabić, M., Maley, J.F. Cresnar, R., Nedelko, Z. (2023). Unappreciated channel of manufacturing productivity under industry 4.0: Leadership values and capabilities. *Journal of Business Research, Vol. 162*.

29. Dartey-Baah, K. (2009). *Douglas McGregor's theoretical models: Their application in assessing leadership styles.* Academic Leadership.

30. Davies, R. (2015). *Industry 4.0: Digitalisation for productivity and growth*. Briefing.

31. Dębicka, D. (2023). *Cechy osobowościowe oraz zachowania charakterystyczne dla kobiet i mężczyzn na stanowiskach przywódczych. Wpływ inteligencji emocjonalnej na styl zarządzania menedżerów*.

32. Deichmann, D. (2015). Leveraging transformational and transactional leadership to cultivate the generation of organization-focused ideas. *The Leadership Quarterly, Vol. 26, Iss. 2*.

33. Dilberoglu, U.M., Gharehpapagh, B., Yaman, U., Dolen, M. (2017). The role of additive manufacturing in the era of industry 4.0. *Procedia manufacturing, 11*, 545-554.

34. Dodziuk, H. (2019). Zastosowania przemysłowe druku 3D zwanego wytwarzaniem przyrostowym. Wstęp. *Napędy i Sterowanie, 21(5),* 88-99.

35. Fahimi, F. (2009). *Autonomous robots*. Boston, MA, USA: Springer.

36. Gajdzik, B. (2019). Zmiany w przedsiębiorstwach hutniczych w kierunku Przemysłu 4.0. *Hutnik, Wiadomości Hutnicze, 86(7),* 211-215.

37. Gajdzik, B. (2021). Changes in Employment and Working Conditions from the Perspective of Industry 4.0. *Zarządzanie Zasobami Ludzkimi, 138-139 (1-2),* 11-26.

38. Gastil, J. (1994). A Definition and Illustration of Democratic Leadership. *Human Relations, Vol. 47, No. 8,* pp. 953-975.

39. Gleick, J. (1987). *Chaos: Making a New Science.* Viking Penguin Inc.

40. Goel, R., Gupta, P. (2020). Robotics and industry 4.0. A Roadmap to Industry 4.0: Smart Production. *Sharp Business and Sustainable Development,* 157-169.

41. Gołębiewski, J. (2009). *Koordynacja czy kierowanie w zarządzaniu kryzysowym*.

42. Grant, R.M., Cibin, R. (1996). The chief executive as change agent. *Planning Review, 24(1),* 22-29.

43. Herder-Wynne, F., Amato, R., Uit de Weerd, F. (2017). *Leadership 4.0 A review of the thinking.* Oxford: Oxford Leadership.

44. Hysa, B. Grabowska, B. (2014). System motywacji pracowników administracji publicznej na podstawie wybranej jednostki ZUS. *Zeszyty Naukowe Politechniki Śląskiej, Organizacja i Zarządzanie*.

45. Iqbal, Z., Abid, G., Arshad, M., Ashfaq, F., Athar, M.A., Hassan, Q. (2021). Impact of Authoritative and Laissez-Faire Leadership on Thriving at Work: The Moderating Role of Conscientiousness. *European Journal of Investigation in Health Psychology and Education*.

46. Jahani, H., Jain, R., Ivanov, D. (2023). Data science and big data analytics: a systematic review of methodologies used in the supply chain and logistics research. *Annals of Operations Research*, 1-58.

47. Janasz, K., Wiśniewska, J. (2013). *Innowacje i jakość w zarządzaniu organizacjami*. Warszawa: CeDeWu.

48. Jayawardena, N.S., Thaichon, P., Quach, S., Razzaq, A., Behl, A. (2023). The persuasion effects of virtual reality (VR) and augmented reality (AR) video advertisements: A conceptual review. *Journal of Business Research, 160*, 113739.

49. Jeżak, J. (1990). *Strategiczne zarządzanie przedsiębiorstwem. Studium koncepcji i doświadczeń amerykańskich oraz zachodnioeuropejskich*. Łódź: Uniwersytet Łódzki.

50. Kania, S. (2015). *Przywódca jako kreator zmian w organizacji*. Gdańsk, Uniwersytet Gdański.

51. Karaszewski, R. (2008). *Przywództwo w środowisku globalnego biznesu*. Toruń

52. Karna ,W.J., Knap-Stefaniuk, A. (2017). *Motywowanie pracowników jako wyzwanie w zarządzaniu zasobami ludzkimi*. Wydział Nauk Ekonomicznych i Zarządzania.

53. Karpacz, J. (2016). Autonomia w kontekście orientacji przedsiębiorczej: Wymiar organizacyjny i indywidualny. *Organizacja i Kierowanie*.

54. Karwowski, M., Pawłowska, K. (2009). Style przywództwa w motywowaniu do twórczej pracy. *Bezpieczeństwo Pracy: nauka i praktyka, 4,* 16-19.

55. Kasapoglu, O.A. (2018). Leadership and Organization for the Companies in the Process of Industry 4.0 Transformation. *International Journal of Organizational Leadership, 7*, 300-308.

56. Kelly, R. (2018). *Constructing leadership 4.0: Swarm leadership and the fourth industrial revolution.* Springer.

57. Khassawneh, O., Elrehail, H. (2022). *The Effect of Participative Leadership Style on Employees' Performance: The Contingent Role of Institutional Theory*. Administrative Sciences.

58. Khodadadi, F., Sinnott, R.O. (2017). A Semantic-aware Framework for Service Definition and Discovery in the Internet of Things Using CoAP. *Procedia Computer Science, Vol. 113*, pp. 146-153.

59. Kim, W.C., Mauborgne, R. (2005). *Blue Ocean Strategy: How to Create Uncontested Market Space and Make the Competition Irrelevant*. Boston, MA: Harvard Business School.

60. Kisielnicki, J., Turyna, J. (2012). *Decyzyjne systemy zarządzania*. Warszawa: Difin.

61. Klein, G. (2023). Transformational and transactional leadership, organizational support and environmental competition intensity as antecedents of intrapreneurial behaviors. *European Research on Management and Business Economics, Vol. 23, Iss. 2.*

62. Kosik, T. (2019). Przemysłowy Internet Rzeczy (IIoT). Fabryka przyszłości w dobie rewolucji przemysłowej. *Napędy i Sterowanie, 21.*

63. Krogh, B.H. (2008). Cyber physical systems: the need for new models and design paradigms. *Presentation Report,* 304.

64. Krok, E. (2017). Chmura obliczeniowa w przedsiębiorstwie. *Organizacja i Zarządzanie: kwartalnik naukowy.*

65. Lee, J., Bagheri, B., Kao, H. (2015). A Cyber-Physical Systems architecture for Industry 4.0-based manufacturing systems. *Manufacturing Letters, Vol. 3*, pp. 18-23.

66. Lumpkin, G.T., Cogliser, C.C., Schneider, D.R. (2009) *Understanding and measuring autonomy: An entrepreneurial orientation perspective. Entrepreneurship: Theory & Practice.*

67. Łuźniak-Piecha, M., Kaczkowska-Serafińska, M., Lenton, A. (2016). *Mentoring odwrócony - korzyści dla organizacji. Edukacja Ekonomistów i Menadżerów.*

68. Malinowski, P. (2013). Przywództwo wojskowe zjawiskiem wielowymiarowym: komunikat naukowy. *Zeszyty Naukowe AON*, 280-287.

69. Malone, T., Crowston, K. (1994). *The interdisciplinary study of coordination. ACM Computing Surveys.*

70. Mazurkiewicz, G. (2015). *Przywództwo edukacyjne: zmiana paradygmatu.*

71. Mdluli, S., Makhupe, O. (2017). *Defining leadership competencies needed for the fourth industrial revolution: leadership competencies 4.0. Africa Expansion Project.*

72. Mesjasz-Lech, A. (2014). Integracja i koordynacja jako determinanty funkcjonowania organizacji sieciowej na przykładzie łańcucha dostaw. *Zeszyty Naukowe Politechniki Śląskiej.*

73. Moore, B. (1927). The May conference on leadership. *Personnel Journal.*

74. Moraes, E.B., Kipper, L.M., Hackenhaar Kellermann, A.C., Austria, L., Leivas, P., Moraes, J.A.R., Witczak, M. (2023). Integration of Industry 4.0 technologies with Education 4.0: Advantages for improvements in learning. *Interactive Technology and Smart Education, 20(2),* 271-287.

75. Morris, R., Seeman, M. (1959). The Problem of Leadership: An Inter-Disciplinary Approach. *American Journal of Sociology, no. 56.*

76. Mrówka, R. (2010). *Przywództwo w organizacjach. Analiza najlepszych praktyk.* Warszawa: Wolters Kluwer Polska.

77. Mrówka, R. (2021). *Przywództwo w organizacjach. Analiza najlepszych praktyk: Analiza najlepszych praktyk.* Wolters Kluwer Polska.

78. Mukhopadhyay, S.C., Suryadevara, N.K. (2014). Internet of things: Challenges and opportunities. Springer International Publishing, pp. 1-17.

79. Nalajala, P., Gudikandhula, K., Shailaja, K., Tigadi, A., Rao, S.M., Vijayan, D.S. (2023). Adopting internet of things for manufacturing firms business model development. *The Journal of High Technology Management Research. Vol. 34, Iss. 2.*

80. Northouse, P.G. (2021). *Leadership: Theory and Practice.* SAGE Publications.

81. Oberer, B., Erkollar, A. (2018). Leadership 4.0: Digital Leaders in the Age of Industry 4.0. *International Journal of Organizational Leadership*.

82. Olausson, D., Berggren, C. (2010). Managing uncertain, complex product development in high tech firms: In search of controlled flexibility. *R&D Management*.

83. Oleksyn, T. (2008). *Zarządzanie zasobami ludzkimi w organizacji. Kanony, realia, kontrowersje*. Kraków: Wolters Kluwer.

84. Penc-Pietrzak, I. (2010). *Planowanie strategiczne w nowoczesnej firmie*. Warszawa.

85. Peters, T. (2001). Leadership is confusing as hell. *Fast Company, 42,* 84-87.

86. Pichlak, M. (2011). Przywództwo czynnikiem rozwoju i wzrostu innowacyjnej organizacji. *Prace Naukowe Uniwersytetu Ekonomicznego we Wrocławiu, 219,* 203-210.

87. Podgórska, M. (2014). Przywództwo w kontekście skuteczności w zarządzaniu projektami. *Zeszyty Naukowe Politechniki Śląskiej. Organizacja i Zarządzanie, z.70, nr kol. 1909*.

88. Qin, J., Liu, Y., Grosvenor, R.A. (2016). Categorical Framework of Manufacturing for Industry 4.0 and beyond. *Procedia CIRP*, 173-178.

89. Racka, K. (2016). Big Data − Znaczenie, zastosowania i rozwiązania technologiczne. *Zeszyty Naukowe PWSZ*.

90. Reis, J.Z., Gonçalves, R.F. (2018). *The role of internet of services (ios) on industry 4.0 through the service oriented architecture (soa)*. Advances in Production Management Systems. Smart Manufacturing for Industry 4.0: IFIP WG 5.7 International Conference, APMS 2018, Seoul, Korea, August 26-30, 2018, Proceedings, Part II (pp. 20-26). Springer International Publishing.

91. Robert, V., Vandenberghe, C. (2021). Laissez-Faire Leadership and Affective Commitment: The Roles of Leader-Member Exchange and Subordinate Relational Self-concept. *J. Bus. Psychol., 36,* 533-551.

92. Rodič, B. (2017). Industry 4.0 and the New Simulation Modelling Paradigm. *Organizacija, 50(3),* 193-207.

93. Rogozińska-Pawełczyk, A. (2022). Przywództwo 4.0 w przedsiębiorstwach business services sector. *Zarządzanie Zasobami Ludzkimi, 146(3-4),* 23-42.

94. Rose, D.C., Bhattacharya, M. (2023). Adoption of autonomous robots in the soft fruit sector: Grower perspectives in the UK. *Smart Agricultural Technology, 3,* 100118.

95. Rose, K., Eldridge, S., Chapin, L. (2015). The internet of things: An overview. *The internet society (ISOC), 80,* 1-50.

96. Rost, J.C. (1991). *Leadership ethics: An introduction*. New York: Cambridge University Press.

97. Rupp, M., Schneckenburger, M., Merkel, M., Borret, R., Harrison, D.K. (2021). Industry 4.0: A Technological-Oriented Definition Based on Bibliometric Analysis and Literature Review. *Journal of Open Innovation: Technology, Market, and Complexity, Vol. 7, Iss. 1*.

98. Sharma, D., Singh, D. (2013). A Study on the Democratic Style of Leadership. *International Journal Of Management & Information Technology*.

99. Siemiński, P., Budzik, G. (2015). *Techniki przyrostowe: druk drukarki 3D*. Warsaw: Oficyna Wydawnicza Politechniki Warszawskiej.

100. Sienkiewicz-Małyjurek, K. (2018). Zwinność koordynacji w sieciach zarządzania bezpieczeństwem publicznym. *Organizacja i Kierowanie*.

101. Sitkin, S.B., George, E. (2005). Managerial trust-building through the use of legitimating formal and informal control mechanisms. *International Sociology*.

102. Skoczylas-Tworek, A. (2013). *Monitorowanie systemu kontroli wewnętrznej organizacji na podstawie modelu COSO III*. Uniwersytet Ekonomiczny w Katowicach.

103. Skórnóg, D. (2023). Wpływ innowacyjnych rozwiązań Przemysłu 4.0 na zarządzanie jakością. *Management & Quality (Zarządzanie i Jakość), 5(1)*.

104. Smith, Ph.M. (1996). Przywództwo. In: A.S.R. Manstead, M. Hewstone (eds.), *Psychologia społeczna. Encyklopedia Blackwella*. Warszawa: Jacek Santorski & Co.

105. Smolarek, M. (2015). Wybrane aspekty planowania strategicznego w instytucjach integracji i pomocy społecznej. *Studia i Prace Wydziału Nauk Ekonomicznych i Zarządzania.*

106. Soliński, B.J. (2023). Model silnego przywództwa jako antidotum na strach. *Teologia i Moralność, 18(1(33)),* 225-252.

107. Srivastava, P., Khan, R. (2018). A review paper on cloud computing. *International Journal of Advanced Research in Computer Science and Software Engineering, 8(6),* 17-20.

108. Steele, L.M., Watts, L.L. (2022). Managing technical innovation: A systematic review of 11 leader functions. *Technovation*.

109. Tay, S., Te, C.L., Aziati, A., Ahmad, A., Nur, A. (2018). An Overview of Industry 4.0: Definition, Components, and Government Initiatives. *Journal of Advanced Research in Dynamical and Control Systems*.

110. Tokar, J. (2010). *Proces samodoskonalenia menedżerów a przywództwo organizacyjne w praktyce.* Rozprawa doktorska.

111. Verburg, R.M., Nienaber, A.M., Searle, R.H., Weibel, A., Den Hartog, D.N., Rupp, D.E. (2017). The role of organizational control systems in employees' organizational trust and performance outcomes. *Group & Organization Management*.

112. Vinitha, K., Ambrose Prabhu, R., Bhaskar, R., Hariharan, R. (2020). Review on industrial mathematics and materials at Industry 1.0 to Industry 4.0. *Procedia Computer Science*.

113. Wang, C., Yin, L. (2023). Defining Urban Big Data in Urban Planning: Literature Review. *Journal of Urban Planning and Development, 149(1),* 04022044.

114. Wang, Q., Hou, H., Li, Z. (2022). Participative Leadership: A Literature Review and Prospects for Future Research. *Frontiers in Psychology*.

115. Weber, M. (1972). *Wirtschaft und Gesselschaft. Grundriss der Verstehnden Soziologie.* J.C.B. Mohr (Paul Siebeck), Tubingen.

116. Williams, M. (2009). *Mistrzowskie przywództwo*. Kraków: Oficyna Wolters Kluwer business.

117. Yin, Y., Zheng, P., Li, C., Wang, L. (2023). A state-of-the-art survey on Augmented Reality-assisted Digital Twin for futuristic human-centric industry transformation. *Robotics and Computer-Integrated Manufacturing, 81*, 102515.

118. Yukl, G.A. (1989). *Leadership in Organization*. New York: Prentice-Hall, Englewood Cliffs.

119. Yukl, G.A. (2002). *Leadership in Organizations*. Upper Saddle River: Prentice Hall.

120. Zdun, M. (2023). Rewolucja przemysłowa 4.0 jako nowy kontekst alienacji w życiu społeczno-gospodarczym. *Studies of the Industrial Geography Commission of the Polish Geographical Society, 37(2),* 36-48.

121. Zheng, Y., Graham, L., Enape, E. (2019). *Service Leadership, Work Engagement, and Service Performance: The Moderating Role of Leader Skills*.

122. Żuchowski, I. (2018). Style kierowania i relacje przełożony-podwładny w praktyce działalności przedsiębiorstw z subregionu ostrołęckiego i kierunki zmian w przyszłości. *Zeszyty Naukowe Uniwersytetu Ekonomicznego w Katowicach, nr 537*.