Determining the Level of Use of the Industry 4.0 Solutions in the COVID-19 Pandemic Era: Results of Empirical Research

Anna Michna * and Joanna Kruszewska

Department of Organization and Management, Silesian University of Technology, 41-800 Zabrze, Poland; joanna.kruszewska@polsl.pl
* Correspondence: anna.michna@polsl.pl

Abstract: Changes in the world’s situation and the need to be competitive and less dependent on the global economy lead to improvements in many organisations. Together with business model transformation, using the latest technologies such as augmented reality, autonomous robots, mobile technologies, big data, cloud computing, and others known as an Industry 4.0 pillars, enterprises are changing the industry status quo. These technologies are widely described and studied in the literature, mainly on the example of large production companies. In order to fill the gap, this article had two objectives. The first objective was to investigate the usage of Industry 4.0 technologies in the time of the COVID-19 pandemic. The second one was to verify the strength of the impact of selected barriers on the level of implementation of individual I4.0 technologies and influence of cooperation during technology implementation. To achieve the objectives of the article, quantitative research was conducted. Data from 125 anonymous survey participants were collected in October 2021 and analysed using a statistical tool. The study results revealed that the term Industry 4.0 is known among industry employees. Surveyed organisations are using I4.0 technologies and still planning to implement them in a wider range despite the pandemic situation. Moreover, the most often-cited barriers in the literature on the subject are costs or employees’ acceptations, too-individualised customer requirements, or insufficient standardisation, which affect the implementation of Industry 4.0 solutions with strengths varying from low to moderate intensity. The information in this paper may be of use to Industry 4.0 solution providers or collaborative and partnership organisations.

Keywords: Industry 4.0; solutions; barriers; perception; driving forces; COVID-19 pandemic

1. Introduction
Since March 2020, we all witnessed the disclosure of two important facts to the public: the European Commission published an industrial strategy which supports transition to a green and digital economy, and the World Health Organization announced the COVID-19 pandemic [1], all enterprises despite their size, localisation, and type of activities must face these special circumstances and adopt a strategy to address this new situation. During that time, the European economy declined by 6.3%. In 2020, 60% of small and medium-sized enterprises (SMEs) reported a decline in turnover. In the same year, there was a 1.4 million decrease in jobs in SMEs. In 2021, a reduction of 45% in investment was expected [1]. Apparent problems with free movements of goods, services, and people, issues with the global supply chain and covering demands, and shortages of critical products lead to a necessity to strengthen European open strategic autonomy by diversification of international partnership, industrial alliances, and monitoring of strategic dependencies on foreign suppliers [1,2]. The six strategic areas on which the EU is dependent include raw materials, batteries, active pharmaceutical ingredients, hydrogen, semiconductors, and cloud and edge technologies. The countries on which Europe mostly depends in terms of those products are China, Vietnam, and Brazil [2]. The digital and green EU strategy affects business model transformation. The assumptions and role of Industry
4.0 became more and more significant, especially in the case of using new technologies, forming alliances, networking, and sharing resources. The main objectives for I4.0 are also to improve the company’s competitive position, to ensure production flexibility, and to be able to respond to changing customer demands and individual needs [3]. Those objectives became more and more significant in the era of the COVID-19 pandemic, where strong and reliable networking, timing, responsiveness, and resource availability were key indicators determining not only the success of the organisation but often its survival.

**Study Target**

The aim of this study was to answer the question of how Industry 4.0 was used and perceived during the COVID-19 pandemic. In connection with the above statement, detailed objectives were established. The main objective is supported by two component objectives, A and B:

**Objective 1.** *Researching the use of Industry 4.0 technologies during the COVID-19 pandemic among exemplary organisations.*

**Objective 1A.** *Researching the strength of the relationship of selected barriers on the level of implementation of individual I4.0 technologies.*

**Objective 1B.** *Study the relationship of inter-organisational partnership in Industry 4.0 on the level of technology implementation.*

The paper is organised as follows: Section 2 highlights the differences in approach and in recent research on Industry 4.0. Section 3 presents methodology of the empirical research while Section 4 presents its results. The theoretical and practical implications, along with limitations and further studies, are discussed in Section 5.

### 2. Literature Review

In the subject literature, the concept of Industry 4.0 is presented as a new paradigm of modern manufacturing [4], or more specifically, as a new paradigm of digitised and connected manufacturing integrating the Internet of Things and services in order to transform factories into smart and autonomous production [5–8]. Preparation for this challenge became a goal for future transformation [4,9–13]. More specifically, according to Kamble et al., 2018 [8], these challenges include manufacturing lead time reduction, quality improvements, and organisational performance improvements [14].

Based on the German Federal Ministry for Economic Affairs and Climate Action [15], Industry 4.0 refers to the “intelligent networking of machines and processes for industry with the help of information and communication technology”. The I4.0 platform managed by the German Ministry [16] also describes Industry 4.0 as “a fundamental process of innovation and transformation in industrial production”. It changes from strictly defined value chains into flexible and connected networks that create new forms of cooperation and shift the centre of gravity from product focus into data-driven business models [16]. The Industry Platform of the Future, the Polish Foundation, managed by the Ministry of Development and Technology, defined Industry 4.0 as a “concept which describes complex process of technological and organisational transformation of enterprises, which includes integration of the value chain, introduction of new business models and digitisation of products and services” [17].

Those two types of Industry 4.0 definitions—ministerial and literature-based—indicate effects, or company transformations, and the causes of its transformation (in the meaning of challenges or driving forces). Both of them are definitely specific for each organisation. Table 1 presents selected definitions of Industry 4.0 with key factors and tools. It contains also aims for Industry 4.0 described by mentioned researchers.
Table 1. Selected definitions of Industry 4.0.

| Source | Industry 4.0 Definition | Key Factors | Tools | Aim |
|--------|-------------------------|-------------|-------|-----|
| Durana et al., 2019 [4] | I4.0 means a new paradigm of modern manufacturing. | Continuous innovation processes; technological development. |  | To be prepared for new challenges. |
| Müller, J. and Voigt, K., 2018 [5,6,8] | New paradigm of digitised and connected manufacturing. | Integrated Internet of Things and Services; Industrial value creation. |  | To transform factories into smart and autonomous production facilities. |
| Kamble et al., 2018 [14] | I4.0 comprises a variety of technologies to enable the development of the value chain. | Digital and automated manufacturing. |  | To reduce manufacturing lead times; Improve product quality; Improve organisational performance. |
| German Federal Ministry for Economic Affairs and Climate Action and Platform I4.0 [15,16] | Intelligent networking of machines and processes for industry with the help of information and communication technology. | Availability; transparency; access to data; ICT—information and communication technology. |  | To work in a connected economy and largely determine competitiveness. |
| Polish Ministry of Development and Technology and Industry Platform of the Future [17] | Concept which describes complex process of technological and organisational transformation of enterprises. | Integration of the value chain; introduction of new business models; digitisation of products and services; |  | To cover individualised customer needs and the growing trend of personalising products and services. |
| Micha and Kmieciak 2020 [18] | Technology-driven paradigm shift of manufacturing industry that will digitally integrate production networks both horizontally and vertically. | Based on cyber-physical systems (CPS) and Internet of Things (IoT). |  | To integrate machines, devices, production, and logistics systems. |
| Li et al., 2019 [19] | Technology-driven paradigm shift of manufacturing industry that will digitally integrate production networks both horizontally and vertically. | Based on cyber-physical systems (CPS) and Internet of Things (IoT). |  | To integrate machines, devices, production, and logistics systems. |

All of the above definitions are connected with organisation transformation in order to meet upcoming challenges, mostly related to being flexible, competitive, and efficient. This fact, together with industrial strategy published by European Commission, supports two main recent goals of the Industry—the transition to a green and digital economy. The transformation should start with needs, and the technology will support the defined goals. The literature shows the diversity of Industry 4.0 technologies. This collection includes, among others, (1) big data and analytics [20–23], (2) autonomous robots [24], (3) simulations [25–30], (4) horizontal and vertical system integration [31,32], (5) Internet of Things—IoT [31], (6) cyber-security [33,34], (7) the cloud, (8) additive manufacturing, (9) augmented reality, (10) artificial intelligence [35], (11) mobile technologies, and (12) RFID and RTLS technologies [12,30,36–42]. Each solution could be independently implemented as a separate project for the organisation. In order to ensure the compliance with the specified requirements (such as time, budget, resources, etc.) organisations should focus on driving forces which motivate them to change and implement these I4.0 solutions, and especially on the barriers which could block or slow down the pace of those activities [36,43]. Barriers, inhibitors, obstacles, roadblocks, or concerns [40,44–48], among other various words are used to describe the issue the enterprises face before, during, or after implementation of a certain solution. Among others, the authors mention lack of understanding of the strategies and the importance of I4.0, lack of standards, insufficient financial and human resources, lack of understanding the interaction between technology and humans, lack of knowledge about I4.0, lack of skilled labour, lack of data protection [36], financial resources, and profitability, organisational transformation, technical integration, human resources, cooperation, and data security [3], organisational challenges, financial issues, and employee competences and resistance [38,49]. Based on the literature research, four barriers were selected for further study: customer requirements, costs, level of standardisation, and
employee acceptance. In order to identify clear interactions between the mentioned factors, the following hypotheses are proposed:

**Hypothesis 1 (H1).** Inter-organisational cooperation in the field of Industry 4.0 supports implementation of Industry 4.0 technological solutions.

**Hypothesis 2 (H2).** Barriers, such as overly individualised customer requirements, insufficient standardisation, costs, and lack of employee’s acceptance, affect the implementation of individual Industry 4.0 solutions with varying intensity.

**Hypothesis 3 (H3).** Barriers, such as overly individualised customer requirements, insufficient standardisation, costs, and lack of employee’s acceptance, affect the inter-organisational cooperation in the Industry 4.0.

The defined hypotheses are shown on the hypothesised research model below—Figure 1.

![Hypothesised research model](image)

**Figure 1.** Hypothesised research model.

The hypothesised research model adopted the cooperation with partners such as organisations, companies or institutions which could provide appropriate technology, assistance, and external sources of funding or knowledge about the solutions sought to support the implementation of the technological pillars of Industry 4.0. Moreover, the model considers that the barriers indicated affect each technology differently.

### 3. Materials and Methods

The items used in this study were part of a pilot study in the research of barriers and drivers for implementing Industry 4.0 and additionally in the research of usage level of this concept among employees at different levels of the organisation [50].

#### 3.1. Sample and Data Collection

The survey was conducted via internet survey available at [www.survio.com](http://www.survio.com) (accessed on 13 October 2020). The link to the survey was directly distributed to potential participants via online communicators available on business and employment-oriented online services. Data collection using an anonymous questionnaire ran from 13 to 21 October 2021. The survey was available for respondents for eight days. During that time, 125 surveys were filled. In total, the web page registered 327 visits, giving a response rate of 38%.

The survey was prepared in two languages: English and Polish. In fact, two independent surveys were performed at the same time. The respondents had the opportunity to fill out the questionnaire in their selected language. Both surveys contained the same set of
questions: metrics and a fundamental set of questions developed on the basis of literature research. General metrics include items directly related to survey participants: questions related to their country of origin (Poland, Germany, India, etc.), role in the company (owner, manager, engineer, employee, etc.), and working area (such as department, e.g., finance, manufacturing, logistics, quality, IT, etc.). The second part of general metrics contains questions related to enterprise: country of operation (Poland, Germany, etc.), years of the enterprise’s existence (the authors decided to divide it as follows: 0–2 years, 2–5 years, 5–10 years, 10–20 years and more), size of the enterprise (micro with 1–9 employees, small with 10–49 employees, medium with 50–249 employees, and large with more than 250 employees), sector of the activity (general groups were proposed, such as manufacturing, service provider, information, and agriculture), and role of the enterprise in the Industry 4.0 with possible answers, such as provider (of I4.0 services, solutions, products), user (of I4.0 services, solutions, products), user and provider, and none of the above [50,51].

3.2. Structure of the Research Group

As for the participants’ nationalities, the vast majority were Polish—108 participants, 86.4%; the remaining 17 were from Germany, Great Britain, Mexico, the Netherlands, India, and Iran. Due to the vast majority of Polish participants, the distribution and size of the research sample is uneven. Nationalities other than Polish were included in the group “other” and the results based on this variable were used primarily for illustrative purposes and preliminary analyses.

Of respondents, 70% represent the managerial level of employment, which includes managers, management board, company owners and co-owners, leaders and supervisors; 27% includes specialists and 3% includes employees—Figure 2. Respondents work in following areas: quality (24.8%), production (14.4%), management board (12.8%), research and development (8.8%), IT (6.4%), technology (5.6%), logistics (5.6%), supply chain (4%), maintenance (4.0%), finance (3.2%), and HR (2.4%). The remaining 8% includes sales, project management, EHS (environment, health and safety), supplier development, product development, and continuous improvements. Eighty-three respondents (66.4%) represent large enterprises (employing more than 250 employees); 15.2%, i.e., 19 persons, are employed in medium-sized enterprises (from 50 to 249 employees), while 13 persons (10.4%) represent small companies and 10 persons, i.e., 8% of total respondents, work in micro companies.

![Figure 2. Respondent employment level.](image)

In terms of company location, 73.6% of companies are located in Poland, 9.6% in Germany, 6.4% in USA, and 3.2% in Great Britain. The remaining 7.2% are companies located, for example, in India, Vietnam, Iran, Mexico, France, or the Netherlands. For further analysis, the group ‘other’ was created, which includes all company countries except the Polish ones. Given the age of companies, the sample consists of the following companies: aged up to 2 years—9; between 2 and 5 years—17; between 5 and 10 years—8; between 10 and 20 years—28, and more than 20 years—63. Given the activity sector of enterprises, 93 of them, 74.4%, represent the industry sector while the rest of them, 32, represent the service sector—see Figure 3. The vast majority of enterprises work in the manufacturing industry—64.8%. The second largest sector is manufacturing of machines and devices—10.4% of all companies. The respondents also represent company fields such
as service, transport and warehouse management, education, IT, trade, HR companies, certification bodies, I4.0 solutions manufacturers, energy producers, finance and insurance companies, and construction enterprises—a total of 28.4%.

![Figure 3. Enterprise sector.](image)

Of the surveyed companies, 46.4% have the “user” role—which means that they use tools and solutions known as an Industry 4.0 technology; 23.2% are providers of I4.0 solutions, while 12.8% have both roles—user and provider. The rest of the respondents, 17.6%, chose the answer ‘none of the above’, which leads to the conclusion that either they are not aware of the Industry 4.0 concept or their companies do not use any of the latest technologies known as I4.0 tools.

### 3.3. Measures

The questionnaire items were examined using a five-point Likert scale, where 1 means “definitely not”, 2—“rather not”, 3—“I have no opinion”, 4—“rather yes”, and 5—“definitely yes”. The second part of the survey contained questions from literature sources such as Refs. [5,18,38,39,47] that were arranged in order to support the stated objectives of the overall study: to identify the usage of the Industry 4.0 during the pandemic in exemplary organisations, to identify the strength of the impact of selected barriers on the level of implementation of individual I4.0 technologies, and to examine the impact of partnerships in Industry 4.0 on the level of technology implementation.

This study examined, in detail, the Industry 4.0 concept’s usage at the actual working stage in surveyed companies. To support the purpose of the verification, the items were generated from the analysis of Türkes et al. [47]’s study on the SMEs in Romania on the “drivers and barriers of implementing Industry 4.0 technology for business development”, i.e., questions related to knowledge about the Industry 4.0 concept and implementation of its technological pillars were introduced to the study. The work of Michna and Kmiecik [18] was used to verify future plans of surveyed companies related to automation, digitalisation, and implementation of Industry 4.0 solutions. The current situation and solutions recently implemented in surveyed companies were verified by using the research of Vuksanovic Herceg et al. [38]. The integrity of digitalisation into company corporate strategy, the connection to the company’s mission and vision, or the use of I4.0 solution in the areas such as warehouse management, transportation, or personnel selection were included in the study. Last but not least, the aspect of fears and barriers assessed by Müller et al. [6] were used to verify the impact of individualised customer requirements, lack of standardisation, costs or aspects directly related to employees, such as fear to be dependent on technology, lack of acceptance, lack of basic knowledge about I4.0, or loss of flexibility and interchangeability due to technology and anonymity.

All items used in this study are presented in Table 2. Those related to actual perception and usage of I4.0 solution were marked as ‘A’, future plans as ‘F’, fears and barriers as ‘B’, and cooperation as ‘C’. The table also shows codified items for technologies used in Industry 4.0. The collected data were analysed using basic statistical methods, such as frequency or contingency tables, using Minitab software. Additionally, participant role, company’s localisation, size, sector, and role were taken as control variables in this study.
Table 2. Constructs and items.

| Item | Questions—Actual Usage (A) |
|------|-----------------------------|
| A1   | Have you heard about the Industry 4.0 concept? |
| A2   | Please specify which technologies ARE used in your company: |
| A2_1 | Big Data and analytics |
| A2_2 | Autonomous robots |
| A2_3 | Simulation |
| A2_4 | Integration of the horizontal and vertical system |
| A2_5 | Internet of Things (IoT) |
| A2_6 | Cyber security |
| A2_7 | Additive manufacturing (e.g., 3D printing) |
| A2_8 | Augmented reality |
| A2_9 | Cloud computing |
| A2_10 | Mobile technologies |
| A2_11 | Artificial intelligence |
| A2_12 | Radio Frequency Identification (RFID) |
| A2_13 | Real-time Location System (RTLS) |
| A3   | Our Company integrates digitalisation as part of the corporate strategy. |
| A4   | Our mission and vision are in line with digital technologies. |
| A5   | Activities in our warehouses are fully automated. |
| A6   | Transport activities are planned with the help of digital technologies. |
| A7   | Our organisation uses digital technologies for the recruitment and selection of personnel. |

| Item | Questions—Future Plans (F) |
|------|-----------------------------|
| F1   | Please specify which technologies WILL BE used in your company. |
| F1_1 | Big Data and analytics |
| F1_2 | Autonomous robots |
| F1_3 | Simulation |
| F1_4 | Integration of the horizontal and vertical system |
| F1_5 | Internet of Things (IoT) |
| F1_6 | Cyber security |
| F1_7 | Additive manufacturing (e.g., 3D printing) |
| F1_8 | Augmented reality |
| F1_9 | Cloud computing |
| F1_10 | Mobile technologies |
| F1_11 | Artificial intelligence |
| F1_12 | Radio Frequency Identification (RFID) |
| F1_13 | Real-time Location System (RTLS) |
| F2   | Over the next 3–5 years, our Company plans to increase the degree of automation |
| F3   | Over the next 3–5 years, our Company plans to significantly increase digitisation and computerisation. |
| F4   | Our Company plans to increase capital expenditure related to Industry 4.0 over the next five years. |

| Item | Questions—Fears and Barriers (B) |
|------|----------------------------------|
| B1   | Customer requirements are too individualised to implement Industry 4.0. |
| B2   | We have too little standardisation to implement Industry 4.0. |
| B3   | For us, the costs outweigh the benefits of Industry 4.0. |
| BP4  | Our employees are afraid of being dependent on Industry 4.0 technologies. |
| BP5  | We expect that Industry 4.0 is not accepted by employees. |
| BP6  | We expect our employees to be unfamiliar with Industry 4.0. |
| BP7  | Industry 4.0 makes us lose our flexibility, requiring expensive solutions. |

Cooperation (C)

| Item | Questions |
|------|------------|
| C1   | We are looking for a partner who will help us implement I4.0 solutions. |
| C2   | We need to find a partner who will help us implement I4.0 solutions. |
| C3   | We plan to find a partner to help us implement I4.0 solutions. |
| C4   | We plan to implement Industry 4.0 solutions. |

As a part of the reliability test of measurement model, Cronbach’s Alpha with a requested minimum value of 0.7 was used. The results are presented in Table 3. The Cronbach’s Alpha value for the constructs ranged from 0.73 to 0.94 for all groups of statements: actual usage, future plans, barriers and fears, and inter-organisational cooperation. All values are higher than the recommended 0.7, which means that the research tool is reliable.
Table 3. Reliability and basic statistics.

| Questions Group     | Item   | Mean  | Std Dev | Cronbach’s Alpha Value |
|---------------------|--------|-------|---------|------------------------|
| Actual usage (A)    | A1     | 3.98  | 1.27    |                        |
|                     | A2_1   | 3.16  | 1.38    |                        |
|                     | A2_2   | 2.55  | 1.46    |                        |
|                     | A2_3   | 3.27  | 1.41    |                        |
|                     | A2_4   | 3.17  | 1.15    |                        |
|                     | A2_5   | 2.94  | 1.34    |                        |
|                     | A2_6   | 4.05  | 1.09    |                        |
|                     | A2_7   | 2.84  | 1.42    |                        |
|                     | A2_8   | 2.46  | 1.20    |                        |
|                     | A2_9   | 2.99  | 1.38    | 0.922                  |
|                     | A2_10  | 3.69  | 1.25    |                        |
|                     | A2_11  | 2.54  | 1.37    |                        |
|                     | A2_12  | 2.87  | 1.48    |                        |
|                     | A2_13  | 2.49  | 1.31    |                        |
|                     | A3     | 3.41  | 1.22    |                        |
|                     | A4     | 3.74  | 1.16    |                        |
|                     | A5     | 2.46  | 1.22    |                        |
|                     | A6     | 3.10  | 1.28    |                        |
|                     | A7     | 2.98  | 1.28    |                        |
| Future plans (F)    | F1_1   | 3.24  | 1.18    |                        |
|                     | F1_2   | 3.06  | 1.35    |                        |
|                     | F1_3   | 3.32  | 1.31    |                        |
|                     | F1_4   | 3.38  | 1.15    |                        |
|                     | F1_5   | 3.19  | 1.22    |                        |
|                     | F1_6   | 4.02  | 1.14    |                        |
|                     | F1_7   | 3.19  | 1.37    |                        |
|                     | F1_8   | 3.00  | 1.21    | 0.949                  |
|                     | F1_9   | 3.35  | 1.34    |                        |
|                     | F1_10  | 3.67  | 1.25    |                        |
|                     | F1_11  | 3.05  | 1.29    |                        |
|                     | F1_12  | 3.21  | 1.34    |                        |
|                     | F1_13  | 2.95  | 1.30    |                        |
|                     | F2     | 3.83  | 1.10    |                        |
|                     | F3     | 3.92  | 1.04    |                        |
|                     | F4     | 3.46  | 1.14    |                        |
| Fears and Barriers (B) | BP4   | 2.36  | 1.01    | 0.802                  |
|                     | BP5    | 2.50  | 1.07    |                        |
|                     | BP6    | 3.05  | 1.21    |                        |
|                     | BP7    | 2.08  | 0.84    |                        |
| Inter-organisational Cooperation (C) | C1    | 3.98  | 1.04    | 0.754                  |
|                     | C2     | 3.90  | 1.09    |                        |
|                     | C3     | 3.02  | 1.00    |                        |
|                     | C4     | 4.00  | 1.00    |                        |

4. Results

4.1. Actual Usage of Industry 4.0 Technology

The general response to question A1—“Have you heard about the Industry 4.0 concept?”—was positive. Of the respondents, 74.4% rather or definitely heard about new industrial revolution, only 5.6% had no opinion on that subject, and 20% showed poor knowledge on the studied concept—see Table 4 and Figure 4.
Table 4. Tally for discrete variable A1.

| A1 | Count | %    | Cumulative % |
|----|-------|------|--------------|
| 1  | 11    | 8.80 | 8.80         |
| 2  | 14    | 11.20| 20.00        |
| 3  | 7     | 5.60 | 25.60        |
| 4  | 40    | 32.00| 57.60        |
| 5  | 53    | 42.40| 100.00       |

Figure 4. Histogram of A1 variable.

Deeper analysis of data showed that definitive knowledge of the Industry 4.0 concept is higher in German companies than in other countries. All participants from those companies gave only positive answers. As the latest revolution started in that country, results were expected. Table 5 shows results for enterprises by two control variables: company country and size. The data showed that German companies placed in the ‘other’ group had the strongest impact on the final values. Participants from Poland in 72.82% (answers 4 and 5) declared their knowledge about the concept of I4.0. In case of company size, representants of both large and small and medium-sized enterprises demonstrated knowledge about the Industry 4.0 concept. Additionally, on the basis of results from descriptive statistical analysis shown in Table 6, mean value of 3.92 was obtained for large companies, while 3.84 for SMEs and 3.7 for Micro enterprises, indicating that I4.0 concept is rather known regardless of company size.

Table 5. Contingency table for variable A1.

| Enterprise | Measures | 1 | 2 | 3 | 4 | 5 | All |
|------------|----------|---|---|---|---|---|-----|
| Other      | Count    | 2 | 4 | 1 | 11| 15| 33  |
|            | % of Row | 6.06| 12.12| 3.01| 33.33| 45.45| 100 |
| Poland     | Count    | 9 | 10| 6 | 29| 38| 92  |
|            | % of Row | 9.78| 10.87| 6.52| 31.52| 41.3| 100 |
| Large      | Count    | 6 | 11| 2 | 29| 35| 83  |
|            | % of Row | 7.23| 13.25| 2.41| 34.94| 42.17| 100 |
| SME        | Count    | 5 | 1 | 2 | 10| 14| 32  |
|            | % of Row | 15.63| 3.13| 6.25| 31.25| 43.75| 100 |
| Micro      | Count    | 0 | 2 | 3 | 1 | 4 | 10  |
|            | % of Row | 0   | 20.00| 30.00| 10.00| 40.00| 100 |
Table 6. Descriptive statistics by control variables.

| Variable              | N  | Mean | StDev | Q1 | Median | Q3  |
|-----------------------|----|------|-------|----|--------|-----|
| **Size**              |    |      |       |    |        |     |
| Large                 | 83 | 3.92 | 1.28  | 1.00 | 4.00   | 4.00 |
| Small and Medium      | 32 | 3.84 | 1.44  | 1.00 | 3.25   | 4.00 |
| Micro                 | 10 | 3.70 | 1.25  | 2.00 | 2.75   | 3.50 |
| **Participant**       |    |      |       |    |        |     |
| Management            | 87 | 4.21 | 1.06  | 1.00 | 4.00   | 5.00 |
| Specialist            | 34 | 3.12 | 1.55  | 1.00 | 1.75   | 4.00 |
| Employee              | 4  | 3.25 | 1.50  | 2.00 | 2.00   | 3.00 |
| **Company sector**    |    |      |       |    |        |     |
| Industry              | 93 | 3.93 | 1.31  | 4.00 | 4.00   | 5.00 |
| Service               | 32 | 3.71 | 1.30  | 3.00 | 4.00   | 5.00 |

Note: (StDev)-standard deviation.

Better knowledge is also more visible in industry than in service companies (mean value of 3.93). In the case of employment participants, a higher knowledge about the concept is visible and was stated at the management level. The mean value of response was 4.21, while for the specialist and employees’ level the mean value was 3.12 and 3.25 respectively (Table 6 and Figure 5).

Verification of actual Industry 4.0 technologies implementation which are included in the pillars of the fourth industrial revolution were provided using medium values of answers to question A2: “Please specify which technologies are used in your company” (Figure 6). The blue line shows data for large companies, grey for SMEs, while orange for micro companies. Additionally, in that case, large companies evaluated results on a higher level. The interesting area of cybersecurity seems to be important regardless of the size of the enterprise. The other interesting subject is the use of additive manufacturing, which was higher for large companies than for medium, small, or micro companies. This confirms the thesis that 3D printing is much more often used, for example, for prototyping in larger companies. Artificial intelligence as well as augmented reality in surveyed companies is also on the low level, regardless of their size. The highest values (4.11) showed data for cybersecurity, mobile technologies, simulations, big data and analytics, integration of horizontal and vertical systems and cloud computing, see Table 7. Popular,
but rated below 3, were also RFID, Internet of Things—IoT, and additive manufacturing (see Figure 5).

![Figure 5. Industry 4.0 technologies actually implemented by company size.](image)

**Table 7. Descriptive statistics for A2.**

| Variable   | Description                                           | Mean  | Median | Mode | StDev | Total Count |
|------------|-------------------------------------------------------|-------|--------|------|-------|-------------|
| A2_1       | Big Data and analytics                                | 3.16  | 3.00   | 4    | 1.36  | 125         |
| A2_2       | Autonomous robots                                     | 2.65  | 2.00   | 1    | 1.50  | 125         |
| A2_3       | Simulation                                            | 3.24  | 4.00   | 4    | 1.41  | 125         |
| A2_4       | Integrat. of the horizontal and vertical syst.        | 3.15  | 3.00   | 3    | 1.18  | 125         |
| A2_5       | Internet of Things (IoT)                              | 2.96  | 3.00   | 3    | 1.37  | 125         |
| A2_6       | Cyber security                                        | 4.11  | 4.00   | 5    | 1.11  | 125         |
| A2_7       | Additive manufacturing (e.g., 3D printing)            | 2.96  | 3.00   | 1; 4 | 1.48  | 125         |
| A2_8       | Augmented reality                                     | 2.51  | 2.00   | 2    | 1.26  | 125         |
| A2_9       | Cloud computing                                       | 3.04  | 3.00   | 4    | 1.36  | 125         |
| A2_10      | Mobile technologies                                   | 3.73  | 4.00   | 4    | 1.22  | 125         |
| A2_11      | Artificial intelligence                               | 2.59  | 2.00   | 1    | 1.38  | 125         |
| A2_12      | Radio Frequency Identification (RFID)                 | 2.98  | 3.00   | 1; 4 | 1.48  | 125         |
| A2_13      | Real-time Location System (RTLS)                      | 2.57  | 2.50   | 1    | 1.34  | 125         |

The question regarding the integration of Industry 4.0 into strategy, mission, vision, and the question related to actual solution used by surveyed companies (fully automated warehouse operations, planning of transport activities, recruitment and personnel selection using digital technologies) were not compulsory questions. An average of 70% of the respondents answered these questions, see Table 8. The respondents tend not to use automated activities for warehouse management, which was confirmed by the lowest mean value of 2.488 and also a mode value of 2. The other variables were rated above 3 for the mean value and the most frequent answer of 4, which allows us to conclude that these items are most frequently used in the surveyed enterprises.
The management level from large companies found that Industry 4.0 is definitely integrated into their corporate strategy (mean value and median = 4), while the same group in micro and SME enterprises rated this item at a lower level (mean value and median = 3), see Figure 6. The contingency Table 9 shows the percentage of surveys with specific answers related to strategy integration with I4.0. The management in large companies in 81.25% found that Industry 4.0 concept is definitely integrated into their company strategy. The specialist level in those companies showed less certainty and in 34.29% chose the answer “rather yes”. The highest percentage of management in SME and micro companies (57.14% and 14.29% respectively) found that Industry 4.0 is unlikely to be integrated into their company strategy. The situation is similar for vision and mission—variable A4. Additionally, management level rates that level as above 3, and as well in large companies it is more common that digital technologies are incorporated into the mission and vision of enterprises (Figure 7).

Table 9. Contingency table for variable A3 by company size and employment level.

| Value | Measures       | Large | Micro | SME | Large | Micro | SME | Large | Micro | SME |
|-------|----------------|-------|-------|-----|-------|-------|-----|-------|-------|-----|
| 1     | Count          | 1     | 0     | 0   | 3     | 0     | 1   | 0     | 1     | 4   |
|       | % of Row       | 10    | 0     | 0   | 33.33 | 0     | 33.33 | 0     | 33.33 | 40  |
| 2     | Count          | 0     | 0     | 0   | 1     | 0     | 0   | 1     | 0     | 4   |
|       | % of Row       | 0     | 0     | 0   | 14.29 | 0     | 0   | 14.29 | 0     | 57.14 |
| 3     | Count          | 0     | 0     | 0   | 5     | 0     | 4   | 7     | 1     | 3   |
|       | % of Row       | 0     | 0     | 0   | 41.67 | 0     | 16.67 | 7     | 20.83 | 33.33 |
| 4     | Count          | 0     | 1     | 0   | 12    | 0     | 1   | 16    | 0     | 3   |
|       | % of Row       | 0     | 20.83 | 0   | 34.29 | 0     | 2.86 | 45.71 | 0     | 5.71 |
| 5     | Count          | 0     | 0     | 1   | 1     | 0     | 2   | 0     | 0     | 3   |
|       | % of Row       | 0     | 0     | 0   | 33.33 | 0     | 6.67 | 68.75 | 0     | 33.33 |
| All   | Count          | 1     | 1     | 0   | 21    | 0     | 6   | 37    | 5     | 17  |
|       | % of Row       | 1.14  | 1.14  | 0   | 23.86 | 0     | 6.82 | 42.05 | 5.68  | 19.32 |

Table 8. Descriptive statistic for A3–A7 variables.

| Variable                                                                 | Mean | Median | Mode | StDev | Total Count |
|--------------------------------------------------------------------------|------|--------|------|-------|-------------|
| A3—Our Company integrates digitalisation as part of the corporate strategy | 3.455| 4.000  | 4    | 1.212 | 88          |
| A4—Our mission and vision are in line with digital technologies           | 3.759| 4.000  | 4    | 1.141 | 87          |
| A5—Operations in our warehouses are fully automated                       | 2.488| 2.000  | 2    | 1.225 | 86          |
| A6—Transport activities are planned using digital technologies            | 3.116| 3.000  | 4    | 1.278 | 86          |
| A7—Our organisation uses digital technologies for the recruitment and selection of personnel | 3.023| 3.000  | 4    | 1.294 | 87          |
A multi-variable analysis was carried out to verify the connections and interactions between selected variables. Figure 8 shows the dependence of planning of transportation activities by using digital technologies (variable A6) of company size. A significantly higher score was rated for large enterprises and the lowest for small and medium-sized companies. The second chart shows the dependence of using cybersecurity technologies (variable A2,6) on the integration of digitalisation into corporate strategy (variable A3). Irrespective of the integration of digitalisation into the company strategy, cybersecurity solutions were rated around or higher than 3.

4.2. Future Plans for Technology Usage

The verification of future plans of evaluated companies was carried out on the basis of forecast usage of Industry 4.0 pillar technologies. A similar analysis was carried out for variables A2 which were dedicated for the actual situation. Table 10 shows the descriptive statistics in which cybersecurity is also rated at the highest level of mean value—4.05. The top three technologies which enterprises are planning to implement despite the cybersecurity are mobile technologies (3.77), and cloud commuting and simulations—both with mean values of 3.38.
Table 10. Descriptive statistic for F1 variables.

| Variable     | Description                                               | Mean  | Median | Mode | StDev | Total Count |
|--------------|-----------------------------------------------------------|-------|--------|------|-------|-------------|
| F1_1         | Big Data and analytics                                    | 3.35  | 3.00   | 3    | 1.18  | 125         |
| F1_2         | Autonomous robots                                         | 3.07  | 3.00   | 4    | 1.35  | 125         |
| F1_3         | Simulation                                                | 3.38  | 4.00   | 4    | 1.31  | 125         |
| F1_4         | Integration of the horizontal and vertical syst.           | 3.35  | 3.00   | 3    | 1.17  | 125         |
| F1_5         | Internet of Things (IoT)                                  | 3.24  | 3.00   | 3    | 1.24  | 125         |
| F1_6         | Cyber security                                            | 4.05  | 4.00   | 5    | 1.12  | 125         |
| F1_7         | Additive manufacturing (e.g., 3D printing)                | 3.21  | 3.00   | 3    | 1.39  | 125         |
| F1_8         | Augmented reality                                         | 3.06  | 3.00   | 3    | 1.18  | 125         |
| F1_9         | Cloud computing                                           | 3.38  | 3.00   | 3    | 1.29  | 125         |
| F1_10        | Mobile technologies                                       | 3.77  | 4.00   | 4    | 1.18  | 125         |
| F1_11        | Artificial intelligence                                   | 3.10  | 3.00   | 3    | 1.25  | 125         |
| F1_12        | Radio Frequency Identification (RFID)                     | 3.22  | 3.00   | 3    | 1.31  | 125         |
| F1_13        | Real-time Location System (RTLS)                          | 2.99  | 3.00   | 3    | 1.25  | 125         |

While large companies plan to implement cybersecurity solutions, small-, medium-, and micro-organisations plan to increase the implementation of mobile technologies. There is a significant decrease in the mean value for big data and autonomous robots—all company types changed responses for those variables—see Table 11 and Figure 9.

Table 11. Differences in mean values for A2 and F1 variables.

| Variable                                               | Large  | SME    | Micro  | All    |
|--------------------------------------------------------|--------|--------|--------|--------|
| Big Data and analytics                                  | -0.75  | -0.82  | -0.43  | -0.76  |
| Autonomous robots                                       | -0.46  | -0.98  | -1.40  | -0.66  |
| Simulation                                              | 0.23   | -0.10  | 0.29   | 0.14   |
| Integration of the horizontal and vertical system       | 0.17   | 0.17   | 0.40   | 0.20   |
| Internet of Things (IoT)                                | 0.15   | 0.12   | -0.50  | 0.09   |
| Cyber security                                          | 1.15   | 0.84   | 0.31   | 1.01   |
| Additive manufacturing (e.g., 3D printing)              | 0.36   | 0.11   | -0.52  | 0.23   |
| Augmented reality                                       | 0.15   | 0.10   | -0.19  | 0.11   |
| Cloud computing                                         | 0.10   | 1.14   | 1.40   | 0.42   |
| Mobile technologies                                     | 1.00   | 1.29   | 1.58   | 1.12   |
| Artificial intelligence                                 | 0.58   | 0.53   | 0.00   | 0.52   |
| Radio Frequency Identification (RFID)                   | 0.77   | 0.38   | 0.52   | 0.65   |
| Real-time Location System (RTLS)                        | 0.63   | 0.06   | 0.45   | 0.47   |

Figure 9. Industry 4.0 technologies planned for implementation by company size.

The planned increase of degree of automation (F2) over 3 to 5 years, the increase of digitalisation also over 3 to 5 years (F3), and the increase of capital expenditures related to
Industry 4.0 (F4) were assessed by 70% of survey participants with the mean value above 3. The increase of automation and digitalisation level with mode value of 4 proves that companies are considering changes related to new industry revolution (Table 12). The increase in automation and capital expenditure was assessed by micro companies with the mean value of 4, while small and medium-sized enterprises rated the same variables lower than other types of companies. Further statistics confirm that large companies plan to increase the level of digitalisation at a higher level than micro, small, or medium companies—Figure 10.

Table 12. Descriptive statistic for F1, F2, and F3 variables.

| Variable                                                                 | Mean | Median | Mode | StDev | Total Count |
|--------------------------------------------------------------------------|------|--------|------|-------|-------------|
| F2—Over the next 3–5 years, our Company plans to increase the degree of automation | 3.89 | 4.00   | 4    | 1.09  | 88          |
| F3—Over the next 3–5 years, our Company plans to significantly increase digitisation and computerisation | 3.86 | 4.00   | 4    | 1.04  | 87          |
| F4—Our Company plans to increase capital expenditure related to Industry 4.0 over the next five years | 3.48 | 2.00   | 3    | 1.13  | 86          |

Figure 10. Planned increase in: (a)—automation; (b)—digitalisation, (c)—capital expenditures.

4.3. Strength of Barriers Influence

Survey participants were asked to choose certain barriers or obstacles that could have an impact on their companies. Figure 11 shows histogram of data for the first three selected barriers: “B1—Customer requirements are too individualised to implement Industry 4.0”, “B2—We have too little standardisation to implement Industry 4.0”, and “B3—For us, the costs outweigh the benefits of Industry 4.0”. None of them were fully confirmed by surveyed participants. A similar approach can be seen in the case of variables representing barriers and fears related to employees—Figure 12. The participants do not fully agree with the following sentences BP4-7: “our employees are afraid of being dependent on Industry 4.0 technologies”, and “we expect that Industry 4.0 is not accepted by employees” as well as “we expect our employees to be unfamiliar with Industry 4.0” and “Industry 4.0 makes us lose our flexibility”. Nevertheless, the highest mean value of response of 2.97 and the mode value of 4 for variable BP6 (Table 13) could lead to the conclusion that participants are aware that employees might have a problem with understanding the key elements related to Industry 4.0, and even more, they could not understand the main principles and assumptions of the actual industrial revolution.
Figure 11. Histogram for barrier variables: (a) customer requirements—B1, (b) standardisation—B2, (c) costs—B3.

Figure 12. Histogram for barrier variables: (a) employee dependency—BP4, (b) employee acceptance—BP5, (c) employee unfamiliarity—BP6, (d) loss in flexibility—BP7.

Table 13. Descriptive statistic for BP4, BP5, BP6, and BP7 variables.

| Variable                                           | Mean | Median | Mode | StDev | Total Count |
|----------------------------------------------------|------|--------|------|-------|-------------|
| BP4—Our employees are afraid of being dependent on I4.0 technologies | 2.35 | 2      | 2    | 1.00  | 123         |
| BP5—We expect that I4.0 is not accepted by employees | 2.43 | 2      | 2    | 1.04  | 105         |
| BP6—We expect our employees to be unfamiliar with I4.0 | 2.97 | 3      | 4    | 1.23  | 102         |
| BP7—I4.0 makes us lose our flexibility, requiring expensive solutions | 2.05 | 2      | 2    | 0.83  | 102         |

Pearson correlation was used to verify the impact of mentioned barriers on actual usage of technological solutions and potential future implementation of I4.0 technology. Table 14 shows Pearson values calculated for actual usage vs. investigated barriers, such as “B1—Customer requirements are too individualised to implement Industry 4.0”, “B2—We have too little standardisation to implement Industry 4.0”, “B3—For us, the costs outweigh the benefits of Industry 4.0”, “BP4—Our employees are afraid of being dependent on Industry 4.0 technologies”, “BP5—We expect that Industry 4.0 is not accepted by employees”, “BP6—We expect our employees to be unfamiliar with Industry 4.0”, and “BP7—Industry 4.0 makes us lose our flexibility, requiring expensive solutions”. The data showed weak and moderately weak negative impacts on the applied technologies. The barriers definitely have a negative impact on the implementation...
of Industry 4.0 solutions, though with low to moderate strength at most. The lack of strong relationships between measured variables could lead to the conclusion that none of them stopped or limited the implementation of these solutions in the surveyed organisations.

Table 14. Correlation—Pearson value for barriers vs actual technologies implemented.

|     | B1   | B2   | B3   | BP4  | BP5  | BP6  | BP7  |
|-----|------|------|------|------|------|------|------|
| A2_1| −0.33| −0.32| −0.44| 0.00 | −0.17| −0.32| −0.13|
| A2_2| −0.14| −0.11| −0.22| −0.05| −0.09| −0.21| −0.10|
| A2_3| −0.26| −0.18| −0.27| −0.16| −0.24| −0.38| −0.17|
| A2_4| −0.29| −0.34| −0.31| −0.13| −0.24| −0.26| −0.13|
| A2_5| −0.29| −0.33| −0.45| 0.01 | −0.11| −0.21| −0.01|
| A2_6| −0.35| −0.40| −0.24| −0.10| −0.20| −0.08| −0.10|
| A2_7| −0.18| −0.02| −0.23| −0.01| −0.07| −0.25| −0.14|
| A2_8| −0.27| −0.20| −0.37| −0.13| −0.10| −0.36| −0.20|
| A2_9| −0.26| −0.30| −0.36| −0.20| −0.21| −0.40| −0.12|
| A2_10|−0.28| −0.23| −0.38| −0.16| −0.19| −0.30| −0.04|
| A2_11|−0.26| −0.32| −0.34| −0.14| −0.15| −0.25| −0.09|
| A2_12|−0.24| −0.20| −0.35| −0.01| −0.16| −0.15| −0.04|
| A2_13|−0.20| −0.19| −0.28| 0.03 | −0.09| −0.19| −0.09|

A similar analysis was carried out to review the impact of mentioned barriers on potential future implementation of I4.0 technology solution. Table 15 shows the results of Pearson value for correlation between barriers and future plans. For most of the data, the values represent a very weak or weak negative correlation between barriers and future plans for big data analytics and mobile technologies usage (Pearson value −0.50 and −0.51 respectively).

Table 15. Correlation—Pearson value for barriers vs. future plans.

|     | B1  | B2  | B3  | BP4 | BP5 | BP6 | BP7  |
|-----|-----|-----|-----|-----|-----|-----|------|
| F1_1| −0.50| −0.47| −0.51| 0.00| −0.13| −0.07| −0.08|
| F1_2| −0.29| −0.23| −0.39| 0.02| −0.03| −0.08| −0.06|
| F1_3| −0.39| −0.30| −0.34| −0.07| −0.11| −0.12| −0.15|
| F1_4| −0.46| −0.35| −0.41| −0.09| −0.05| −0.06| −0.19|
| F1_5| −0.42| −0.32| −0.47| 0.03 | −0.07| −0.12| −0.01|
| F1_6| −0.42| −0.45| −0.36| −0.02| −0.10| −0.02| −0.13|
| F1_7| −0.28| −0.28| −0.37| 0.05 | −0.01| −0.08| −0.06|
| F1_8| −0.39| −0.36| −0.40| −0.06| −0.07| −0.19| −0.11|
| F1_9| −0.42| −0.31| −0.40| −0.12| −0.16| −0.21| −0.10|
| F1_10|−0.51| −0.45| −0.51| −0.06| −0.12| −0.02| −0.09|
| F1_11|−0.40| −0.39| −0.36| −0.09| −0.09| −0.10| −0.04|
| F1_12|−0.25| −0.24| −0.38| 0.08 | −0.01| 0.00 | −0.02|
| F1_13|−0.29| −0.34| −0.42| 0.09 | −0.08| −0.07| −0.03|

The highest correlation was assessed for variables collected in Table 16. The highest negative value indicates correlation between costs (B3) as a barrier and “plans to increase capital expenditure related to Industry 4.0 over the next five years” (F4). The strongest positive correlation is shown by the actual usage and plans to implement RFID (A2_12; F1_12) and RTLS (A2_13; F1_13) technologies with Pearson values of 0.72 and 0.81 respectively. Employees’ fear of being dependent on I4.0 technologies (BP4) has a strong positive correlation with the BP5 variable—the expectation that I4.0 will not be accepted by employees, which may lead to the conclusion that the employees’ fear of being dependent on modern technologies may lead to significant barriers and limitations in understanding the idea of Industry 4.0 and changes implemented in the enterprise. A strong positive impact was
found in the case of F2 variable—the increase in the degree of automation, and F3—the increase of digitalisation and computerisation, on the F4 variable—the increase of capital expenditure related to Industry 4.0. The enterprises which also plan to develop their technologies and improve operational processes in the next 5 years will invest in Industry 4.0. The research also proves that companies that use Internet of Things—IoT (A2_5) also point to big data and analytics (A2_1) as a method of analysing and using the collected data. The integration of vertical and horizontal systems (A2_4) also has a strong positive correlation with IoT.

Table 16. Correlation with highest values.

| Variable 1 | Variable 2 | Pearson Value |
|------------|------------|---------------|
| B3         | F4         | −0.71         |
| BP5        | BP4        | 0.74          |
| F2         | F4         | 0.74          |
| F3         | F4         | 0.73          |
| A2_1       | A2_5       | 0.71          |
| A2_4       | A2_5       | 0.71          |
| A2_12      | A2_13      | 0.72          |
| A2_2       | F1_2       | 0.75          |
| A2_3       | F1_3       | 0.74          |
| A2_6       | F1_6       | 0.70          |
| A2_7       | F1_7       | 0.75          |
| A2_11      | F1_11      | 0.71          |
| A2_12      | F1_12      | 0.80          |
| F1_2       | F1_12      | 0.70          |
| F1_3       | F1_4       | 0.77          |
| F1_8       | F1_13      | 0.70          |
| F1_12      | F1_13      | 0.81          |

Interesting results were obtained from the correlation analysis of the variables related to actual used technologies and future plans for technology implementation. The variables such as using autonomous robots (A2_2), simulations (A2_3), cybersecurity (A2_6) and additive manufacturing (A2_7), artificial intelligence (A2_11), and radio frequency technologies—RFID (A2_12) also showed strong positive correlations (with Pearson value between 0.70 and 0.80) with future implementation or continuation of the same technology. Regarding the plans for technology implementation, strong correlations were found between the future usage of autonomous robots (F1_2) and RFID tools (F1_12). Both technologies are complementary in warehouse operations and broadly understood logistics. Similarities can be seen in the case of plans to implement augmented reality (F1_8) and Real-time Location System (RTLS) technologies (F1_13), which are similarly characterised by complementarity.

4.4. Cooperation Influence

Surveyed participants had an opportunity to share information regarding their company’s plans for future inter-organisational cooperation in partnerships in the implementation of new technology. Three statements were mentioned in the survey: “C1—We are looking for a partner who will help us implement I4.0 solutions”, “C2—we need to find a partner who will help us implement I4.0 solutions”, “C3—we plan to find a partner to help us implement I4.0 solutions”, and generally “C4—we plan to implement Industry 4.0” provide us knowledge about the needs and future plans for technological solutions implementation. Table 17 shows quantity of collected samples depending on each question and their percentage in total answers.
Table 17. Number of samples collected for C.

|     | C1 Count |  | %   | C2 Count |  | %   | C3 Count |  | %   | C4 Count |  | %   |
|-----|----------|---|-----|----------|---|-----|----------|---|-----|----------|---|-----|
| 1   | 7        |  | 6.60 | 1        | 4 | 7.14 | 1        | 3 | 5.45 | 1        | 2 | 2.74 |
| 2   | 25       |  | 23.58| 2        | 3 | 5.36 | 2        | 2 | 3.64 | 2        | 5 | 6.85 |
| 3   | 49       |  | 46.23| 3        | 15| 26.79| 3        | 17| 30.91| 3        | 9 | 12.33|
| 4   | 18       |  | 16.98| 4        | 13| 23.21| 4        | 11| 20.00| 4        | 36| 49.32|
| 5   | 7        |  | 6.60 | 5        | 21| 37.50| 5        | 22| 40.00| 5        | 21| 28.77|

N = 106  
N = 56  
N = 55  
N = 73

Confirmation for statement “C1—We are looking for a partner who will help us implement I4.0 solutions” was indicated by 23.58% of the surveyed companies, while 30.18% had a negative opinion on that subject. The vast majority indicated that they plan to find a partner to help implement I4.0 solutions (C3)—60.00%. The statement “C2—We need to find a partner who will help us implement I4.0 solutions” also received high positive results. Of the respondents, 60.71% confirmed their needs in the examined aspects. Over 78% of companies admitted that they plan to implement Industry 4.0 in the future (C4). The presented data might lead to the conclusion that the organisations and institutions which could help in the implementation process have a potential area to create new partnership, even if there is a certain group of organisations which is not interested in implementing new industry solutions even with help from external partners.

Table 18 shows correlation between barriers and partnership statements. A negative correlation is noticeable. All the mentioned barriers do not support activities related to cooperation with external partners. The higher score was obtained for costs (B3) and customer requirements (B1) indicating a moderately negative impact on future partnerships as well as on the I4.0 implementation itself.

Table 18. Correlation—Pearson value for barriers vs partnership.

|          | B1   | B2   | B3   | BP4  | BP5  | BP6  | BP7  |
|----------|------|------|------|------|------|------|------|
| C1—We are looking for a partner who will help us implement I4.0 solutions | −0.28 | 0.09 | −0.17 | 0.12 | 0.22 | 0.23 | 0.02 |
| C2—We need to find a partner who will help us implement I4.0 solutions | −0.34 | −0.23 | −0.38 | 0.14 | 0.10 | 0.13 | −0.04 |
| C3—We plan to find a partner to help us implement I4.0 solutions | −0.53 | −0.41 | −0.57 | −0.07 | −0.11 | −0.14 | −0.30 |
| C4—We plan to implement Industry 4.0 | −0.44 | −0.25 | −0.49 | 0.14 | 0.04 | −0.05 | −0.10 |

The above analysis, included in Table 19, confirms a positive moderate correlation between I4.0—C4 implementation plan and the need to find a partner who will support the organisation in its transformation. A stronger correlation can be seen between the need to have a partner and plans to find partnership. In order to perform deeper investigation of future plans for Industry 4.0 technologies, the authors used Multi-Variable analysis presented at Figure 13 together with mean value for C1, C2, and C3 in relation to C4—Table 20. Both results support the abovementioned statement—companies that plan to implement I4.0 technologies chose confirmation of needs and planned to find inter-organisational partnership.

Table 19. Correlation—Pearson value for Partnership vs. Implementation plans.

|     | C1   | C2   | C3   |
|-----|------|------|------|
| C2  | 0.434|      |      |
| C3  | 0.284| 0.731|      |
| C4  | 0.471| 0.534| 0.18 |
Table 20. Mean value for C1, C2, and C3 in relation to C4.

| C4 | C1    | C2    | C3    |
|----|-------|-------|-------|
| 1  | 1.00  | 1.00  | 3.0   |
| 2  | 1.80  | 3.50  | 3.50  |
| 3  | 2.85  | 3.33  | 3.50  |
| 4  | 3.16  | 4.25  | 3.91  |
| 5  | 3.31  | 3.14  | 4.3   |

Table 21 shows a positive correlation of cooperation statements versus future technologies F2_1–F2_13 of moderate strength. The highest values were reached by the correlation between having a partner (C1) and Internet of Things (IoT) F2_5 and F2_10—Mobile technologies.

Table 21. Correlation—Pearson value for partnership vs future technology use.

| F2_1 | F2_2 | F2_3 | F2_4 | F2_5 | F2_6 | F2_7 | F2_8 | F2_9 | F2_10 | F2_11 | F2_12 | F2_13 |
|------|------|------|------|------|------|------|------|------|-------|-------|-------|-------|
| C1   | 0.19 | 0.27 | 0.14 | 0.22 | 0.27 | 0.16 | 0.04 | 0.20 | 0.15  | 0.21  | 0.10  | 0.28  | 0.20  |
| C2   | 0.08 | 0.10 | 0.22 | 0.14 | 0.26 | 0.19 | 0.19 | 0.18 | 0.00  | 0.26  | 0.11  | 0.20  | 0.21  |
| C3   | 0.22 | 0.10 | 0.22 | 0.26 | 0.36 | 0.27 | 0.28 | 0.27 | 0.14  | 0.38  | 0.33  | 0.31  | 0.33  |
| C4   | 0.29 | 0.29 | 0.06 | 0.18 | 0.18 | 0.33 | 0.22 | 0.23 | 0.11  | 0.24  | 0.20  | 0.18  | 0.17  |

Figure 14 below shows the dependence between planned future technologies and chosen answers for statement C1—“We are looking for a partner who will help us implement 4.0 solutions”. Those companies which look for partnership in the area of new technology implementation confirmed future plans to implement solutions, such as big data and analytics, autonomous robots, Internet of Things (IoT), cloud computing, mobile technologies, and RFID tools. As stated in the previous analyses, cybersecurity is implemented regardless of the company size, area of operation, and, according to this analysis, regardless of plans for inter-organisational partnership. Additionally, additive manufacturing is a technology which is not related to plans for partnership.
Figure 14. Multi-variable analysis for C1 and F1_1–F1_13.
5. Discussion and Conclusions

5.1. Summary of Main Research Results

This research presented results from a survey study on the usage of Industry 4.0 technologies during COVID-19. Two main research areas were defined: the relationship and its strength between selected barriers and the level of individual Industry 4.0 technologies implementation level; relationship between inter-organisational partnership in Industry 4.0 and the level of technology implementation. Those objectives were supported by three hypotheses. The reported results are as follows:

- There is a moderate positive correlation between cooperation in the field of Industry 4.0 and future implementation of Industry 4.0 individual technological solutions. Specifically, the technologies, such as big data and analytics, cloud computing, IoT, and mobile technologies are directly related to Industry 4.0 future plans. It is also a fact that specific Industry 4.0 technologies are implemented by organisations regardless of cooperation with the external parties or other partnerships, i.e., cybersecurity or additive manufacturing.

- Barriers, such as too-individualised customer requirements, insufficient standardisation, costs, and lack of employee’s acceptance, affect the implementation of individual Industry 4.0 solutions with varying intensity. An obvious negative correlation between barriers and technology implementation was confirmed; nevertheless, its strength varies from low to moderate. The lack of strong relationship between measured variables could lead to the conclusion that none of them could stop or limit the implementation of these solutions in the surveyed organisations.

- Barriers, such as too-individualised customer requirements, insufficient standardisation, costs, and lack of employee’s acceptance, affect the cooperation in the field of Industry 4.0. A negative correlation between them was confirmed. All mentioned barriers do not support activities related to cooperation with external partners.

The above results allowed the development of theoretical and practical implications.

5.2. Theoretical Contribution

The presented results of the pilot study contribute to the theory of Industry 4.0 and cover a certain gap mentioned in the subject literature [36,44]: “future research on the Industry 4.0 subject needs to analyse variability of readiness and practice across industries and nations, barriers of implementation and also subjects as usage of specific Industry 4.0 technologies in certain industry sectors” [36]. The presented work fills this gap by removing limitations related to the type and size of the enterprise and the sector of activity. The pilot research trial allowed obtaining preliminary information on the use of Industry 4.0 solutions in the era of pandemic restrictions. This research also confirmed the results of Türkes et al., 2019 [47] in Romania, where 80% of respondents had a knowledge about Industry 4.0, as well as the research of Ślusarczyk [52]. In this research, the authors stated that 74.4% of respondents were familiar with the concept of Industry 4.0. A significantly higher degree of knowledge was found among big enterprises and at a higher management level. Regarding the area of partnership and cooperation for implementation of Industry 4.0 technical solution, the authors also confirmed the results of Türkes et al., 2019 [47], where around 24% of managers sought partnerships to implement new technologies, while 26% already had a partnership. The study results confirm this status with 24% of surveyed companies that admitted partnership. Of the received answers to the question related to a plan to find a partner (C3), 60% were positive. Presented data may lead to the conclusion that the organisations and institutions, which could help in the implementation process, have a potential area to create new partnerships even if there is a certain group of organisations which are convinced of their own knowledge and competencies in subject matter. Barriers, especially costs, negatively affect partnerships but there also exist plans to increase capital expenditure related to Industry 4.0 over the next five years. The results also confirm that activities which induce the organisation to engage in external cooperation and support or improve employee competencies in the field of Industry 4.0 also lead the
organisation to a higher level of implementation of Industry 4.0 solutions. In this case, knowledge management becomes another crucial subject regarding the implementation of the latest solutions [53].

The presented results regarding exact technologies chosen by organisations, especially during the pandemic, showed that regardless of the company type and size, cybersecurity and mobile technologies are implemented as the first choice and are continuously the subject of future development. In recent years, both of them became the core technologies and requirements for daily company operations. The research also confirms that companies which use the Internet of Things also point out the big data and analytics as a method of analysing and using the collected data. The integration of vertical and horizontal systems also showed a strong positive correlation with IoT. Technologies, such as autonomous robots, simulations, cybersecurity, additive manufacturing, artificial intelligence, and radio frequency technologies have a similar strong positive correlation with future implementation or continued development of the same technology. The future use of autonomous robots is also positively correlated with RFID tools. This could lead to the conclusion that certain technologies are planned to be used at the same time in the future. Generally, new investments and future developments in digitisation were confirmed by big enterprises. Importantly, the managers state that digitisation is embedded in their company’s strategy and policy.

5.3. Practical Contribution

The practical implication of this study needs to focus on four specified barriers selected as the most important by surveyed enterprises: customer requirements, insufficient standardisation, costs, and lack of employee acceptance. The positive aspect is that the surveyed participants are aware that employees might have a problem with understanding the key items related to Industry 4.0; even more, they could not understand the main principles and assumptions of actual industrial revolution. Being aware of this state of affairs can help to overcome this barrier. Another aspect is the focus on expenses while, in general, SMEs are more focused on operational activities in this regard [18,36]. As investments in new technologies can in turn lead to financial backlogs and further complications, employees from those enterprises can see some benefits for their daily operational work. The practical implications for organisations and institutions, which provide support and partnership to successfully implement new technologies, can provide information regarding a certain percentage of organisations that seek this type of cooperation or are open to it. Additionally, by providing information regarding what complementary technologies will be used by organisations in the future, providers of new technological solutions receive comprehensive information about the market potential.

5.4. Limitations and Further Studies

The used research methodology provided an opportunity to collect information from various enterprises, sectors, and from each of employment level of the organisations, and thus the collected data represent a wide scope. The used analytics presented detailed results related to knowledge of the Industry 4.0 term, barriers which interfere with the implementation of the specific pillar’s technology, and cooperation plans and needs. For future research it would be interesting to consider a specific industry and a specific group of actors in an organisation in order to obtain homogeneous data. The limitations of this research include the fact that surveyed companies in the vast majority are Polish companies, and the results thus showed an uneven distribution of data. Further research should be carried out on a larger research sample. The results do not include the economic situation of individual countries. Other studies in terms of objectives analysed in this study may lead to different results and conclusions, especially due to the fact that the survey’s participants were anonymous and represented companies that do not have any connections with manufacturing or studied technologies.
Future research objectives should include wider research on the use of the latest technologies, especially in small and medium-sized organisations, as well as research on the barriers and factors that lead to successful implementation of Industry 4.0 solutions.

**Author Contributions:** Conceptualization, A.M. and J.K.; methodology, A.M. and J.K.; validation, A.M.; formal analysis, J.K.; investigation, A.M.; writing—original draft preparation, J.K.; writing—review and editing, A.M.; visualization, J.K.; supervision, A.M.; project administration, A.M.; funding acquisition, A.M. All authors have read and agreed to the published version of the manuscript.

**Funding:** This paper was published with the research funds of the Faculty of Organization and Management of the Silesian University of Technology.

**Institutional Review Board Statement:** Not applicable.

**Informed Consent Statement:** Not applicable.

**Data Availability Statement:** Data are contained within the article.

**Conflicts of Interest:** The authors declare no conflict of interest. The founders had no role in the design of the study, in the collection, analyses, or interpretation of data; in the writing of the manuscript, or in the decision to publish the results.

**References**

1. European Industrial Strategy. Available online: https://ec.europa.eu/info/strategy/priorities-2019-2024/europe-fit-digital-age/european-industrial-strategy_en (accessed on 25 April 2022).
2. In-Depth Reviews of Strategic Areas for Europe’s Interests. Available online: https://ec.europa.eu/info/strategy/priorities-2019-2024/europe-fit-digital-age/european-industrial-strategy/depth-reviews-strategic-areas-europes-interests_en (accessed on 25 April 2022).
3. Kiel, D.; Müller, J.M.; Arnold, C.; Voigt, K.I. Sustainable industrial value creation: Benefits and challenges of Industry 4.0. *Int. J. Innov. Manag.* 2017, 21, 1740015. [CrossRef]
4. Durana, P.; Kral, P.; Stehel, V.; Lazaroiu, G.; Sroka, W. Quality Culture of Manufacturing Enterprises: A Possible Way to Adaptation to Industry 4.0. *Soc. Sci.* 2019, 8, 124. [CrossRef]
5. Müller, J.M.; Voigt, K.-I. Sustainable Industrial Value Creation in SMEs: A Comparison between Industry 4.0 and Made in China 2025. *Int. J. Precis. Eng. Manuf. Green Tech.* 2018, 5, 659–670. [CrossRef]
6. Müller, J.M.; Kiel, D.; Voigt, K.-I. What Drives the Implementation of Industry 4.0? The Role of Opportunities and Challenges in the Context of Sustainability. *Sustainability* 2018, 10, 247. [CrossRef]
7. Jahani, N.; Sepehri, A.; Vandchali, H.R.; Tirkolaee, E.B. Application of Industry 4.0 in the Procurement Processes of Supply Chains: A Systematic Literature Review. *Sustainability* 2021, 13, 7520. [CrossRef]
8. Arnold, C.; Veile, J.W.; Voigt, K.-I. What Drives Industry 4.0 Adoption? An Examination of Technological, Organizational and Environmental Determinants. In Proceedings of the IAMOT 2018 Conference Proceedings, Birmingham, UK, 22–26 April 2018; pp. 1–19.
9. Wagire, A.A.; Joshi, R.; Rathore, A.P.S.; Jain, R. Development of Maturity Model for Assessing the Implementation of Industry 4.0: Learning from Theory and Practice. *Prod. Plan. Control.* 2021, 32, 603–622. [CrossRef]
10. Basl, J. Pilot Study of Readiness of Czech Companies to Implement the Principles of Industry 4.0. In *Proceedings of the 19th International Conference on Production Economics, June 25–26, 2018, Szeged, Hungary*. 2018; Volume 1, pp. 1–10. [CrossRef]
11. Fitsilis, P.; Tsotitsa, P.; Gerogiannis, V. Industry 4.0: Required Personnel Competences. *Industry* 2018, 3, 130–133.
12. Hernandez-de-Menendez, M.; Morales-Menendez, R.; Escobar, C.A.; McGovern, M. Competencies for Industry 4.0. *Int. J. Interact. Des. Manuf.* 2020, 14, 1511–1524. [CrossRef]
13. Issa, A.; Hatiboglu, B.; Bildstein, A.; Bauerhansl, T. Industrie 4.0 Roadmap: Framework for Digital Transformation Based on the Concepts of Capability Maturity and Alignment. *Procedia CIRP* 2018, 72, 973–978. [CrossRef]
14. Kamble, S.S.; Gunasekaran, A.; Gawankar, S.A. Sustainable Industry 4.0 Framework: A Systematic Literature Review Identifying the Current Trends and Future Perspectives. *Process Saf. Environ. Prot.* 2018, 117, 408–425. [CrossRef]
15. What Is Industrie 4.0? Available online: https://www.plattform-i40.de/IP/Navigation/EN/Industrie40/WhatIsIndustrie40/what-is-industrie40.html (accessed on 25 April 2022).
16. 2030 Vision. Available online: https://www.plattform-i40.de/IP/Navigation/EN/Industrie40/Vision/vision.html (accessed on 25 April 2022).
17. Przemysł 4.0—Czym Jest Czwarta Rewolucja Przemysłowa? Available online: https://przemyslpoczyszlosci.gov.pl/tag/przemysl-4-0/ (accessed on 25 April 2022).
18. Michna, A.; Kmieciak, R. Open-Mindedness Culture, Knowledge-Sharing, Financial Performance, and Industry 4.0 in SMEs. *Sustainability* 2020, 12, 9041. [CrossRef]
19. Li, D.; Fast-Berglund, Å.; Paulin, D. Current and Future Industry 4.0 Capabilities for Information and Knowledge Sharing. *Int. J. Adv. Manuf. Technol.* 2019, 105, 3951–3963. [CrossRef]

20. Zamani, R.; Moghaddam, M.P.; Haghifam, M.-R. Dynamic Characteristics Preserving Data Compressing Algorithm For Transaction Energy Management Frameworks. *IEEE Trans. Ind. Inform.* 2022. [CrossRef]

21. Erboz, G. How to Define Industry 4.0: The Main Pillars Of Industry 4.0. In Proceedings of the 7th International Scientific Conference on Managerial Trends in the Development of Enterprises in Globalization Era (ICoM), Nitra, Slovakia, 1–2 June 2017; pp. 761–767.

22. Mahmud, M.S.; Huang, J.Z.; Salloum, S.; Emara, T.Z.; Sadatiyinov, K. A Survey of Data Partitioning and Sampling Methods to Support Big Data Analysis. *Big Data Min. Anal.* 2020, 3, 85–101. [CrossRef]

23. Cui, Y.; Kara, S.; Chan, K.C. Monitoring and Control of Unstructured Manufacturing Big Data. In Proceedings of the 2020 IEEE International Conference on Industrial Engineering and Engineering Management (IEEM), Singapore, 14–17 December 2020; pp. 928–932.

24. Barbie, A.; Hasselbring, W.; Pech, N.; Sommer, S.; Flögel, S.; Wenzhofer, F. Prototyping Autonomous Robotic Networks on Different Layers of RAMI 4.0 with Digital Twins. In Proceedings of the 2020 IEEE International Conference on Multisensor Fusion and Integration for Intelligent Systems (MFI), Karlsruhe, Germany, 14–16 September 2020; pp. 1–6.

25. Hoffa-Dabrowska, P.; Grzybowska, K. Simulation Modeling of the Sustainable Supply Chain. *Sustainability* 2020, 12, 6007. [CrossRef]

26. Kádáróvá, J.; Trebuná, P.; Lachvajderová, L. Model for Optimizing the Ratios of the Company Suppliers in Slovak Automotive Industry. *Sustainability* 2021, 13, 11597. [CrossRef]

27. Kliment, M.; Pekarčíková, M.; Trebuna, P.; Trebuná, M. Application of TestBed 4.0 Technology within the Implementation of Industry 4.0 in Teaching Methods of Industrial Engineering as Well as Industrial Practice. *Sustainability* 2021, 13, 8963. [CrossRef]

28. Miskiewicz, R.; Wolniak, R. Practical Application of the Industry 4.0 Concept in a Steel Company. *Sustainability* 2020, 12, 5776. [CrossRef]

29. Ondov, M.; Rosova, A.; Sofranko, M.; Feher, J.; Cambal, J.; Fecková Skrabuláková, E. Redesigning the Production Process Using Simulation for Sustainable Development of the Enterprise. *Sustainability* 2022, 14, 1514. [CrossRef]

30. Pekarčíková, M.; Trebuná, P.; Kliment, M.; Dic, M. Solution of Bottlenecks in the Logistics Flow by Applying the Kanban Module in the Tecnomatix Plant Simulation Software. *Sustainability* 2021, 13, 7989. [CrossRef]

31. Lučeki, V.; Varela, L.; Machado, J. Simulation of Vertical and Horizontal Integration of Cyber-Physical Systems. In Proceedings of the 2020 7th International Conference on Control, Decision and Information Technologies (CoDIT), Prague, Czech Republic, 29 June–2 July 2020; pp. 282–287.

32. Konstantinidis, F.K.; Mouroutos, S.G.; Gasteratos, A. The Role of Machine Vision in Industry 4.0: An Automotive Manufacturing Perspective. In Proceedings of the 2021 IEEE International Conference on Imaging Systems and Techniques (IST), Kaohsiung, Taiwan, 24–26 August 2021; pp. 1–6.

33. Mullet, V.; Sondi, P.; Ramat, E. A Review of Cybersecurity Guidelines for Manufacturing Factories in Industry 4.0. *IEEE Access* 2021, 9, 23235–23263. [CrossRef]

34. Kalhara, D.; De Alwis, U.; Jinadasa, A.; Randunu, D.; Nuwanthika, W.S.; Abeygunawardhana, P.K.W. Comprehensive Security Solution for an Industry 4.0 Garment Manufacturing System. In Proceedings of the 2021 3rd International Conference on Artificial Intelligence and Computer Engineering (ICAICE), Colombo, Sri Lanka, 9–11 December 2021; pp. 67–72.

35. Tirkolaee, E.B.; Sadeghi, S.; Mooseloo, F.M.; Vandchali, H.R.; Aeini, S. Application of Machine Learning in Supply Chain Management: A Comprehensive Overview of the Main Areas. *Math. Probl. Eng.* 2021, 2021, 1476043. [CrossRef]

36. Moghos, M.F.; Eleftheriadis, R.J.; Myklebust, O. Enablers and Inhibitors of Industry 4.0 Readiness and Practice: A SME Perspective with Empirical Evidence. In Proceedings of the 52nd Hawaii International Conference on System Sciences, Maui, HI, USA, 8–11 January 2019; Volume 6, pp. 5155–5164.

37. Essakly, A.; Wichmann, M.; Spengler, T.S. A Reference Framework for the Holistic Evaluation of Industry 4.0 Solutions for Small-and Medium-Sized Enterprises. *IFAC-PapersOnLine* 2019, 52, 427–432. [CrossRef]

38. Vuksončič Herceg, I.; Kuč, V.; Mijušković, V.M.; Herceg, T. Challenges and Driving Forces for Industry 4.0 Implementation. *Sustainability* 2020, 12, 4208. [CrossRef]

39. Kliment, M.; Pekarcikova, M.; Trebuna, P.; Trebuna, M. Application of TestBed 4.0 Technology within the Implementation of Industry 4.0 in Teaching Methods of Industrial Engineering as Well as Industrial Practice. *Sustainability* 2021, 13, 8963. [CrossRef]

40. Veile, J.W.; Kiel, D.; Müller, J.M.; Voigt, K.-L. Lessons Learned from Industry 4.0 Implementation in the German Manufacturing Industry. *JMTM* 2019, 31, 977–997. [CrossRef]

41. Khazieva, N.; Kovalev, A.; Caganova, D. Does Industry 4.0 Require Business Model Innovation? In Proceedings of the International Conference Theory and Applications in the Knowledge Economy, Poznan, Poland, 11–13 July 2018; pp. 49–58.

42. Kabowska, S. Model Biznesu 4.0. *Architektura, Tworzenie Wartości, Ocena Konkurencyjności i Efektywności*; TNOiK: Torun, Poland, 2021.

43. Karamitsos, I.; Apostolopoulos, C.; Bugami, M.A. Benefits Management Process Complements Other Project Management Methodologies. *JSEA* 2010, 3, 839–844. [CrossRef]

44. Müller, J.M. Assessing the Barriers to Industry 4.0 Implementation from a Workers’ Perspective. *IFAC-PapersOnLine* 2019, 52, 2189–2194. [CrossRef]
45. Horváth, D.; Szabó, R.Z. Driving Forces and Barriers of Industry 4.0: Do Multinational and Small and Medium-Sized Companies Have Equal Opportunities? Technol. Forecast. Soc. Change 2019, 146, 119–132. [CrossRef]

46. Michna, A.; Kmiecik, R.; Czerwińska-Lubszczyn, A. Dimensions of Intercompany Cooperation in the Construction Industry and Their Relations to Performance of SMEs. Eng. Econ. 2020, 31, 221–232. [CrossRef]

47. Türkeş, M.; Oncioul, I.; Aslam, H.; Marin-Pantelescu, A.; Topor, D.; Capusneanu, S. Drivers and Barriers in Using Industry 4.0: A Perspective of SMEs in Romania. Processes 2019, 7, 153. [CrossRef]

48. Michna, A.; Kruszewska, J. Industry 4.0 Solution Implementation Factors: Driving Forces, Barriers and Chances. Planned Research of SME. In Sustainable Economic Development and Advancing Education Excellence in the Era of Global Pandemic, Proceedings of the 36th International Business Information Management Association (IBMIA), Cordoba, Spain, 4–5 November 2020; IBIMA: King of Prussia, PA, USA, 2020; pp. 13924–13927.

49. Bajic, B.; Rikalovic, A.; Suzic, N.; Piuri, V. Industry 4.0 Implementation Challenges and Opportunities: A Managerial Perspective. IEEE Syst. J. 2021, 15, 546–559. [CrossRef]

50. Michna, A.; Kmiecik, R.; Kruszewska, J. Industry 4.0 Implementation in Automotive Sector: Driving Forces, Barriers and Competencies. Pilot Empirical Study. In Proceedings of the 38th International Business Information Management Association (IBMIA), Seville, Spain, 23–24 November 2021; pp. 9444–9450, ISBN 978-0-9998551-7-1.

51. Michna, A.; Kruszewska, J. Driving Forces, Barriers and Competencies in Industry 4.0 Implementation. In Proceedings of the 37th International Business Information Management Association (IBMIA), Cordoba, Spain, 30–31 May 2021; pp. 11112–11117.

52. Ślusarczyk, B. Industry 4.0—Are We Ready? PJMS 2018, 17, 232–248. [CrossRef]

53. Michna, A.; Brzostek, K.; Kmiecik, R. Zarządzanie Wiedzą Małego i Średniego Przedsiębiorstwa w Warunkach Orientacji Rynkowej—Zależności, Modele i Utwarunkowania Organizacyjne; Wydawnictwo Politechniki Śląskiej: Gliwice, Poland, 2020.