
Adaptation of Polish Enterprises to Industry 4.0 Model

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Abstract:

Purpose: The aim of the paper is to present results of empirical research on adjustment of industrial enterprises in Poland to the conditions of Industry 4.0

Design/Methodology/Approach: Based on the analysis of the literature on the subject, the main features of the Industry 4.0 model were determined and then the main dimensions of empirical research were designed. The questionnaire survey covered 100 industrial enterprises from 19 industries operating throughout Poland. The questions were closed questions, related to the 1-5 (Likert) scale, and the 0-1 scale.

Findings: Adaptations of enterprises to Industry 4.0 were sought in 6 dimensions: 1/ changes in industrial manufacturing paradigms, 2/ changes in manufacturing technologies, 3/ changes in Information and Communication Technologies, 4/ changes in human capital, 5/ changes in supporting processes, 6/ changes in enterprise agility. Considering technical infrastructure, manufacturing technologies, information technologies and the integration of these technologies, the potential close to Industry 4.0 has only a dozen or so percent of the surveyed companies.

Research limitations / implications: Only large and medium-sized enterprises were included in the research, as the pilot study indicated problems related to the low level of knowledge and understanding of the topic among small business owners. Moreover, this article is mainly limited to the presentation of quantitative data on the structure and frequency of phenomena.

Practical Implications: The results of the study show the gap between the current state of industrial development in Poland and the global level determined by the Industry 4.0 model. This may be helpful in shaping the directions of raising the competitiveness of Polish enterprises.

Originality/Value: Partial research results on changing industrial manufacturing paradigms and adapting maintenance systems to Industry 4.0 were published in 2020 by Pawłowski K. (2020), Pawłowski E. (2020), Trzcielinski S. (2020). This article is the first synthesis of the whole research.

Keywords: Industry 4.0, enterprise adaptation.

JEL Classification: M2, L6.

Paper Type: Research article.

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1. Introduction

The development of the company can be analyzed from different points of view. The trend of strategic management, which emerged in the 60s and 70s of the twentieth century, introduced a paradigm of adapting the company to its environment in the macro dimension (economic, legal, social, and technological) and in the micro dimension - the adjustment to the competitive environment.

Adaptation in the technological dimension has also become a competitive challenge in relation to the third and fourth phases of the industrial revolution. The concept of Industry 4.0 appeared formally in 2011, the first publication in 2012, more than 100 publications in 2014, 1200 publications in 2017 (Krdzalic and Hodzic, 2019), and in 2019 almost 4000 publications (according to Scopus database). In 2015, PwC surveyed 2,000 companies from 26 countries in the industrial production sectors. In this Global Industry 4.0 survey, 30% of companies had already achieved advanced levels of integration and digitization, and 72 percent expected to reach that point by 2020 (Geissbauer, Vedso, and Schrauf, 2016). The concept of Industry 4.0 is developing so rapidly that it is now a paradigm of industrial development in both theory and practice of management.

In this context, in 2019, at the Faculty of Management Engineering of the Poznan University of Technology, a long-term research project has been launched entitled "Management in Industry 4.0 (No: 11/145/SBAD/2952)".

The subjects of the research are:

1. Changes in company paradigms,
2. Base and development technologies Enterprise 4.0,
3. Reactivity of the Enterprise 4.0,
4. Agile Systems,
5. Management of processes and resources of Enterprise 4.0.

The aim of the research is to identify, analyze and evaluate the adjustment of the Polish industry to Industry 4.0 model. The first empirical study was conducted in early 2020. Partial results from this research on, changing industrial manufacturing paradigms, adapting maintenance systems, and changing human capital in the context of Industry 4.0 were published in 2020 by Pawłowski K. (2020), Pawłowski E. (2020), Trzcielinski S. (2020a; 2020b). This article is the first synthesis of the whole research.

2. Literature Review

2.1 Conceptual Scope of Industry 4.0

The final phase of the industrial revolution associated with the concept of Industry 4.0 began back in the late 20th century, although the name formally emerged in 2011. The characteristics of Industry 4.0 and the 4.0 enterprise have evolved over the years. Most definitions emphasize the development of information technologies and their integration into production systems. According to Geissbauer, Vedso, and Schrauf (2016), the

term Industry 4.0 refers to the combination of several major innovations in digital technology, all coming to maturity right now, all poised to transform the energy and manufacturing sectors. The main components of Industry 4.0 technology are listed as (Brunelli *et al.*, 2017):

1. Advanced robots (autonomous, cooperating industrial robots),
2. Additive manufacturing (3D printers, used predominantly to make spare parts and prototypes),
3. Augmented reality (, which facilitates maintenance and logistics, and display devices),
4. Simulation (network simulation and optimization, which use real time data,
5. Horizontal and vertical system integration (data integration within across companies),
6. The industrial Internet of Things a network of machines and products
7. Cloud computing (real time communication for production systems),
8. Cybersecurity (the management of heightened security risks),
9. Big data and analytics (the comprehensive evaluation of available data and support for optimized real time decision making).

2.2 Readiness and Maturity of Industry 4.0

Many different models have been developed for readiness and maturity assessment of industry 4.0. An extended review of the literature on this topic is presented in the article by Mrugalska and Stasiuk-Piekarska (2020). These models propose a multivariate assessment, ranging from 3 to 9 dimensions, and the most complex 9-dimensional model includes the following assessment components (Schumacher *et al.*, 2016):

1. Strategy: implementation of I40 roadmap, resources for realization, etc.
2. Leadership: eagerness of leaders, competences, etc.
3. Customers: utilization of data, digitalization of sale, etc.
4. Products: individualization, digitalization, etc.
5. Operations: decentralization, modelling, simulation, etc.
6. Culture: sharing knowledge, open-innovation, etc.
7. People: ICT competences, openness to new technology, etc.
8. Governance: labor regulations for I40, etc.
9. Technology: modern ICT, mobile devices, etc.

In other models, the dimensions are more aggregated and include most of the dimensions listed above.

3. The Research

3.1 Methodology

Based on the analysis of the literature on the subject, the main features of the Industry 4.0 model were determined and then the main dimensions of empirical research were designed.

Adaptations of enterprises to Industry 4.0 were sought in 6 dimensions: 1/ changes in industrial manufacturing paradigms, 2/ changes in manufacturing technologies, 3/ changes in Information and Communication Technologies, 4/ changes in human capital, 5/ changes in supporting processes, 6/ changes in enterprise agility.

The questionnaire survey covered 100 industrial enterprises from 19 industries operating throughout Poland. The questions were closed questions, related to the 1-5 (Likert) scale, and the 0-1 scale.

The questionnaire consisted of 9 blocks of questions:

- B1. Identification of company size and industrial sector
- B2. Changes in the macroenvironment and their impact on business
- B3. Changes in industrial manufacturing paradigms
- B4. Changes in manufacturing technology
- B5. ICT (Information and Communication Technologies) Changes
- B6. Changes in the human capital
- B7. Changes in the Maintenance Systems
- B8. Agility - using opportunity analysis
- B9. Company's metric (company age, turnover).

3.2 The Results

The results for issues B3 - B7 are presented below. Issues B2 and B8 will be the subject of a separate paper.

3.2.1 Changes in industrial manufacturing paradigms

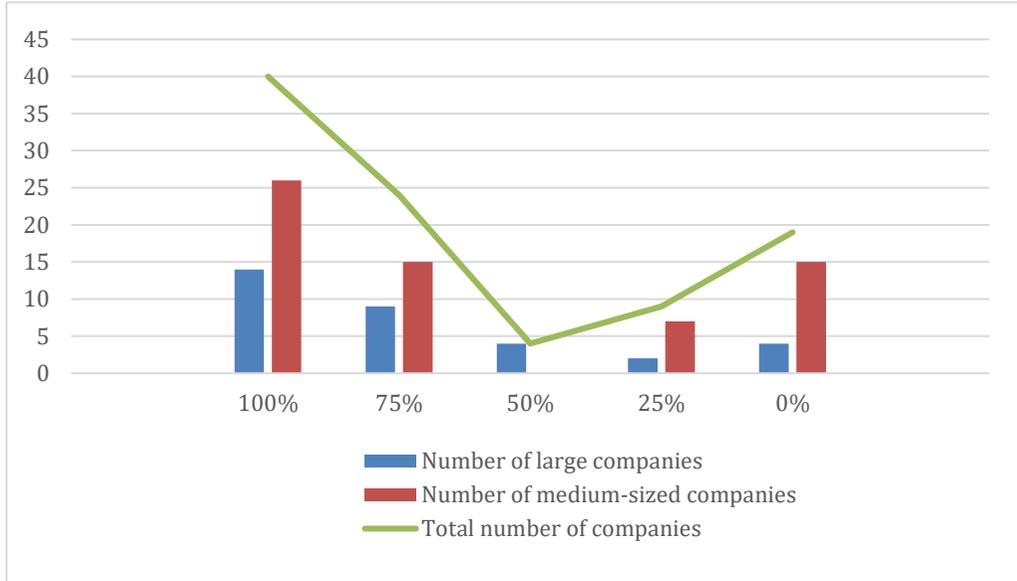
The research questions were formulated in 2 blocks: 1/ Level of production customization, 2/ Scope of implemented new management methods and techniques. The results are presented in Figures 1 and 2. Of the 100 enterprises surveyed, 40% show a mass or large-scale production profile. Small batch and unit production is declared by 19% of the respondents, including 15 medium-sized enterprises and only 4 large enterprises. Full implementation of modern management concepts and methods is declared by several to a dozen enterprises. At the same time from several to 37 enterprises have not implemented any of the methods mentioned.

3.2.2 Changes in manufacturing technology

The research questions were formulated in 3 blocks: 1/ What types of machines are used in the production process, 2/ What is the level of production automatization, 3/ Whether and to what extent the company uses or intends to use machines communicating with each other. The results are presented in Figures 3, 4 and 5. CNC machines dominate in the surveyed companies (respectively – 86% of large companies and 63% of medium-sized companies, which can be considered as a correct trend. However, manipulators and robots are already used in a much smaller group, in 40 large enterprises and 20 medium-sized enterprises. Production automation is at a low level, it is used to a large extent in 20 large companies and 9 medium-sized companies.

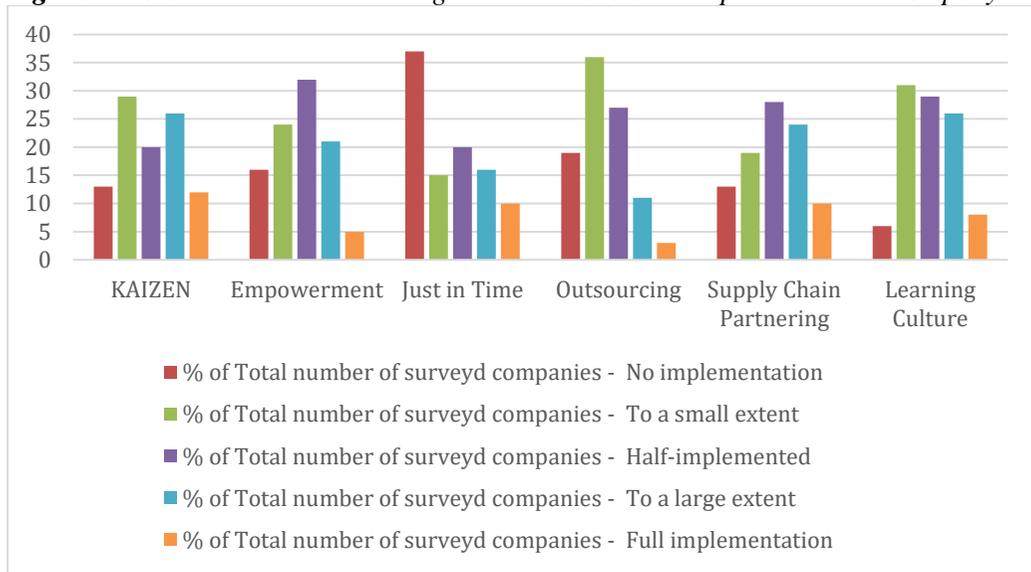
The use of machines and equipment that communicate with each other is declared by 29 large enterprises and 18 medium-sized enterprises. 21 enterprises declare implementation of this technology in the next 2 to 5 years. Such a trend can be considered correct.

Figure 1. What part of the company’s assortment of final products/services is offered on a mass scale



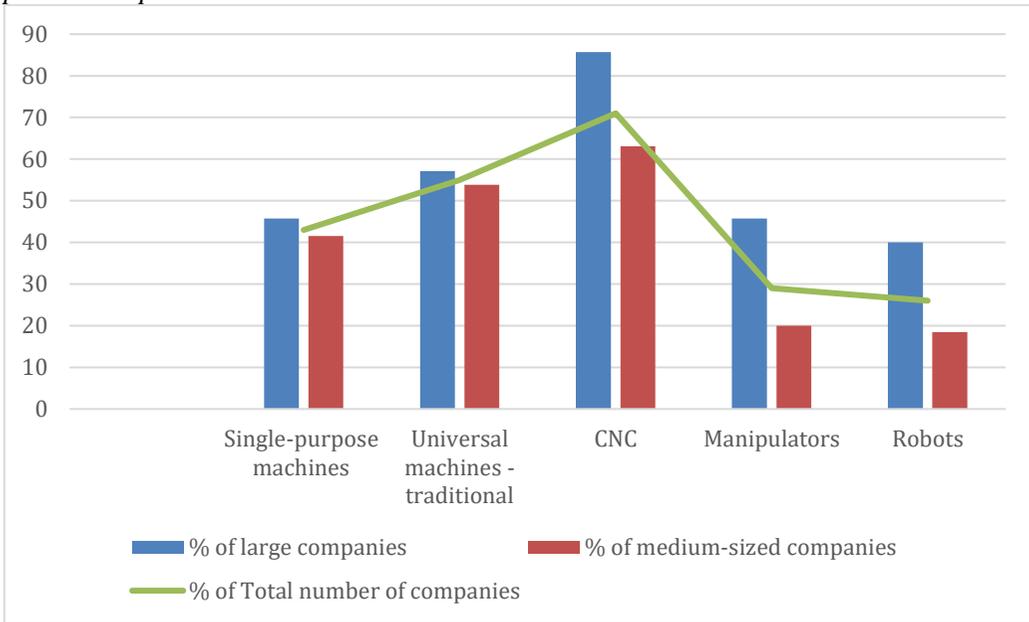
Source: Own study.

Figure 2. To what extent have management methods been implement in the company?



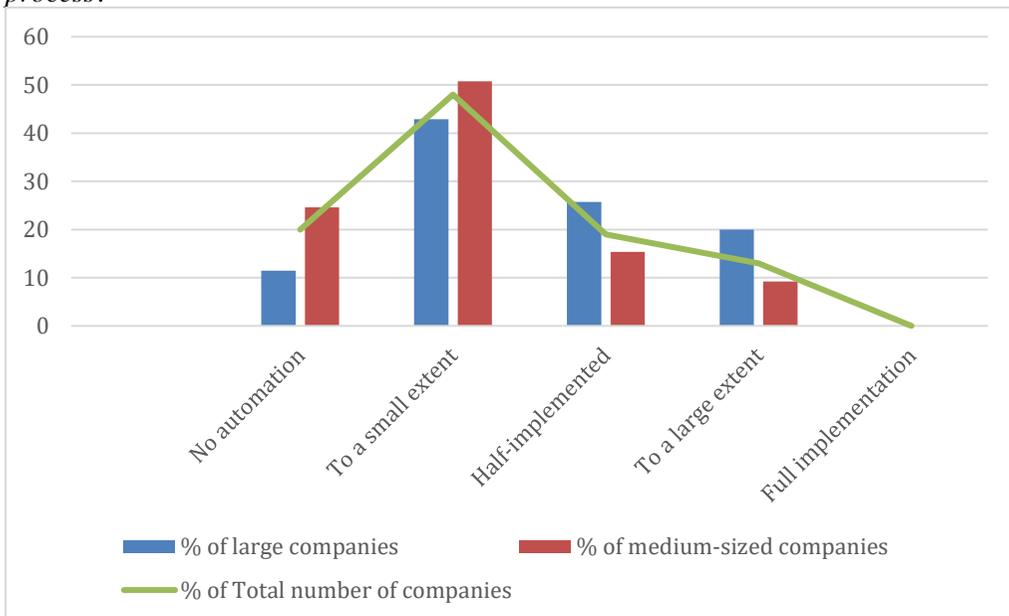
Source: Own study.

Figure 3. What types of machines/equipment are used in your company's primary production process?



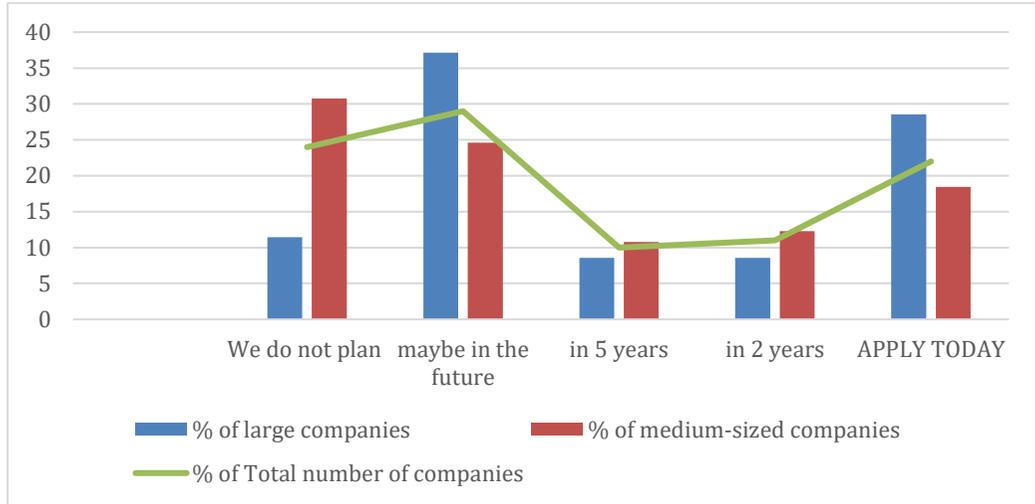
Source: Own study.

Figure 4. What is the level of automation of your company's primary manufacturing process?



Source: Own study.

Figure 5. What is the company's policy on machines/equipment communicating with each other?

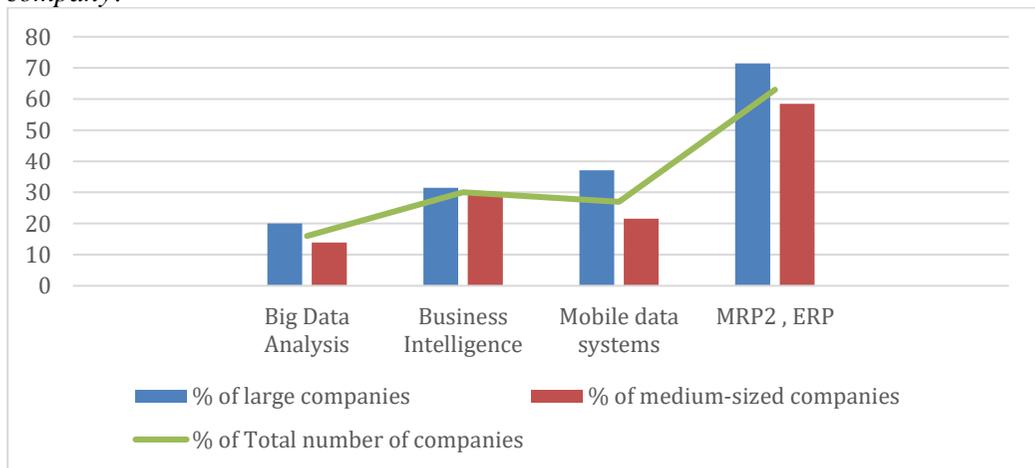


Source: Own study.

3.2.3 ICT (Information and Communication Technologies) Changes

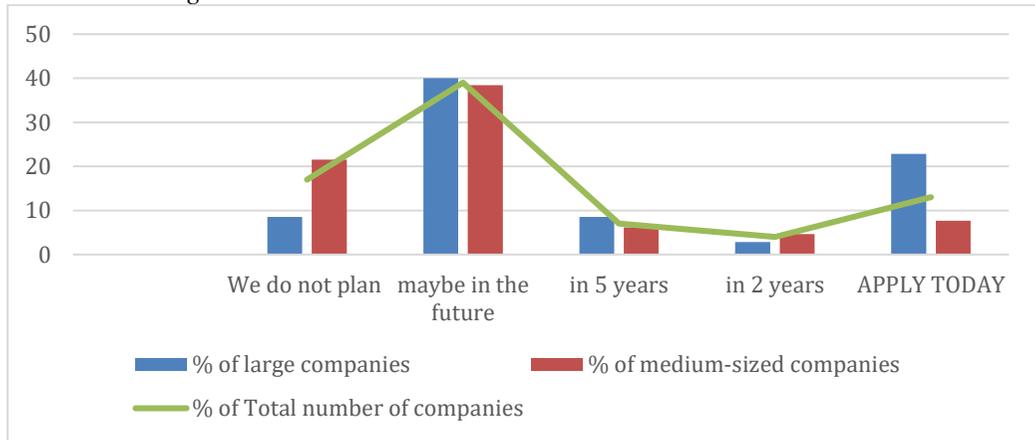
The research questions were formulated in 2 blocks: 1/ Using what tools/methods/systems is the company's management supported? 2/ What is the company's policy for pursuing Big Data Analytics and/or Business Intelligence?. The results are presented in Figures 6 and 7. Most enterprises (63%) have implemented an MRP or ERP system. 30% of enterprises use Business Intelligence Systems, but Big Data Analysis systems are already used by only 20 large enterprises and 14 medium-sized enterprises. 40% of enterprises have no plans to implement Business Intelligence Systems, and Big Data Analysis in the coming years.

Figure 6. What tools/methods/systems are used to support the management of your company?



Source: Own study.

Figure 7. What is your company's policy on pursuing Big Data Analytics and/or Business Intelligence?



Source: Own study.

3.2.4 Changes in the human capital

The research questions were: To what extent are the various competencies/skills of executive staff relevant to the development of the business? The results are presented in Table 1.

Table 1. To what extent are the following executive staff competencies/skills relevant to your business development?

Is and how important is it to the company?		% of Total number of surveyed companies				
		definitely not important	no matter	neither important nor not important	important	critical
1	Innovation and willingness to come up with new ideas and solutions to improve the business	1	2	6	40	51
2	Ability to analyze data	0	6	13	52	29
3	Willingness to learn and grow	0	2	10	36	52
4	Openness to changes in how and where work is done	0	10	16	47	27
5	Adaptability (overcoming resistance) of the employee to perform tasks in cooperation with the robot	8	17	13	39	12
6	Multitasking	0	2	14	46	38
7	Narrow specialization	2	22	33	33	10

Source: Own study.

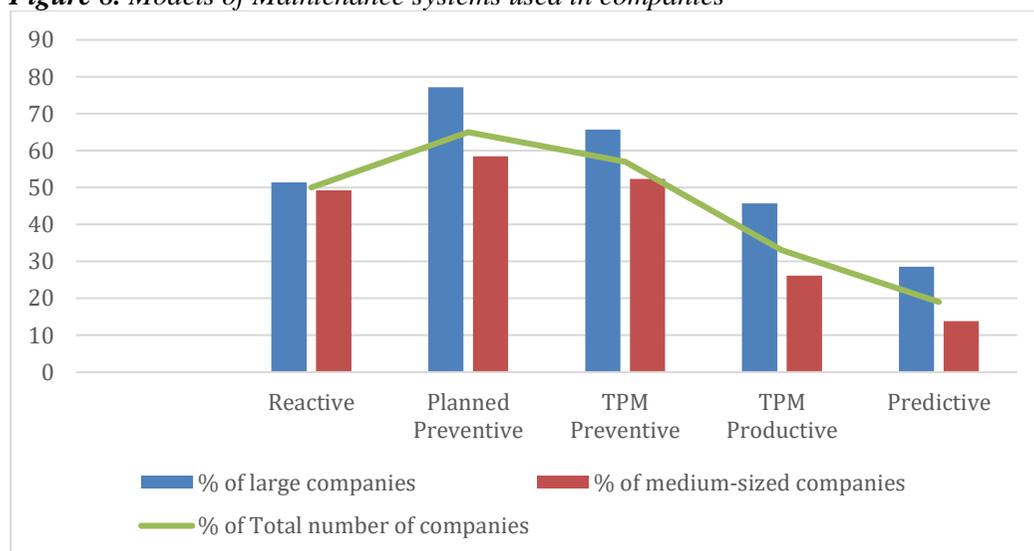
Very important or critical to companies are innovations, ability to analyze data, willingness to learn and grow, multitasking and openness to changes in how and where work is done.

3.2.5 Changes in the Maintenance Systems

The research questions were formulated in 2 blocks: 1/ What models of "Maintenance" are used in the company? 2/ What part of machinery in the company is maintained according to each system. The results are presented in Figures 8. Most companies use several systems in parallel. The high level of application of Reactive Maintenance (more than 50% of the companies surveyed, both medium-sized and large) is surprising. The most frequently used system is Planned Preventive Maintenance (77% of large companies and 62% of medium-sized companies).

Total Preventive Maintenance is used by 66% of large companies and 54% of medium-sized companies. Modern systems are used twice as often by large companies as by medium-sized companies (Total Productive Maintenance – 46% large companies and 26% medium-sized companies, and Predictive Maintenance – 29% large and 14% medium-sized companies). In summary, more than half of the companies still use the archaic Reactive Maintenance system but at the same time, almost half of the large companies use the modern Total Productive Maintenance system. The latest digital technology-based systems, Predictive Maintenance, are already known and used in approximately 30% of large companies.

Figure 8. Models of Maintenance systems used in companies



Source: Own study.

4. Conclusions

Industry is evolving globally towards automated, intelligent manufacturing. Industry 4.0 models are theoretically well described and supported by a great number of practical applications, mainly in large corporations. Taking up the research topic of the level of adaptation of Polish enterprises to the conditions of Industry 4.0, we expected to obtain a much higher level of adaptation than the one we identified.

Polish enterprises clearly diverge from the level achieved by enterprises in Western Europe and the USA. This applies both to the level of technical and technological production equipment, application of ICT technologies and implementation of modern concepts and methods of business management.

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