Management and Production Engineering Review
Volume 11 • Number 4 • December 2020 • pp. 92–103
DOI: 10.24425/mper.2020.136123

INDUSTRY 4.0 DESIDERATA AS MICRO FOUNDATIONS IN THE ASSESSMENT OF COMPANIES' MATURITY – CASE STUDY

Bogdan Nogalski[1], Przemysław Niewiadomski[2]

[1] *WSB University in Gdansk, Institute of Management and Finance, Poland*
[2] *University of Zielona Góra, Faculty of Economics and Management, Poland*

Corresponding author:
Przemysław Niewiadomski
University of Zielona Góra
Faculty of Economics and Management
Podgórna 50, 65-246 Zielona Góra, Poland
phone: +48 692446716
e-mail: p.niewiadomski@wez.uz.zgora.pl

Received: 21 January 2020
Accepted: 16 September 2020

Abstract
The industry transformation to the digital model 4.0 will be a significant change from the perspective of the organisation and processes. In the context of the above, the research was undertaken, the principal aim of which constituted the attempt to answer the question concerning the technological advancement level of manufacturing companies operating in the agricultural machinery sector. It is about identifying what adaptation projects in the context of the fourth generation industry era should be undertaken by the Polish manufacturers operating in the agricultural machinery sector. The achievement of the main objective required formulation and implementation of partial objectives, which, according to the authors, include: $C^{(1)}$ – defining the Industry 4.0 axiom merit; $C^{(2)}$ – using the subject literature reconstruction and interpretation methods – nomination of areas, on the one hand essential from the perspective of the model 4.0, and on the other hand those that may demonstrate the maturity in the domain of the adopted desiderata; $C^{(3)}$ – compilation of the research model, in the form of an assessment sheet, being a resultant of literature studies and research conducted among deliberately selected domain experts; $C^{(4)}$ – based on the selected indicators, the technological advancement level recognition of the studied companies; specification of a technological gap (questioning among experts).

Keywords
Industry 4.0, adaptation, digitisation, robotics, business model, agricultural machinery manufacture.

Introduction (Starting point)

The considerations conducted by the authors of this work are moving towards the era of the fourth generation [1]. They result in a comparative analysis of old and new desiderata and the emergence of a new holistic paradigm, taking into account the building of electronic business activity channels [2], i.e. the virtual dimension of conducting business activity associated with the networking of key (often strategic) business areas.

The manufacture management processes in their current shape will be significantly changed. The entire industry transformation to the digital model 4.0 will be a significant change from the perspective of the organisation and processes. Unlike previous industrial revolutions, the current one is progressing at a much faster pace. This is due to the fact that each new technology gives rise to a newer, even more efficient one.

The main objective of this study was to obtain objective information on the maturity of enterprises from the perspective of the implementation stage of the idea of Industry 4.0. The research was conducted among Polish producers of the agricultural machinery sector. Its implementation related to 4 specific objectives covering the following issues:

1) defining the merits of the Industry 4.0 axiom (characteristics and etymology);

2) nomination of areas that, on the one hand, are important from the point of view of Industry 4.0, and on the other hand that may determine the maturity of companies in the domain of accepted desiderata (reconstruction and interpretation of literature);
3) compilation of the research model, in the form of an assessment sheet, being a resultant of literature studies and research implemented among deliberately selected experts;
4) recognition of the technological advancement level of the surveyed enterprises; specification of the gap (indication among selected manufacturing companies).

In order to conduct the study, secondary sources were analysed, i.e. scientific and non-scientific literature (including strategic documents) regarding Industry 4.0 and related issues. In addition, statistical analyses were carried out based on data obtained as part of the study. In order to implement research problems, a brainstorming (author's method 335) was carried out with representatives of manufacturing enterprises (including the sector), followed by individual in-depth interviews and CAWI among selected enterprises whose head offices are located in Poland.

The results of the research are presented in this research paper within individual chapters. As a result of the research, satisfactory results were obtained, which gave the opportunity to indicate constructive conclusions and recommendations.

Material and methodology of testing

Research questions and hypotheses

Based on a widespread discussion that has recently been taking place in the environment of agriculture machinery manufacturers, once again the question arises about the stage of Industry 4.0 implementation. Nevertheless, the analysis of the literature on the subject showed that so far only partial research on the direction of adaptation activities in the context of the fourth generation industry era has been conducted [3]. This inference was based mainly on literature or empirical research conducted at enterprises from other sectors of the economy [4]. To date, no comprehensive, analysed research, either in Poland or abroad, has been carried out at a large number of manufacturing companies operating in the agricultural machinery sector.

Aiming to fill the existing knowledge gap, a series of studies was conducted, the subject of which was an attempt to model the implementation assessment method of selected Industry 4.0 desiderata. In-depth studies in the area of the problem outlined above, own observations of economic practice and conducted empirical research have led to the formulation of specific questions, the solution of which was the answer to the main problem:

- *What is the level of technological advancement of manufacturing companies operating in the Polish agricultural machinery sector?*
- *Which of the listed management concepts have been put in place by the surveyed manufacturers?*
- *Which management support tools, in the context of the idea of industry 4.0, are applied by the surveyed enterprises?*
- *What level of domain knowledge do the surveyed companies represent?*
- *Are the surveyed companies oriented towards relations and ecology?*

The formulated questions and belief on the existence of economic demand for results of application nature, on the one hand, were the main inspiration to undertake the research, while, on the other, they became the starting point for formulating the below presumptions:

P_1: *The surveyed manufacturers demonstrate a high level of domain knowledge and the ability to implement selected management concepts.*

P_2: *The research model resulting from the expert discussion reflects the directions of actions that should be undertaken by the surveyed enterprises in the context of Industry 4.0. (research coincidence).*

P_3: *More and more companies organise a business model, in which the reference point is the Industry 4.0 concept.*

P_4: *The process of transforming enterprises into a model based on digital technologies is relatively low.*

Research implementation scheme

In order to learn the views of representatives of production companies of the Polish agricultural machinery sector on Industry 4.0 and technology, as well as their needs and challenges, a market survey was conducted which covered micro, small, medium and large production companies.

The research was conducted in September-December 2019. In the first stage of the study constituting the preparatory study (A^0), the authors used the literature study (A^1) and expert study (A^2) methods. The preparatory study conditioned the conduct of the main study (B^0). The research scheme is illustrated in Fig. 1.

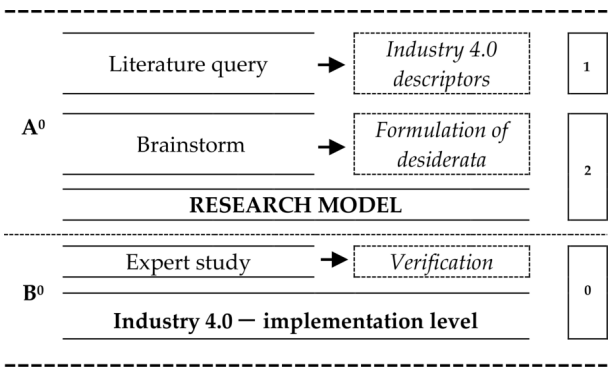

Fig. 1. Research implementation scheme (own development).

Formulation of the research model [A^0]

Applying the method of reconstruction and interpretation of available research and the literature on the subject (among others: [1, 2, 5–21]) supported by the authors' observations, a catalogue of desiderata related to the idea of Industry 4.0 was drawn up[1]. In the next stage, a team of 7 experts (Table 1) was appointed who worked on ideas and solutions.

Table 1
List of experts (own development).

Expert	Speciality	[%]
Owners of enterprises operating in the agricultural machinery sector [7]	Organisation and management; owner's supervision	42.86
Manager – Marshal's Office of the Greater Poland Voivodeship [5]	Industry 4.0 – active participation in creating implementation conditions	14.29
University representative [6]	Industry 4.0 idea	28.57
Manager [5]	Digital technologies	14.29

The expert discussion [22, 23] was based on the authors' original '335 method'. Within 5 minutes, each person had the opportunity to write 3 desiderata determining the maturity of enterprises in the context of the Industry 4.0 idea. Then, after 3 minutes they gave the sheet to the subsequent person who added his/her observations. After next 5 minutes, the sheet went to the hands of another person. Therefore, after 3 rounds, a group of 7 experts generated 63 variables. After the end of the session, the assessment of the obtained results was summed up. The authors of the study wrote down all the listed proposals, grouped similar ideas, which in perspective allowed them to determine the final list, in which 53 variables referring to six areas of enterprise maturity were distinguished (Table 2).

Table 2
Assessment space (own development).

Item	AREA	ACRONYM
1	Digital technologies	Tech. 4.0
2	Management concepts	M_Conc.
3	Integration tools	4.0_Integ.
4	Domain knowledge	4.0_Knowl.
5	Ecological competence	Eco_conc.
6	Relations 4.0	4.0_Relat.

Constructive thinking, expressed by the ability to apply knowledge in a practical manner, was adopted as the basic criterion for selecting an expert. An equally important feature characterizing an expert is his/her creativity, i.e. the expert's ability to solve creative tasks and act independently (conformity).

The study involved 3 owners (42.86%), 2 managers (28.57%) and 2 university representatives (28.57%). The age of the respondents was between 40 and 74 (including 42.86% of those surveyed in the 40-50 age range, 14.29% in the 50-60 age range; 42.86% of the surveyed persons being over 60). The group of people with higher education (71.43%) predominated among the respondents; the other experts had secondary (14.29%) and vocational (14.29%) education.

The conducted research helped to generate areas for the next study. They provided interesting information on the language that "industry experts" use to describe the phenomena constituting the subject matter of the research. The authors believe this allowed to avoid mistakes at the level of constructing questions and to adapt the language to the potential respondents. This research significantly made it much easier for researchers to approach the 'natural world', which greatly helped to appropriately carry out the quantitative research while ensuring full understanding of the tested phenomena among potential respondents.

According to the assumption, the proposed developed model is to be a versatile and useful tool for assessing the company's maturity level, as well as to constitute a significant instrument for strategic planning. As a result, the companies can make self-assessment and determine which Industry 4.0 elements may be of immediate benefit, and which have more long-term application.

[1]Bibliographic knowledge accumulated for the purposes of this research includes the following three thematic resources (frameworks): innovation management, strategic management and production engineering.

Basic study

The basic research was carried out on a sample of 71 enterprises representing Poland's agricultural machinery sector. The respondents were selected in a targeted manner based on the criterion of managerial maturity perceived from the perspective of 8 desiderata. Maturity expresses the expert's level of qualification in a given field. It was determined on the basis of an expert's creative analysis, knowledge of the field, and understanding of problems. Expert maturity was assessed on the basis of the competence coefficient, which expressed the dependence of the informativity coefficient [Ki] (knowledge of the given issue) and argumentation coefficient [KA]. The owners or managers were qualified for the research who:

1) Are involved in the implementation of the company's strategic goals;
2) Can and are initiators of changes;
3) Constantly raise their own knowledge seeking opportunities to improve the organization;
4) Positively approach new experiences and changes, treating them as an opportunity for improvement;
5) Are happy to communicate and share knowledge with other employees;
6) Eagerly undertake innovative activities;
7) Implement their own ideas to improve work, without fear of failure;
8) Understand the impact of their own work on the quality and results of the company.

The implementation of research with the participation of experts seems appropriate, especially in relation to those research areas that require advanced professionalisation (the authors consider recognition of the idea of Industry 4.0 as such an area). It should be emphasized that the area of research, specified in this paper, required those who take actions to have appropriate expertise (a randomly selected respondent may be deprived of it); especially since it concerns primarily problems in the field of professional activity. The application of expert interviews seems appropriate and desirable, bringing specific cognitive benefits and organizing the research process in a friendly and attractive way for the respondents themselves, which, from a 'qualitative' point of view, was also important.

The diagnosis was made among experts representing: micro (8.45%), small (29.58%), medium (50.70%) and large (11.27%) manufacturing companies operating in the agricultural machinery sector (Fig. 2). Manufacturers of tractors, harvesters, trailers, tilling sets, seed drills, silos, forklifts and other various agricultural equipment took part in the study.

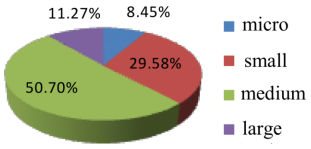

Fig. 2. Size of surveyed enterprises

A group of people between 41 and 50 years old (36.62%) dominated among the respondents; only 2.82% were respondents in the age group up to 30 years old, 21.13% of the respondents were between 31 and 40 years old, 26.76% were from 51 to 60 years old, 12.68% were over 60. The detailed research results are shown in Table 3.

Table 3
Characteristics of the studied population by age (N = 71).

Age bracket	Experts	
	Number	[%]
Up to 30 years	N = 2	2.82
31 to 40	N = 15	21.13
41 to 50	N = 26	36.62
51 to 60	N = 19	26.76
over 60	N = 9	12.68
In total	N = 71	100.00

Among the respondents, the group of persons with higher education clearly dominated (59.15%); 25.35% had secondary education, 15.49% had vocational education. Detailed characteristics are shown in Table 4.

Table 4
Characteristics of the studied population by education (N = 71).

Age bracket	Experts	
	Number	[%]
Vocational	N = 11	15.49
Secondary	N = 18	25.35
Higher	N = 42	59.15
In total	N = 71	100.00

Within the conducted research, an attempt was made to interpret the results and conduct a thorough analysis based on the respondents' declarations. A key stage was a description of the obtained data and its interpretation as highlighted in the further part of this publication.

Results of own research

Industry 4.0, i.e. basing industrial processes on advanced data processing systems, automation, the Internet of Things and intelligent technologies, is

a concept that is often invoked in the context of specific business needs. It is also a response to staffing problems and trends in the field of customization.

The maturity assessment of the Industry 4.0 level realization is quite difficult, however, an attempt to conduct it was taken in the study. Adjustment, in this respect, is one of the key factors determining the capability of enterprises to maintain their ability to compete. Changes in the environment force changes in the organization of production, which in turn determines changes in resources, processes and products under the so-called target productivity. It is not a surprise, therefore, that the agenda of the debate on the effective implementation of the idea of Industry 4.0 is becoming more and more the issue of assessing partial activities. Observed trends in management create grounds for concluding that in the second decade of the 21st century the interest in new technologies, knowledge, tools, concepts and ecological competences determining this idea will increase significantly in both the theory and practice of management.

In the context of the above, research was undertaken in which information was obtained, implying an answer to questions about the level of maturity of Polish enterprises of the agricultural machinery sector in the activation of the idea of Industry 4.0. To conduct the assessment, a five-point scale was adopted to describe the maturity level of individual descriptors corresponding to the selected areas of Industry 4.0. (5 – high level of maturity, 1 – low). The test results are presented in Tables 3 to 8.

Industry 4.0 maturity is perceived as a highly implemented set of features. Some should be selected since they are relevant to the idea of Industry 4.0. These features are treated as assessment criteria (descriptors). Eleven characteristics have been distinguished in the context of assessing the level of maturity in the field of technology 4.0 (Table 5).

Table 5
Maturity level in terms of Technology 4.0 [Tech. 4.0].

Item	Desiderata	Average
1	Production automation	4.56
2	Production robotisation	4.14
3	Mobile technologies	4.35
4	Big Data	3.69
5	Internet of Things	3.37
6	Cloud Computing	3.93
7	3D printing	3.48
8	Nanotechnology	2.86
9	Micro and nanoelectrics	2.80
10	Machine learning	3.04
11	Virtual reality VR/AR	3.13

The conducted analysis indicates that the technology within Industry 4.0 that is significantly used by the surveyed enterprises, is production robotisation (average rating 4.14; 46.5% indications for 5 points). Among the respondents, we can find companies that have undergone full automation (average rating 4.56; 64.8% of indications for a rating of 5 points). By assumption, automation in logistics or in production is advisable in the case of product repeatability. The majority of Polish enterprises of the agricultural machinery sector do not mass-produce, but offer their products only on request. This fact does not eliminate the manufacturers' use of solutions compatible with industry 4.0. In addition, changes carried out in companies that lead to the automation of production are sometimes forced by health and safety regulations or employee protection regulations (in the case of a life-threatening environment). Adapting to the current situation on the labour market, as well as the above-mentioned environmental regulations and EU standards have brought about a situation in that the owners of companies have thought about replacing the work of many people with one robot or machine.

Indeed, mobile technologies are used (average rating 4.35; 50.7% of indications for a 5 point rating) and Cloud Computing (average rating 3.93; 35.2% of the indications for a 5 point rating). The surveyed enterprises apply 3D printing to a moderate extent (average grade 3.48; 21.1% of indications for a 5 point rating), as well as VR and AR technologies (average rating of 3.13; 11.3% of indications for a 5 point rating). Nonetheless, the modern form of presenting products (designs of parts or subassemblies) in the form of both 3D printed mock-up models, as well as immersive VR visualisations and interactive visualisations is an increasingly common solution.

Among the key technologies that contribute to the activation of the concept of Industry 4.0 is the analysis of large data sets – Big Data. However, there is a demand for the limited ability of enterprises to collect, store and analyse a huge amount of data, the analysis of which is used to identify inefficiencies and production bottlenecks, optimize production and maximize its quality, save energy and improve service and device diagnostics (average rating 3.69; 22.5% of indications for the assessment of 5 points). In the context of Industry 4.0, the collection and comprehensive assessment of data from many different sources – production equipment and systems, as well as enterprise and customer management systems – will become a standard aimed at supporting real-time decision-making, which should be taken into account by the surveyed manufacturers.

The implementation of the Internet of Things (IoT) concept based on the idea of communication between devices (M2M – machine to machine) is postulated to a limited extent. Although it creates the possibility of communication, collection and processing of data and their exchange by these devices via a computer network without human intervention, the level of its use is relatively low (average rating 3.37; 21.1% of indications for a rating of 5 points).

In spite of the fact that the manufacturers have sufficient computing power, have the right amount of data and knowledge about modelling calculations, they are not fully aware of how much artificial intelligence, including machine learning, entered the business, especially in the perspective of Industry 4.0 (average rating 3, 04; 12.7% of indications for the assessment of 5 points).

Nanotechnology is still a poorly known area, which is one of the main obstacles to its development. Knowledge about nanotechnology, as a factor determining the development of technological potential, is very limited among the surveyed companies, and entrepreneurs often evaluate phenomena using generalisations. In the opinion of the authors of the study, company representatives exhibit rather general knowledge; have clear difficulties in identifying specific nanotechnology names specific to the sector being investigated (average score 2.86; 5.6% of the indications for 5 point score). According to the authors, this is a matter of proper marketing and a question about the price of the product and whether nanotechnology-based products will increase sales. In addition, the question arises: Will the additional costs associated with the implementation of nanotechnology be ever acceptable? Despite the knowledge deficit, it is high time to accelerate the development of nanotechnology in Poland, especially in view of the idea of Industry 4.0.

Despite the fact that Industry 4.0 promotes micro- and nanoelectronics as the key technologies for the development of traditional industry, in the assessment of the surveyed enterprises, very limited activity in this area is noticed (average rating 2.80; 7.0% of indications for the assessment of 5 points).

In order to ensure sustained growth of 4.0 technology in Polish enterprises of the agricultural machinery sector in the medium term, it is recommended to create a broad program promoting cooperation between business and scientific entities in the field of artificial intelligence. Such a program should be realized by taking into account the 'open innovation' model, as a result of which enterprises will not rely solely on their own data and the results of their own research and development work, but instead use external sources of innovation and cooperate extensively with other entities, as well as with the sphere of research and development. In the short term perspective, it is recommended to take educational measures on a 'learning by doing' basis, in the medium term, it is recommended to take measures enabling Polish enterprises to avoid the equivalent of a 'medium development trap' in the data-based economy, while in the long term, the emphasis ought to be placed on building permanent global dominance of domestic enterprises in selected specialisations.

Modern 4.0 enterprises are required to be able to take advantage of market opportunities, which on the one hand necessitates the prior implementation of a lean enterprise model, and on the other hand, compels the use of selected concepts and management methods. In this area, research was undertaken, the main purpose of which was an attempt to answer the question referred to the level of maturity of Polish manufacturers of the agricultural machinery sector in the area of utilizing modern management concepts. The research results are shown in Table 6.

Table 6
Maturity level in the field of applied management concepts [M_Conc.].

Item	Desiderata	Average
12	LM (Lean management)	4.56
13	FL/AG (Agility and Flexibility)	4.55
14	TQM (Total Quality Management)	4.54
15	BEN (Benchmarking)	4.46
16	CI (Continuous Improvement)	4.37
17	CE (Concurrent Engineering)	4.38
18	SCP (Supply-Chain Partnering)	4.49
19	OC (Outsourcing)	4.46
20	TBW (Team-Based Working)	4.30
21	TPM (Total Productive Maintenance)	4.35
22	JIT (Just in Time)	4.45
23	BPR (Business Process Reengineering)	4.30

An expression of the prevailing belief that counteracting waste is one of the possibilities to increase the efficiency of an enterprise's operation is the implementation of the Lean management concept (average rating 4.56; 59.2% of indications for a rating of 5 points). The entire industry transformation to 4.0 model is also a significant change from the point of view of organisations and processes that will undergo important modifications in their current shape. The currently observed management trends create premises to conclude that the interest in individual Lean management tools will continue to increase. The constant pressure on cost reduction means that effective supply chain management becomes one of the priorities of enterprise management. In the con-

text of Industry 4.0, it is emphasised that the importance of relationships with customers, suppliers and employees is rising. The conducted research procedure is an important knowledge base that authorises the authors to state that the SCP concept is highly realized by the surveyed enterprises (average rating 4.49; 54.9% of indications for a rating of 5 points).

The key issue for Industry 4.0 is the constant search for new opportunities to reduce costs. One way, applied by the surveyed companies, is to move from traditional sequential simulation of production processes to the use of concurrent engineering (average rating 4.38; 47.9% of indications for a rating of 5 points). Instead of looking for their own solutions, which is usually a long and costly process, the surveyed companies try to use the experience of others; while the idea of Industry 4.0, as in the case of the respondents, assumes creative imitation (average rating 4.46; 53.5% of indications for a rating of 5 points).

In the context of the idea of Industry 4.0, there is a growing demand for an enterprise model that flexibly adapts to constant and turbulent changes occurring in the environment, and is able to function in chaos. It should be even more emphasised that the surveyed enterprises are characterized by sensitivity and the ability to quickly identify opportunities and use them for their own development (average rating 4.55; 60.6% of indications for a rating of 5 points).

The premise of Industry 4.0 is the tendency to delegate tasks that can be abandoned so that the manufacturer could focus on key activities. The OC concept is to a great extent implemented by these surveyed enterprises, which isolate the areas of secondary or ancillary activity from the company's operations processes and transfer them for activation to external entities (average score 4.46; 50.7% of the indications for 5 point score).

In order to reduce work in progress and the level of inventories in the entire production and warehouse process, as well as the costs associated with its implementation, enterprises willingly use the Just in Time concept (average rating 4.45; 49.3% of indications for a rating of 5 points). Thanks to such a system, the warehouse inventory of both the raw material and the finished product is kept at the minimum level, hence the compatibility of the JIT concept with the idea of Industry 4.0.

Manufacturers pay special attention to meeting the assumptions of the TQM concept, which provides solutions that fit the idea of Industry 4.0 (average rating 4.54; 56.3% of indications for a rating of 5 points). Among the surveyed enterprises, it is easy to notice the systematic engagement in the production system improvement (average rating 4.37; 49.3% of indications for a rating of 5 points). Employees enacting minor improvements every day make that the organization itself is improving and is faster in acquiring competences, hence, implying that it is effectively functioning in the conditions set out by the era of Industry 4.0. In such enterprises, teams are formed, consisting of a small group of people with complementary skills who are engaged in achieving a common goal, using jointly set performance standards, for which they are responsible for each other (average rating 4.30; 43.7% of indications for a rating of 5 points).

The idea of Industry 4.0 assumes taking actions that involve the safety of machines, operation and the environment – that is everything that affects the well-being of employees. The maturity of enterprises in this area expresses the use of appropriate quality tools and conducting technical analyses related to the operation of individual machine elements, which are responsible for potential errors affecting the final product (average rating 4.35; 46.5% of indications for a rating of 5 points). The Idea of Industry 4.0 requires focus on processes, monitoring the basic assumptions of processes implemented so far, as well as the need to integrate process redesign based on a business strategy adopted by the company. It should be emphasised that the surveyed enterprises eagerly use the BPR concept (average rating 4.30; 45.1% of indications for a rating of 5 points), which represents their maturity within the mentioned assessment space.

Twelve descriptions were selected when evaluating the level of maturity in the field of tools used by enterprises (Table 7).

In the era of Industry 4.0, attention is drawn to the need to transfer the entire function of managing the manufacturing process to specialised devices; usually computers. That is why it is so important for companies to effectively utilize IT tools enabling integrated product design (average rating 4.25; 40.80% of indications for a rating of 5 points). Attention is paid to the relatively high level of implementation of the module for dynamic management of the production progress path with the customer's order (average rating 4.07; 35.2% of indications for a rating of 5 points).

As part of the assumptions related to the idea of Industry 4.0, the need to implement integrated tools supporting analyses in the field of production controlling is pointed out. In response to the mentioned postulate, the surveyed companies declare that they have tools that enable analysing and budgeting of production costs; budget performance analysis, budget deviation analysis or investment profitability analysis (average rating 4.17; 39.4% of indications for a rating of 5 points).

Table 7
Maturity level in the scope of applied tools [4.0_Integ.].

Item	Desiderata	Average
24	Module for dynamic management of the production progress path with the customer's order	4.07
25	IT tools enabling integrated product design	4.25
26	Module supporting analyses in the field of production controlling	4.17
27	Dynamic product base management tools	4.24
28	Implementation of systems for automatic handling of product defects	4.07
29	Module for dynamic processing and management with material flow	4.11
30	Application of ERP system calculation algorithms	4.08
31	Tools supporting production instrumentation management	3.75
32	Integration of the purchasing platform with supplier systems and logistics services	3.90
33	Module providing the option of electronic exchange of documents	4.06
34	Tools supporting electronic customer service (elements of transaction marketing)	4.23
35	Introduction of solutions within the sales platform enabling integration with the production department	3.90

The problem of managing a huge amount of product information in a structured manner and the possibility of its transparent presentation pose significant challenges in the context of the era of industry 4.0. The potential for savings and streamlining the purchasing, production and sales processes is vital, it opens the way for enterprises to put in place a software platform for managing product and catalogue information (average rating 4.24; 43.7% of indications for a rating of 5 points).

In the era of industry 4.0, planning activities and responding to irregularities are of particular importance to ensure the maximum availability at minimal costs. This forces enterprises to perform much more in-depth data analyses than the available warehouse programs allow. The need to realize modules for centralisation and automation of inventory management is also taken into consideration (average rating 4.11; 35.2% of indications for a rating of 5 points).

The key tool for business management at the stage of company 4.0 is the ERP system. Research shows that the use of computational algorithms is a strategic business decision for companies (average rating 4.08; 35.2% of indications for a rating of 5 points). Part of this plan, in case of some enterprises, is the utilization of applications enabling production instrumentation management (average rating 3.75; 25.4% of indications for a rating of 5 points). In the face of the fourth generation industry, the necessity to gradually implement applications that provide the possibility of integration with the computer systems of shipping companies is also highlighted. Increasingly, among the surveyed companies, the possession of tools supporting the generation of printouts according to specific templates, generation of individual shipment markings for each forwarder, or automatic settlement of collected amounts is also noted (average rating 3.90; 32.4% of indications for a rating of 5 points).

Moreover, relevant from the point of view of Industry 4.0 is the multi-directional communication and information flow, including correlation of data from correspondence with data from systems. It is therefore reasonable to put in place a module that creates the possibility of electronic exchange of documents between contractors according to the EDI standard (Electronic Data Interchange), which is the case for the surveyed enterprises (average rating 4.06; 35.2% of indications for a rating of 5 points). High maturity can also be noticed in the activation of transaction marketing postulates, which is manifested in the systematic introduction of tools supporting electronic customer service (average rating 4.23; 43.7% of indications for a rating of 5 points), including (to a slightly smaller extent) focus on handling product exchanges, returns or complaints (average rating 4.07; 33.8% of indications for a rating of 5 points).

In order to guarantee a uniform state of information across the enterprise, the database should be synchronized with partial resources in other systems. Therefore, it is important to introduce comprehensive and, open to integration, sales platforms (orders, statistics panels, analytical panels, control panels) enabling integration with the production department (average rating 4.01; 38.0% of indications for a rating of 5 points).

When assessing the level of maturity in the field of "Knowledge 4.0" desiderata, the following ten variables were distinguished (Table 8).

Table 8
Maturity level in the field of "Knowledge 4.0" desiderata [4.0_Knowl.].

Item	Desiderata	Average
36	Level of competences held by employees (including technological competences)	4.18
37	Presence of innovative knowledge workers in the enterprise	4.17
38	Employees' responsibility for taken decisions	4.24
39	Matching contractors to the held manufacturing system	4.18
40	Activities aimed at increasing employee satisfaction with their work	4.31
41	Cooperation with science parks and universities	4.11
42	Employee training	4.13
43	Skills to transfer knowledge to other employees	4.21
44	Multitasking	4.17
45	Orientation towards research and development	4.06

The contemporary employee is a person who does his/her job very well, has relevant knowledge and skills and is able to properly use them in changing situations (average rating 4.18; 43.7% of indications for a rating of 5 points). High expectations regarding knowledge, skills, attitudes, abilities and predispositions addressed to employees are reflected in the significant number of innovations they propose (average rating 4.17; 40.8% of indications for a rating of 5 points). In the course of the conducted research, attention was paid to the high level of employee responsibility for decisions (average rating 4.24; 39.4% of indications for a rating of 5 points).

The research results confirmed the authors' belief that cooperation between universities and science parks with enterprises, however justified for the creation and development of innovations based on scientific ideas, is not realized at the highest possible level, and requires improvement (average rating 4.11; 31.0% of indications for 5 points). Observations and interviews conducted by the authors predispose them to the view that some entrepreneurs (in the activities of science parks and universities) perceive the threat of reducing the role and participation of the enterprise in transforming the results of scientific research into technological innovations.

An important determinant of Industry 4.0 is, and enacted at a good level, training policy (average rating 4.13; 33.8% of indications for a rating of 5 points). From this perspective, the motives for knowledge-sharing behaviour are equally important. They are currently complex, ranging from altruism, trust, reciprocity rules, to the desire to build self-image as an expert and specialist (average rating 4.21; 46.5% of indications for a rating of 5 points).

'Multi-positioning' of employees (average score 4.17; 36.6% of indications for a rating of 5 points), which translates into a high level of adaptation of contractors to the production process (average rating 4.18; 36.6% of all indications for the assessment of 5 points) and a focus on conducting research and development works (average rating of 4.06; 32.4% of indications for the assessment of 5 points) is considered to be the determinant of the maturity level of enterprises.

The ecological competences of enterprises are nowadays an important element of building proper interactions with the environment; they cover a complex and diverse range of issues and are built in many different areas. They are complex relationships of collective learning skills and therefore were used in the context of assessing the level of maturity in the field of Industry 4.0 desiderata (Table 9).

Table 9
Maturity level in the field of "Ecological competences" desiderata [Eco_conc.].

Item	Desiderata	Average
46	Development strategy including eco-innovation in the corporate objectives bundle	3.89
47	Multi-directional information flow in areas related to eco-innovation	3.92
48	Orientation towards the future	4.25
49	Ecodesign	3.99
50	Efficiency of resource management throughout the entire life cycle	4.27

Ecological competences allow for the creation of an ecological quality strategy. It is a company development strategy combining elements of quality and ecology in the form of ecological quality. It should be a strategy based mainly on the value of ecological technologies or products. An element of ecological competence is the ability to introduce ecological quality requirements into individual stages of strategy construction; from the company's mission, strategic analysis, through the selection of the strategic option, to strategy implementation and strategic controlling.

The development strategy of the surveyed enterprises, for the most part, includes the inclusion of eco-innovation in a bundle of enterprise goals (average rating 3.89; 31.0% of indications for a rating of 5 points). There is a growing flow of information in areas related to eco-innovation (average rating 3.92; 31.0% of indications for a rating of 5 points).

The subject of eco-design or the inclusion of thinking in decision-making processes with the perspective of the entire product life cycle is relatively new in economic practice. It does not mean that this concept is not used by the surveyed enterprises (average rating 3.99; 35.2% of indications for a rating of 5 points). This is due to the very concept of life-cycle category thinking, which is one of the fundamental assumptions of this strategy.

In the era of Industry 4.0, particular focus is paid to environmental criteria, which should be included both at the stage of selection of raw materials and materials used for production, as well as the production processes themselves (sustainable production). Products should be designed in such a way so that they could be suitable for recycling or reuse, making waste management easier and less costly.

The surveyed enterprises improve their own processes, exert influence on suppliers and other market entities with whom they come into contact at various stages of the life cycle of their products. They are characterized by resource management efficiency throughout the entire life cycle (average rating 4.27; 45.1% of indications for a rating of 5 points). By caring for and monitoring environmental impact, they implement the idea of thinking in terms of the life cycle in their strategy and decision-making processes, hence one can speak of their maturity in the context of Industry 4.0.

What distinguishes the industrial revolution 4.0 is customer centricity. Using the tools offered by Industry 4.0 will not only improve the quality of the product, speed of its delivery, but, above all, will allow for the better adaptation of the product to customer needs. Although current activities are highly focused on deepening or building relationships with customers and suppliers (average rating 4.48; 54.9% of indications for a rating of 5 points), this approach will further strengthen the customer-supplier relationship (Table 10).

Awareness of the employee's needs and building a full relationship with them is the key to 4.0 company success. A modern relationship is one in which the employer is aware of the multidimensional needs of the employee, and therefore is able to take care of his/her financial situation, emotional well-being, relationships at work, atmosphere, and broadly understood organisational culture.

The conducted interviews convince the authors that the surveyed companies offer a friendly workplace, where employees can achieve their goals, and at the same time are appreciated and motivated (average rating 4.44; 53.5% of indications for a rating of 5 points). From the perspective of the surveyed companies, it is imperative to build a long-term relationship with the employee, thanks to which the staff turnover is relatively low.

The era of digital technology has contributed to the enrichment of discussions on human-machine relations. It is assumed that to establish meaningful human-robot relationships, it is necessary to use generally accepted social mechanisms. One of their key elements is empathy, which is often seen as the foundation of social relations, necessary for their proper course. In the context of the above, it was established that as a result of the relatively poor 'personality' of robots, the assessed persons cannot be empathic towards them (average rating 3.65; 25.4% of indications for a rating of 5 points). Despite the efforts of scientists, the creation of an emotionally intelligent machine is currently far from perfect. Undoubtedly, however, exploring the topic of the relationship between the machine and man can be considered one of the most interesting challenges in the context of the idea of Industry 4.0.

Table 10
Maturity level in the field of "Relations 4.0" [4.0_Relat.].

Item	Desiderata	Average
51	Activities aimed at deepening or building relations with customers and suppliers	4.48
52	Activities aimed at deepening or building relations with employees	4.44
53	Empathy in the human-machine relation	3.65

Conclusions

The Idea of Industry 4.0, most comprehensively of all business development models, applies to the area of the economy. Thus, it is de facto a special direction of the country's economic development.

With reference to the above considerations, several trends should be highlighted, the impact of which on the development of enterprises and the entire economy will be a key issue.

Thus, the purpose of the deliberations undertaken in this research paper was to obtain information on the stage of activation of the idea of Industry 4.0 among Polish manufacturers of the agricultural machinery sector. Its implementation is related to 4 specific objectives that were fully achieved. The study defines the merits of the Industry 4.0 axiom, which subsequently allowed nominating the areas that are vital, on the one hand, from the point of view of Industry 4.0, and, on the other hand, determine the maturity of companies in the domain of accepted desiderata. In the course of the conducted investigation, a research model was compiled that implied recognition of the level of technological sophistication of the surveyed enterprises and the specificity of the gap (indication among selected manufacturing companies).

The gathered research material enabled to draw conclusions of a general and cognitive nature. The presumptions adopted in the paper were fully confirmed by the theoretical and empirical arguments carried out (Table 11).

The Idea of Industry 4.0, most comprehensively of all business development models, applies to the area of digitisation. Nowadays, we are no longer talking about the digitisation of simple services and individual tasks, but about the digitisation of the entire production process and intellectual work. Therefore, digitisation cannot take place in an insular manner, but must be a thoughtful process of building a digital platform enterprise (State as a Platform). This requires defining a new approach to data that become a production resource creating value. They can be used in various ways; to optimise processes, teach artificial intelligence algorithms, or extract new information (Data Mining). It is thus recommended to better prepare companies and employees for emerging challenges in order to maximise profits resulting from digital progress.

Another macro trend is the construction of a circular economy. The increasing environmental pressure and shrinking of natural resources will force closing the circulation of raw materials and reusing resources previously treated as waste. This is a serious challenge and requires a number of adjustments on the part of the surveyed enterprises. For companies, it is also a technological challenge, as the circular economy will need new materials and new design methods.

An important point on the development map of the surveyed enterprises will be satisfying the challenges associated with low-carbon production. It is the task of enterprises to take appropriate measures in order to increase the efficiency in creating new management models.

Bioeconomy seems to be the last predicted element of the great revolution in the world economy. On the one hand, it will concern traditional sectors, which will increasingly use raw materials and materials of natural, in particular vegetable, origin. On the other hand, it means the rapid development of biotechnology and its applications in new production areas; in this respect, in the opinion of the surveyed enterprises, a significant gap is emerging, and it undoubtedly needs to be filled.

In spite of the awareness of the great development challenges arising from macro trends and the successful adaptation of enterprises to concept 4.0, there are still a number of delays and internal conditions that require state intervention. This is especially so in that many of them are associated with the occurrence of development barriers resulting from the existing institutional and legal environment.

Table 11
Presumptions testing results.

P	Content	Test
P_1:	*The surveyed manufacturers demonstrate a high level of domain knowledge and the ability to implement selected management concepts.*	√
P_2:	*The research model resulting from the expert discussion reflects the directions of actions that should be undertaken by the surveyed enterprises in the context of Industry 4.0. (research coincidence).*	√
P_3:	*More and more companies organise a business model, in which the reference point is the Industry 4.0 concept.*	√
P_4:	*The process of transforming enterprises into a model based on digital technologies – compared to other spaces – is relatively low.*	√

References

[1] Lasi H., Fettke, P., Kemper, H., Feld, T., Hoffmann M., *Industry 4.0*, Business & Information Systems Engineering, 6, 239–242, 2014.

[2] Garrett G.A., Parrott G.A., *E-Business – Understanding Key Trends and Applaying Best Practices*, Contract Management, 7, 34–42, 2005.

[3] Nogalski B., Niewiadomski P., Szpitter A., *Fourth Generation Industry and Strategic Adaptation Activities of Polish Agricultural Machinery Manufacturers* [in Polish: *Przemysł czwartej generacji a strategiczne działania dostosowawcze polskich wytwórców sektora maszyn rolniczych*, Przegląd Organizacji, 11, 6–13, 2018.

[4] Fischer M., *Glass industry 4.0, i.e. the fourth industrial revolution* [in Polish: *Przemysł szklarski 4.0 czyli czwarta rewolucja przemysłowa*, Świat Szkła, No. 2, 2018.

[5] Atzori L., Iera, A., Morabito G., *The Internet of Things: A survey*, Computer Networks, 54, 15, 2787–2805, 2010.

[6] BCG – Boston Consulting Group (Hg.), *Industry 4.0: The Future of Productivity and Growth in Manufacturing Industries*, München 2015.

[7] Fallera C., Feldmüllera D., *Industry 4.0 Learning Factory for regional SMEs*, Procedia CIRP, 32, 88–91, 2015.

[8] Gamst G., Meyers L.S, Guarino A.J., *Analysis of Variance Designs. A Conceptual and Computational Approach with SPSS and SAS*, Cambridge University Press, New York, 2008.

[9] Hirsch-Kreinsen H., *Wandel von Produktionsarbeit – "Industrie 4.0"*, Soziologisches Arbeitspapier, No. 38, 2014.

[10] https://przemyslprzyszlosci.gov.pl/artykuly/; date of access: 24.01.2020.

[11] Kagermann H., Wahlster W., Helbig J., *Recommendations for implementing the strategic initiative Industrie 4.0: Final report of the Industrie 4.0*, National Academy of Science and Engineering, Munich, 2013.

[12] Lasi H., *Industrial intelligence – a business intelligence-based approach to enhance manufacturing engineering in industrial companies*, Procedia CIRP, 12, 384–389, 2013.

[13] Lee J., *Industry 4.0 in Big Data Environment*, German Harting Magazine, pp. 8–10, 2013.

[14] Lee J., Kao H-A, Yang S., *Service innovation and smart analytics for Industry 4.0 and big data environment*, Procedia CIRP, 16, 3–8, 2014.

[15] Qin J., Liu Y., Grosvenor R., *A Categorical Framework of Manufacturing for Industry 4.0 and Beyond*, Procedia CIRP, 52, 173–178, 2016.

[16] Roland Berger Strategy Consultants, *Industry 4.0. The new industrial revolution How Europe will succeed*, March 2014.

[17] Schlund S., Hämmerle M., Strölin T., *Industrie 4.0 eine Revolution der Arbeitsgestaltung – Wie Automatisierung und Digitalisierung unsere Produktion verändern wird*, Ingenics AG, Ulm-Stuttgart, 2014.

[18] Schmidt R., Möhring M., Härting R.C., Reichstein C., Neumaier P., Jozinović, P., *Industry 4.0 – Potentials for Creating Smart Products: Empirical Research Results*, [in:] Business Information Systems, Abramowicz W. [Ed.], Switzerland: Springer International Publishing, pp. 16–27, 2015.

[19] Subashini S., Kavitha V., *A survey on security issues in service delivery models of cloud computing*, Journal of Network and Computer Applications, 34, 1, 1–11, 2011.

[20] This World Economic Forum white paper, *Readiness for the Future of Production: Country Profiles*, March 2017.

[21] Zuehlkea D., *SmartFactory – Towards a factory-of-things*, Annual Reviews in Control, 34, 1, 129–138, 2010.

[22] Okoli C., Pawlowski S., *The Delphi Method as a Research Tool: An Example, Design Considerations and Applications*, Information & Management, 42, 1, 15–29, 2014.

[23] Paliwoda S.J., *Predicting the Future Using Delphi*, Management Decision, 21, 1, 31–38, 1993.