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Research paper

The impact of selected components of industry 4.0 on project management

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A R T I C L E I N F O

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A B S T R A C T

Purpose: Effective project management has contributed to successful operations and process management. The aim of this article is to scrutinize the relationship between a project success and the selected components of Industry 4.0. Instead of being reactive to measuring cost, timeliness, and quality (customer requirements), a more predictive indicator on a project success is needed.
Design/methodology/approach: The survey involved a group of 370 respondents working in digital (information and communication) technology. The survey questionnaire contained 55 questions focused on 109 features. Data analysis was performed using several statistical techniques .
Findings: On the basis of a comprehensive survey, the findings show strong possibility for components of Industry 4.0 to be adapted as a predictor of project success, especially for digital upgrade and improvement. Selected components of Industry 4.0 play a key role in assuring effective (and successful) project management.
Originality/value: The study highlights the impacts from effective project management on industrial and organizational operations. This highlight is based on the attempt to determine whether the components of Industry 4.0 contribute to project success. In this study, in addition to the three traditional factors of cost, timeliness, and quality (or requirements), Industry 4.0 should be considered as a predictor of project management' success.
Research limitations/implications: The survey was addressed to selected companies operating in the ICT industry (IT projects). The sample selection is based on the non-probability sampling. A novel method of converting respondents' answers into binary form was adopted.

Introduction

Production industry has an immense impact on economic growth, creation of new jobs, business innovation, lower cost of labour or new economic opportunities. The uncertainty of environment and changes occurring in enterprises are the factors forcing the introduction of new approaches in organisation management.

With the arrival of the fourth industrial revolution, new challenges arise both for enterprises and projects implemented by them. A question arises whether Industry 4.0 components may affect project success. This paper aims to answer this question constituting the research topic covered by the study, thus giving managers practical knowledge on how to manage their projects better.

The validity of this problem is confirmed by the reviewed literature on the subject, which indicated a research gap in this area. Thus far, the research pertaining to Industry 4.0 and project success has focused on individual issues without attempting to identify their interdependence. Awareness of these dependencies opens a new perspective for management, focusing attention around the components of Industry 4.0 that support the effective performance of undertakings. Thus, the purpose of this paper was to identify the factors determining project success from the perspective of key components of Industry 4.0.

Identifying the relationship is crucial for effective management, as companies more and more frequently decide to assume a project-based approach to management. Proper performance of projects contributes to gaining competitive edge. That is why the issues concerning effective company management are so important. Still, successful completion of project tasks remains a significant challenge for managers. The more complex components the project involves, the

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greater the uncertainty of the final effects. This happens despite considerable progress in methodology and application (Anke & Ringeisen, 2021; Harwardt, 2020; Kiani Mavi & Standing, 2018; Sanchez et al., 2017; Sicotte & Delerue, 2021). However, it should be noted that the relations between project success and different success factors change depending on the maturity of an organisation. What is more, the factors may be perceived differently by individual project participants (Iriarte & Bayona, 2020).

It is particularly important, because Industry 4.0 applies to the entire organisation, providing digital solutions through integration of complex, mutually related technologies, as well as transforming manufacturing processes and systems from a centralised decisive process into a decentralised one, both within the scope of production as well as supply chain Barata (2021). Furthermore, such an approach strengthens organisations in terms of knowledge sharing which leads to the development of new, often revolutionary solutions as well as supports the company's innovation capabilities (Adamides & Karacapilidis, 2020; Camisón-Haba et al., 2019; Natu & Aparicio, 2022).

This paper provides a review of the publications concerning the conditions and factors affecting project success as well as the issues related to Industry 4.0 concept/theory. The next stage consists of an analysis of reports and materials provided by organisations and associations dealing with the issues concerning project management, ICT projects in particular, as well as the data made available by statistical offices and financial institutions. The last stage presents the analysis of survey results that allowed the critical project success factors to be determined, particularly the identified components of Industry 4.0.

Industry 4.0 – definitions

Industry 4.0 has been considered not only as a concept itself, but also in terms of specific applications implemented in enterprises. It is assumed that the term "Industry 4.0″ was coined at a trade fair in Hannover in 2011, where a German industrial plan called "Industrie 4.0″ was announced. The plan was to encourage German companies to computerise production (Humayun, 2021).

In view of the absence of a single definition, many researchers have attempted to develop an exhaustive definition of Industry 4.0 concept (Figueiras et al., 2021; Horváth & Szabó, 2019; Jiao et al., 2021; Raj et al., 2019). Nevertheless, literature studies prove that the definition of Industry 4.0 is ambiguous and that it is in fact an interdisciplinary issue. For the purpose of this paper, it has been assumed that Industry 4.0 is a smart combination of machines and industrial processes in a network based on new information and communication technologies (Zhang et al., 2021).

Industry 4.0 involves advanced algorithms, data collection methods and data processing methods for the purpose of production management in real time. It allows a managing party to promptly respond to changes occurring directly at the production level. Advanced algorithms are to support managers by providing appropriate recommendations, forecasts or notifications concerning ongoing changes (J Pizoń, Kulisz & Lipski, 2021). Industry 4.0 allows the current status of an object to be monitored in real time, the impact on its present operation to be observed and its future to be foreseen (Kenett & Bortman, 2021; Semeraro et al., 2021). Fourth industrial revolution involves cyber physical production systems (CPPS) (Jakub Pizoń & Lipski, 2016), industrial internet of things, cloud computing, big data, machine learning, integration of industrial information sources and service-orientated architecture (SOA). The key task of these technologies is to improve the production efficiency (Herceg et al., 2020).

The core idea the concept of Industry 4.0 is based on is horizontal integration (Sun et al., 2020) in production management. Industry 4.0 is therefore not only a new industrial revolution, but also a challenge in terms of integration of people, data, services and objects. It requires coherent interaction of a number of components. The key aspects of Industry 4.0 are devices, connectivity, properly handled services and suitable data (Zhang et al., 2021). Unlike vertical integration, where decisions are made following the aggregation of data from operational levels to the management level, in horizontal integration decisions are made in the same place where an action is taken. Naturally, a decision about horizontal integration should comply with the strategy adopted by a company. It enables to considerably reduce time required to make a managerial decision – reliable data is provided in real time. As a result, decisions in necessary areas can be made promptly. It leads to a situation where at a specific level of an organisation, process data and management instructions for a specific batch of materials or products are distributed. The swiftness of decisions and optimisation potential prove the advantage of this approach.

Components of industry 4.0

Publications on the subject characterise Industry 4.0 by a list of its components. Listing them provides an opportunity to properly decompose and categorize specific solutions as part of Industry 4.0 approach. It allows comprehensive solutions to be created considering the importance of individual components. Furthermore, it provides an opportunity to evaluate whether the adopted solution complies with the concept of Industry 4.0 or not.

An extensive literature review (e.g. Hermann et al., 2015; Lu, 2017; Meissner et al., 2017; Oztemel & Gursev, 2018; Vogel-Heuser & Hess, 2016; Zhang et al., 2021) has shown that identifying the components of Industry 4.0 is a complex issue. The publications in this field provide a diverse set of components; some of them are highly specialized while others focus on practical applications of individual components of Industry 4.0. Therefore, the following criteria were adopted to select the components for further research: the number of citations of an article and its scope (state-of-the-art theory or practical application). Furthermore, the selection was supported by years of practical experience gained by the authors, in addition to their previous research in this area (Chadam & Kański, 2020, 2021; Kański & Pizoń, 2022; J Pizoń, Kulisz, Lipski et al., 2021; Jakub Pizoń et al., 2019, 2022; Jakub Pizoń & Gola, 2023; Stączek et al., 2021).s

It should be noted that this selection does not exhaust all the possibilities; nevertheless, in the perspective of the conducted analyses, as well as the purpose of the paper, these components can be considered representative from the viewpoint of project success. Finally, the following set of Industry 4.0 components was adopted for further research:

- Real-time data management – tracking the system through online monitoring to prevent shortage in case of a failure.
- Interoperability – communication between elements of cyber-physical systems with the use of industrial Internet and regular standardisation processes in order to create a smart factory.
- Virtualisation – system monitoring, adaptation of a new system improvement by means of simulation tools or augmented reality.
- Decentralisation – understood as a place of making decisions both at management and executive level (independent decision-making by machines, learning from previous events and actions).
- Agility – ability to adapt to changing requirements by replacing or improving separate modules based on standardised software and hardware interfaces.
- Service orientation – satisfaction with adapting customer's requirements to the system with the use of a perspective relying on the integration of internal and external subsystems.
- Integrated business process – a link between physical systems and software platforms allowing communication and coordination mechanism supported by corporate data management services and connected networks (Salkin et al., 2018).

With the set of identified components of the Industry 4.0 concept, a question arises which components of this solution have a key impact on the success of company projects, and what mutual dependencies exist between the components?

In times of dynamic growth, success of an organisation depends largely on its ability to foster new technologies, particularly the ones representing Industry 4.0. The technologies that will be particularly beneficial in production processes and improving new products contribute to gaining a competitive advantage in all sectors, particularly in manufacturing industry, as it is exceptionally innovative and competitive (Rehman et al., 2021).

Industry 4.0 is becoming strategically important in project management. It results from the fact that the implementation of Industry 4.0 solutions enables optimisation of time and costs, which streamlines critical aspects of large manufacturing companies. All of the improvements listed above are possible to be achieved by means of real-time insights. Organisations should be capable of adapting to changes and new business models (Jally et al. n.d.).

Project and project success

Pusblications on the subject in question present different definitions of the term “project”. The definitions provided by associations, institutes and organisations such as IPMA, Axelos, ISO or PMI place particular emphasis on the unique nature of the process aimed at product manufacturing. The definitions formulated by individual researchers, in turn, emphasize the unique and specific nature of a product, although clear relationship between actions (manufacturing process) and product is also visible (Banica et al., 2017; Cova & Salle, 2005; Dandage et al., 2017; Di Muro & Turner, 2018; IPMA, 2015; Kostalova et al., 2015; Matuhina et al., 2021; Mcgrath et al., 2020; Project Management Institute, 2017; Takagi & Varajão, 2020; Tatjewski, 2002).

Analysis of the data provided above leads to the conclusion that owing to the multitude of definitions, approaches and interpretations the term “project” seems inconclusive and leads to discrepancies in theoretical considerations. However, it can be assumed that a project is *a time-, cost- and resource-constrained unique, standalone undertaking (organisation) aimed at producing a complete, inimitable (in terms of features or production process) product or service.* It is basically expected that a project is deemed to succeed. However, an attempt at drawing up a proper definition of project success is in fact, fraught with difficulties.. It results from the absence of an unambiguous criterion for evaluating the final effect or, in other words, final evaluation depends on the adopted assessment criterion.

The theory of project success existing in practice is to a large extent based on the work by Pinto and Slevin. According to these researchers, project success is evaluated with the use of criteria related to the project, such as time, cost and efficiency, and the ones related to the customer, which include functionality, satisfaction and effectiveness (Terzieva & Morabito, 2016). Bearing the above considerations in mind, numerous managers have called to include a broader scope of proactive success criteria in project management (i.e. the more predictable ones), because budget, schedule and quality are considered reactive (mapping information from the past to the present) (Alexandrova, 2020; Davis, 2017; Tarba et al., 2017). Another approach associates project success with efficiency and effectiveness of its completion (Pankratz & Basten, 2018; Pollack et al., 2018). Contrary to the search for a general measure of success, publications on the subject also refer to project contingency theory (PCT) (Leskovec et al., N.D. Nawawi & Salin, 2018). The studies based on PCT describe four foundations used in project success evaluation (NTCP), i.e. novelty, technology, complexity and pace.

The following research described herein resulted in a short list of components that broadly represent project success. Out of the listed components, the following criteria were selected: importance for project success theory, effectiveness of project actions, authors own study and business experience. Finally, nine key components were selected for further analysis, enabling the evaluation of project success:

- Compliance with the budget.
- Compliance with the schedule.
- Ensuring functionality.
- Customer satisfaction.
- Project team members’ satisfaction.
- Ensuring benefits to the company.
- Achieving the company’s strategic objectives.
- Work environment and knowledge sharing culture .
- Contractual penalties.

Further on, the paper attempts to analyse the impact of individual components of Industry 4.0 on project success components, and, consequently, determine the impact of Industry 4.0 on successful project completion. The analysis was carried out with the use of dedicated statistical methods.

Research methodology

Research model, objectives, hypothesis

The adopted research model (Fig. 1) consisted of three stages: defining the research problem and formulating study objectives (Stage I), four indirect steps related to research process (Stage II), and discussion on the results and drawing up recommendations for application (Stage II).

The first step of Stage 2 involved identification of key components ensuring project success and the most important components of

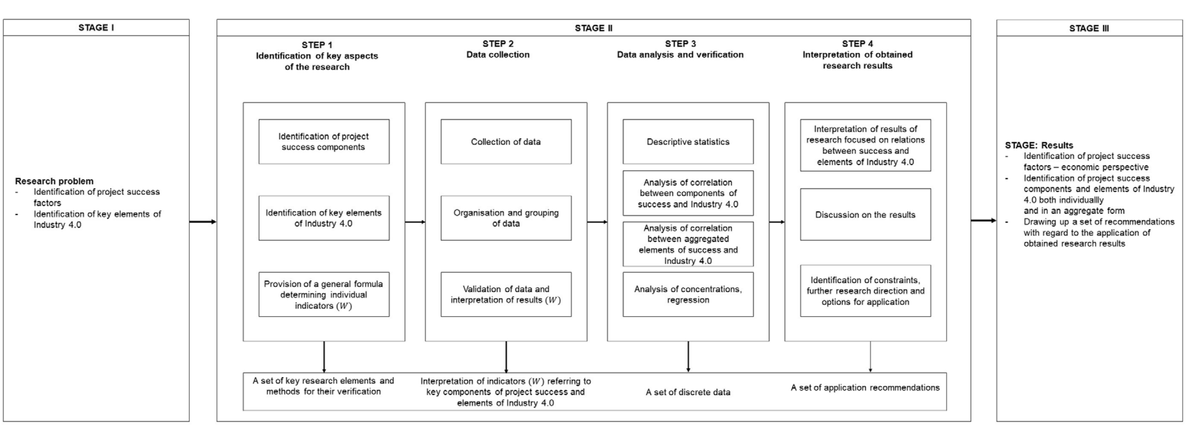

Fig. 1. Research model diagram. Source: own study.

Industry 4.0. The second step consisted in collecting, aggregating and validating the collected data. The results, particularly those concerning the evaluation of project success components and Industry 4.0 concept, were also subject to interpretation. The third step was the crucial stage of the study. It involved characterisation of the research sample together with justification of statistical methods used for the purpose of verifying the relations between project success and Industry 4.0 components. The last (fourth) step was the interpretation of research results, particularly the determination of dependencies between components of Industry 4.0 and components of project success, as well as project success in an aggregate form, with the use of a developed formula for determining indicators (W). The result of this step was the development of a set of application recommendations.

The fundamental reason for starting the survey was an attempt to identify the components of Industry 4.0 concept which are most commonly applied in economic practice and check how they affect the final result of works as part of a project. The analysis led to the definition of the following research problem: there is insufficient understanding of the relations between project success and Industry 4.0 components. Therefore, the main purpose of the study was to identify the conditions and factors affecting the success of projects in the context of commonly applied assumptions of Industry 4.0 concept. On the basis of the identified research problem, the following main research hypothesis was developed:

H1 **Choosing the right configuration of Industry 4.0 components is the key condition for successful project completion.**

In order to make the main hypothesis more detailed and the conducted survey more comprehensive, two supporting hypotheses were formulated:

H1.1 **The level of implementation of Industry 4.0 solutions in companies affects project success (a relationship exists between these components).**

H1.2 **There are co-dependencies between components of Industry 4.0 and project success components.**

Research methods

The implementation of the adopted research methods was preceded by a review of publications concerning the conditions and factors affecting project success and other issues related to Industry 4.0 concept. An extensive analysis of reports and materials provided by organisations and associations dealing with the issues related to project management (see Project Management Institute, 2017; The Standish Group, 2020; Axelos Global Best Practice, 2019; Reputation Institute, 2019; Interbrand, 2020), Industry 4.0 (Deloitte Developments, 2020; Industry 4.0 Opportunities & Challenges of the Industrial Internet, 2014); Deloite, PWC) and the data made available by statistical offices and financial institutions was carried out. For the purposes of the authors' own study, a survey was developed to determine critical project success factors, and identified Industry 4.0 components in particular.

The methodology adopted for the survey consisted in the development of a questionnaire, analysis and interpretation of the results, and discussion of research implications. The sample of survey respondents was selected based on non-probability sampling technique. The participants were required to have the experience in managing large-scale investment projects, as well as in creation of corporate standards on project management practice. The survey questionnaire was the basic research tool. It was composed of four sections and included 55 questions addressing 109 parameters. In the majority of questions, a five-point Likert scale was applied. It is a bipolar interval scale for measuring respondents' attitudes and opinions. Bipolarity is understood as the occurrence of two opposite extremes – on both ends of the scale there are opposite opinions. Interval-based structure indicates that subsequent points of the scale are ranked in order, and the distance between them is the same. Likert scale was interpreted in a traditional manner (1 – I strongly disagree, 2 – I rather disagree, 3 – inconclusive, 4 – I rather agree, 5 – I strongly agree). Some of the survey questions used dedicated measurement scales depending on the purpose of the survey and on the adopted research method (nominal, dichotomous, ordinal and interval scale). Respondents completed the survey in an electronic format, following the instructions provided on the website.

The survey was carried out with the use of LimeSurvey online tool, while statistical analyses were performed with the use of IBM SPSS Statistics and StatSoft Statistica software. Inference was based on selected descriptive statistics of project success and components of Industry 4.0. Further, for the purpose of analyses, also correlations (Spearman's rank correlation analysis) between project success and components of Industry 4.0 and between project success and "clustered" components of Industry 4.0 were applied. Additionally, cross-tabulations and model-based approach, i.e. multivariate and logistic regression were used. For each data set, Cronbach's alpha coefficient (AC) was estimated, each time testing the internal consistency of the survey tool (AC>0.6). The analyses were based on the data obtained directly from survey questionnaires and converted to 0–1 form using the formula below (Formula 1). For the purposes of statistical data analysis, measurements (variables) were standardised. The purpose of standardisation was to transform measurements expressed in different units into uniform scales expressed in consistent units (standardised measurement - deviation of results expressed in the value of standard deviation from mean value being 0). Standardisation of variables allowed the unification of statistical inference, which made it possible to define the strength with which individual variables affected the analysed phenomenon and to identify the variables deviating from estimated values.

Methodology of statistical data analysis

The data obtained from the survey was analysed in two phases. The analyses of source data (prior to transformation) were carried out first. In the second phase, indicators based on the data (transformed source data) were developed and used for further analyses.

The collected data were analysed with the use of selected descriptive statistics measures and statistical tests (chi-squared test, Yates's correction for continuity, Cramér's V, determination coefficient, likelihood ratio, linear relationship test). Reliability of the adopted scales was analysed with the use of Cronbach's alpha coefficient as a technique measuring homogeneity.

An original formula for determining the value of indicators (W) of meeting of specific criteria was developed for groups of questions selected in the survey (Formula 1). The indicators were used to determine the degree of achieving selected aspects of project success and to evaluate specific components of Industry 4.0, and, consequently, to determine the level of company's industrialisation in the context of Industry 4.0 and the success of the entire project. Categorical variables that took values from 1 (strongly disagree) to 5 (strongly agree) were divided into three categories: *'0'* (strongly disagree, disagree), *'i'* (inconclusive), *'1'* (agree, strongly agree).

Formula 1. General formula for determining the indicator (W)

$$W = \begin{cases} 0, \ for \sum_{i=1}^{n} x_i < 3n \\ inconclusive, \ for \ \sum_{i=1}^{n} x_i = 3n \\ 1, \ for \ \sum_{i=1}^{n} x_i > 3n \end{cases}$$

W – designated indicator,

n – the number of components (taken into account in development of the indicator),

i – subsequent number of analysed response (assessment),

x_i – value of response (evaluation) expressed by a respondent for the ith object included in the indicator, $x_i \in \{1, 2, 3, 4, 5\}$.

The resulting W indicator was interpreted as follows:

- 0 – means the value of the indicator for the sum of points below $3n$ – interpreted as condition unfulfilled,
- *Inconclusive* – means that a value of 0 or 1 cannot be assigned to an indicator for a sum of points equal to $3n$,
- 1 – means the value of the indicator for the sum of points above $3n$, interpreted as condition fulfilled.

As a limit of the positive verification of each determined indicator, a middle value was adopted ($3n$) between the minimum (n) and maximum ($5n$) value of obtained score for each determined indicator. The minimum value of possible points determining a given indicator (feature) is a product of the number of responses and the value of 1 (from five-point Likert scale). The maximum value for a given indicator (feature) is the product of the number of responses and the value of 5 (from five-point Likert scale).

With the use of processed data, an attempt was made to develop a model (multiple and logistic regression analysis) of the project success's dependency on identified Industry 4.0 components.

Characteristics of research data

The research was quantitative, with non-probability sampling. It was carried out amongst active large-scale project managers and people developing company project management standards (managerial staff, product managers, project managers and users). The research covered people participating in the execution of projects in the broadly-understood industrial area, as well as providing advisory and consultancy services in this domain, third party experts and contract engineers in particular. The scope of research covered the analysis of the role of a general contractor (supplier) and a subcontractor (subsuppliers) in the project. On the contractor's part, respondents included project managers, product managers and representatives of executives. On the subcontractor's part, respondents included project managers and representatives of executives. Taking the above assumptions into account, research questionnaires were addressed to industrial sector employees. The survey was carried out in enterprises having their head offices or divisions in Poland, although it covered projects executed in the international, mostly European, market. In total, 370 completed questionnaires were collected.

In the analysed cases, the role of a general contractor was represented by 71.9% of respondents, while the role of a subcontractor by 28.1% of respondents. The respondents represented micro- (21.6%), small- (25.9%), medium- (31.9%) and large-sized enterprises (20.5%). It should be noted that 67.8% of respondents were employed by the companies operating in the market for more than 5 years. The most numerous group were the employees of the electromechanical industry (22.2%) and light industry (20%). The most numerous group of all, i.e. 38.6% of respondents, were aged 36–50. In turn, 30% of respondents were senior managers. The participants of the survey were the employees with over 6 years' work experience (62.1%), including those with over 10 years' experience in project management (43.2% of respondents).

The analysis of the results showed that 41.6% of respondents worked in middle-volume production, 38.6% in low-volume production and 19.7% in lhigh-volume production. In addition, 37% of respondents declared that in their factories there were 51–100 machines, 28.6% reported 11–50 machines, 25.4% declared the use of fewer than 10 machines and 8.9% of respondents said their factories used more than 100 machines. The full research allows concluding

Table 1
Characteristics of the research sample.

Characteristics of companies represented by respondents Type of customers served by the company		
Domestic	79.2%	
Foreign	20.8%	
Number of production system machines and devices in the company		
1 to 10	25.4%	
11 to 50	28.6%	
51 to 100	37%	
Over 100	8.9%	
Degree of digitisation of production system machines and devices		
No digitisation	17.3%	
Low digitisation	22.7%	
Average digitisation	8.6%	
High digitisation	32.4%	
Very high digitisation	18.9%	
Type of production		
low-volume	38.6%	
middle-volume	41.6%	
high-volume	19.7%	
Prevailing role of the company		
General contractor / Supplier	71.9%	
Subcontractor / Sub-supplier	28.1%	
Categories of surveyed companies according to their size		
Micro	21.6%	
Small	25.9%	
Medium	31.9%	
Large	20.5%	
Duration of operation		
Up to 1 year	10.3%	
From 1 year to 5 years	21.9%	
From 6 years to 10 years	36.8%	
Over 10 years	31.1%	
Industry in which the company operates		
Electromechanical industry		22.2%
Light industry		20%
Construction and real estate		7.6%
IT/ICT		5.7%
Energy&Power		5.9%
Fuel and energy		1.9%
Metallurgical industry		7%
Chemical industry		3%
Mineral industry (glass and ceramic production)		4.3%
Wood and paper industry		7.8%
Food industry		8.4%
High-tech industry		5.9%
Other		0.3%
Characteristics of respondents		
Respondents' age		
Up to 25 years	23%	
From 26 to 35 years	30%	
From 36 to 50 years	38.6%	
Over 50 years	8.4%	
Respondents' work positions		
Production employee	23.2%	
Low- or mid-level manager	27.6%	
High-level manager	30%	
President-CEO / Member of the Management Board	19.2%	

(*continued*)

Table 1 (*Continued*)

Respondents' professional experience	
Respondents' professional experience	
Less than one year	13.2%
From 2 to 5 years	24.6%
From 6 to 10 years	18.9%
Over 10 years	43.2%

Source: own study. $N = 370$.

that the analysis covered large-scale and very complex projects, i.e. those that involve large project teams. Table 1 presents a summary of the research sample.

The impact of components of industry 4.0 on project success – research results

Analysis of the degree of incorporation of individual components of industry 4.0 concept

First of all, the degree of incorporation of individual components of Industry 4.0, playing a crucial role in an enterprise, was analysed. The respondents were asked 24 questions concerning the degree of fulfillment of Industry 4.0 specific components. The value of Cronbach's alpha coefficient ($AC = 0.976$) indicates thata the selection of variables adopted for the purpose of determining the application of Industry 4.0 solutions in an enterprise was adequate. The results of data analysis concerning individual parameters of Industry 4.0 are presented in Table 2.

On the basis of the results obtained, the conclusion can be drawn that the majority of respondents did not indicate the occurrence of components of Industry 4.0 in their work, which is proven by the mean value ($\overline{X} < 3.0$). The lowest mean value ($\overline{X} = 2.51$) was obtained for the use of data in response to the change (failure) of machine status. Only in four cases the mean value was above $3,0:$ management decisions concerning the manufacturing process are made at a higher level of organisation and cascaded to executive level (3.18), production process is carried out accordingly to the process needs (3.07), provision of services and products is adapted to individual customers' needs (3.09) and modification of the production system accordingly to customers' needs (3.05). It proves a positive perception of components of Industry 4.0, while the analysis of other components shows a positive trend in their perception and understanding their relevance. The conducted analysis as well as the values of the remaining indicators presented in Table 2 allow positive verification of H2 which can also be interpreted that the levels of individual components of Industry 4.0 reported in companies are similar to each other.

On the basis of components of Industry 4.0, the indicators concerning the achievement of specific levels by individual components in accordance with Formula 1 were determined. For each of the seven main components, sums of partial responses that were used to determine the indicators and applied in regression analyses, were specified. The evaluation of components of Industry 4.0 was verified with a different number of questions, depending on the analysed feature (data management – 7 questions, interoperability – 4 questions, decentralisation – 2 questions, agility – 2 questions, service orientation –2 questions, integrated business processes – 3 questions and virtualisation – 4 questions). All the questions ($n = 24$) were developed on the basis of a 5-point Likert scale. With the use of the indicators it was determined whether, according to respondents, a specific level of individual components of Industry 4.0 was reached (indicators for each case in the surveyed sample were estimated). Next, the frequencies for three distinguished groups (negative verification,

Table 2
Identification of the degree of incorporation of individual components of Industry 4.0 in the execution of project tasks.

Selected components of Industry 4.0		Mean $\overline{X}$
Data management	The company obtains the data from sensors in production system machines and devices.	2.79
	The company collects the data from sensors in production system machines and devices as part of a central data inventory.	2.88
	The company analyses the collected data under one database.	2.70
	The company presents the collected data to company employees in real time (on screens placed all over company premises or on mobile devices).	2.68
	The company uses the data to monitor machine status. In the event of a failure, the data indicates when and where the failure occurred.	2.75
	The company uses the data to respond to machine status changes. If the permitted values are exceeded, a notification on the probability of a failure is generated.	2.51
	The company uses the data to forecast future status of production system machines and devices. The algorithms applied indicate possible time of failure.	2.71
Interoperability	The company is in possession of computer and network infrastructure allowing the transfer of data from the source (machine, sensor, operator) to a place where it is stored and analysed.	2.86
	The data is transferred from the source to the place where it is processed in one standardised form for all production system machines and devices.	2.72
	The company obtains data concerning production processes in real time (time in which events related to the execution of production processes occur).	2.88
	The company collects data concerning production processes in defined time intervals.	2.96
Decentralisation	Management decisions concerning the production process are made at higher level and cascaded to executive level.	3.18
	Management decisions concerning the production process are made at executive level adequately to the conditions at this level.	2.86
Agility	The company pursues the production process on the basis of a closed, specialist production process. It is not possible to modify the components of the production process.	2.83
	The company pursues the production process by reorganising the production process depending on the process needs.	3.07
Service orientation	The company provides services and products adjusted to the needs of individual customers.	3.09
	The production process is modified accordingly to the needs of individual customers.	3.05
Integrated business processes	The company manages its operations on the basis of defined business processes.	2.84
	The defined processes of the organisation ensure communication and coordination of actions.	2.91
	Communication and coordination of actions is based on IT workflow tools, using the data obtained from production system machines and devices.	2.65
Virtualisation	General use.	2.85
	Use in monitoring.	2.69
	Use in designing.	2.97
	Use in data analysis.	2.68

Source: own study. $N = 370$.

Table 3
Evaluation of Industry 4.0 components (%).

Components of Industry 4.0	Negative verification of the indicator	Inconcl-usive	Positive verification of the indicator
Data management	57%	0%	43%
Interoperability	50.8%	1.1%	48.1%
Decentralisation	40.8%	7.3%	51.9%
Agility	43%	11.6%	45.4%
Service orientation	44.9%	6.5%	48.6%
Business processes	50.8%	2.7%	46.5%
Virtualisation	48.1%	1.9%	50%

Source: own study. $N = 370$.

inconclusive, positive verification – Table 3) were counted. For most projects, respondents more often indicated positive verification of Industry 4.0 partial component indicator than negative.

The next step consisted in the verification of Industry 4.0 application (aggregate form). The analyses were carried out based on the responses to all questions ($n = 24$) concerning the evaluation of objects comprising Industry 4.0 indicator – in accordance with Formula 1. The limit value indicating the application of Industry 4.0 or the absence of its application was 72. With such a criterion, frequency of occurrence of Industry 4.0 and its absence was determined. The conducted analysis shows that 52.4% of respondents indicated more frequent application of Industry 4.0 in their undertakings. The result is satisfactory, because the participation of people applying Industry 4.0 in the survey allows the actual conditions of project success to be investigated in the context of application of Industry 4.0 components.

Project success analysis

Secondly, a similar analysis of factors considered to be of key significance to project success was carried out. The components were selected on the basis of an extensive review of publications on the subject, as described in the first part of the paper. Respondents were asked 12 questions concerning the degree of occurrence of individual project success components (5-point Likert scale). The value of Cronbach's alpha coefficient ($AC = 0.938$) indicates proper selection of the adopted variables for the purpose of determining project success. The results of data analysis concerning individual parameters of project success were presented in Table 4.

Mean values ($\overline{X}$) for nine analysed variables were between 3.09 and 3.27. In three cases, (customer satisfaction, assistance provided to colleagues, contractual penalties) the result was below 3.0. The components with the highest mean values were project team members' satisfaction ($\overline{X} = 3.26$), work environment and the culture of sharing knowledge ($\overline{X} = 3.27$). The results of the analysis allow the conclusion that in most cases analysed the summary of project execution and fulfillment of assumed objectives is conducive to project success with a reservation that it is not tantamount to the meeting of all project objectives to the greatest extent possible. Just as in the case above, the results of analysis were presented in Table 4. This means that the frequencies of project success components reported in companies are similar.

On the basis of success components, the indicators related to the achievement of specific levels of individual project success components in accordance with Formula 1 were determined. The respondents were asked one question. With the use of the calculated indicators, it was determined whether individual project success components reached specified levels according to respondents (for each case in the research sample the indicators were estimated). Next, frequencies for three distinguished groups (negative verification, inconclusive, positive verification – Table 5) were counted. In the evaluated projects, respondents more often indicated positive verification of the indicator of success partial components than the negative one.

In the next step, the fact that the project was successful underwent verification (aggregate form). Analyses were conducted based on the responses to all survey questions ($n = 12$) concerning the evaluation of project success indicator constituents – in accordance with Formula 1. The threshold value indicating project success or failure was 36. With this criterion, frequency of project success and failure was determined. The conducted analysis shows that 51.4% of respondents indicated more frequent success than failure in executed undertakings. The result is satisfactory, because the participation of people whose projects have been successful in the research makes allows investigation of actual conditions of project success.

Industry 4.0 vs. project success

Previous analyses concerned an independent approach to both components of Industry 4.0 and project success. A summary of these two areas is presented below. The research on Industry 4.0 currently carried out by researchers leaves no doubt that the implementation of solutions derived from Industry 4.0 concept is conducive to the successful completion of a project. Similar conclusions are drawn from the analysis of the authors' own research. For the purposes of the analysis, the collected responses concerning success and failure were listed along with the information on the actual implementation of Industry 4.0 solutions.

The scatter diagram below (Fig. 2) illustrates the aggregate responses of survey participants regarding Industry 4.0 – horizontal axis $\langle 24; 120 \rangle$ and regarding project success – vertical axis $\langle 12; 60 \rangle$.

The figure presents two clusters marked with rectangles. The horizontal line dividing the two clusters results from the threshold value

Table 4
Results of individual project success components analysis.

Selected components of project success		Mean $\overline{X}$
Compliance with the budget		3.13
Compliance with the schedule		3.09
Ensuring functionality		3.11
Customer satisfaction		2.95
Project team members' satisfaction		3.26
Ensuring benefits to the company	Execution of projects/orders ensures required technical benefits to the recipients of project products	3.18
	Execution of projects/orders ensures required organisational benefits to the recipients of project products	3.09
	Execution of projects/orders ensures required business benefits to the recipients of project products	3.19
Achievement of company's strategic objectives		3.14
Work environment and the culture of sharing knowledge	Work environment and organisation of project/order execution environment are friendly and mature; the culture of sharing knowledge is promoted.	3.27
	You eagerly help your colleagues selflessly	2.96
Contractual penalties		2.66

Source: own study. $N = 370$.

Table 5
Evaluation of project success components (%).

Project success components	Negative verification of the indicator	inconclusive	Positive verification of the indicator
Compliance with the budget	45.01%	4.1%	50.08%
Compliance with the schedule	44.6%	3.5%	51.9%
Ensuring functionality	47.6%	3.2%	49.2%
Customer satisfaction	50.8%	8.4%	40.8%
Project team members' satisfaction	40.8%	5.4%	53.8%
Ensuring benefits to the company	47%	2.7%	50.3%
Achievement of company's strategic objectives	43.8%	3.2%	53%
Work environment and the culture of sharing knowledge	41.4%	5.4%	53.2%
Contractual penalties	50.5%	34.3%	15.1%

Source: own study. *N* = 370.

at 36 pts. This value means that it remains inconclusive whether a project was successful. The set above represents project success, whereas the set below illustrates project failure. The vertical line dividing the two sets results from the threshold value at 72 pts. This value means that it remained inconclusive whether the solutions supporting Industry 4.0 were applied. The set to the left represents the absence of Industry 4.0, whereas the set on the right illustrates the approach applying Industry 4.0. A conclusion can be drawn from the presented diagram that increased application of Industry 4.0 solutions significantly increases the chance of project success. The analyses showed that these undertakings were carried out with the use of Industry 4.0 solutions. The value of $R^2 = 0.754$ coefficient proves correct adjustment of the model.

In conclusion, it has been proven that the extent of implementation of Industry 4.0 solutions in an enterprise affects project success (there is a relationship between these components), which allows positive verification of the first supporting hypothesis H1.1.

In the adopted research model, application of the solutions promoted by Industry 4.0 is the factor affecting the achievement of project success. Firstly, the analyses of correlations were conducted with the use of determined indicators of Industry 4.0 (7 components) and project success components (9 components). The analyses were carried out on standardised data. In total, 63 coefficients were obtained. The results of the analysis (Spearman's correlation) of Industry 4.0 components and project success components are presented in Table 6.

The strongest correlations were reported for: data management and project team's satisfaction (0.700); data management and ensuring benefits for the company (0.788); integration of business processes and scheduling (0.706). The lowest impact of individual components of agility were reported for contractual penalties – weak correlation in three cases [data management (0.352), interoperability (0.399), integration of business processes (0.342)].

Further, a generalisation was made and the correlation of aggregate components of Industry 4.0 with individual project success components was analysed. The analysis of results (correlation coefficients) showed a strong correlation of aggregate components of agility with all the remaining project success components apart from contractual penalties: budget (0, 672), schedule (0, 717), functional performance (0.691), customer satisfaction (0.568), team members' satisfaction (0.711), achievement of company's strategic objectives (0.634), ensuring benefits to the company (0.788), work environment and the culture of sharing knowledge (0.618), and contractual penalties (0.491).

By means of another generalisation, a correlation of aggregate components of Industry 4.0 and project success was analysed. Table 7

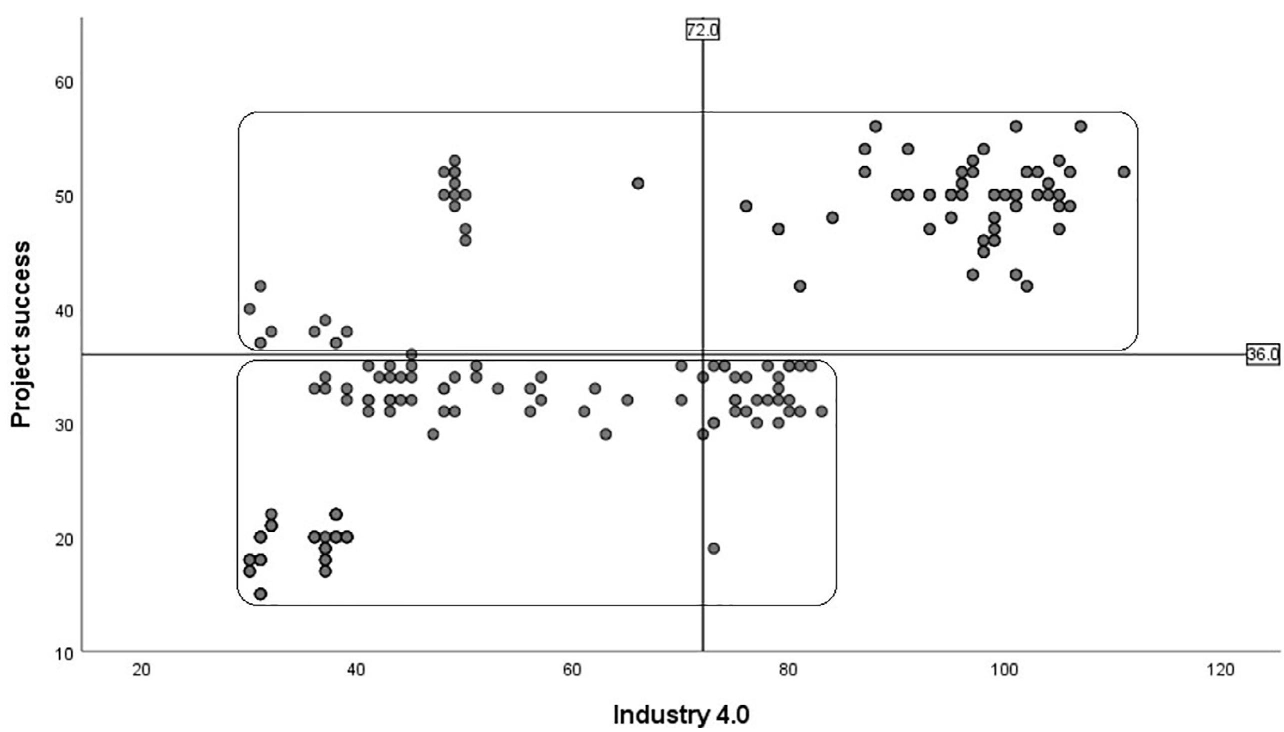

Fig. 2. Scatter diagram for Industry 4.0 and project success (summary). Source: own study. *N* = 367.

Table 6
Results of correlation analysis (Spearman's rho) – Identified components of Industry 4.0 / project success.

Components of Industry 4.0		Project success								
		Budget	Schedule	Functionality	Customer satisfaction	Team members' satisfaction	Achievement of company's strategic objectives	Ensuring benefits to the company	Work environment and the culture of sharing knowledge	Contractual penalties
Data management	Correlation coefficient	0.658**	0.666**	0.676**	0.611**	0.700**	0.583**	0.788**	0.579**	0.352**
Interoperability	Correlation coefficient	0.586**	0.607**	0.654**	0.535**	0.629**	0.491**	0.660**	0.409**	0.399**
Decentralisation	Correlation coefficient	0.545**	0.635**	0.562**	0.476**	0.553**	0.559**	0.632**	0.553**	0.505**
Agility	Correlation coefficient	0.588**	0.632**	0.597**	0.402**	0.510**	0.551**	0.646**	0.487**	0.468**
Service orientation	Correlation coefficient	0.431**	0.507**	0.454**	0.472**	0.513**	0.553**	0.645**	0.549**	0.489**
Integrated business processes	Correlation coefficient	0.689**	0.706**	0.606**	0.497**	0.620**	0.461**	0.618**	0.441**	0.342**
Virtualisation	Correlation coefficient	0.645**	0.647**	0.675**	0.509**	0.639**	0.503**	0.679**	0.467**	0.422**

Source: own study. For all coefficients – significance (bilateral) $p < 0,001$. $N = 370$.

Table 7
Table of contingency for project results and organisational culture.

		Project result		TOTAL
		Failure	Success	
Industry 4.0	Absence	40.6%	6.45%	47.14%
	Presence	7.63%	45.23%	52.86%
TOTAL		48.23%	51.77%	100%

Source: own study. $N = 367$.

presents (in%) the frequency of project success/failure occurrence depending on the presence or absence of Industry 4.0 solutions in an enterprise.

Absence of Industry 4.0 solutions results in project failure – as has been proven by 40.6% of respondents. The analysis conducted clearly shows that implementing Industry 4.0 solutions significantly increased the probability of a project being successful. As a conclusion of the analyses concerning the relationship between Industry 4.0 and project success, the strength of this relationship was verified. All of the obtained results are statistically significant ($p < 0.001$). The result of the chi-squared test ($\chi^2 = 188.259;\ df = 1$) indicates that there is dependence between Industry 4.0 and project success. The ϕ measure $\left(\lambda(x) = 208.848;\ df = 1,\ \varphi = 0.716\right)$, Cramér's V ($Cramer's\ V = 0.716$) and Spearman's rank ($\rho_S = 0.716$) correlation prove considerable dependence between project result and solutions promoted by Industry 4.0.

Summing up, it has been proven that there are relationships between project success components and individual components of Industry 4.0, both individually (in various approaches) and in an aggregate form. **Positive verification of the second supporting hypothesis H1.2 has confirmed that there are strong dependencies between Industry 4.0 and successful execution of tasks.**

The adopted research model generally indicated Industry 4.0 as the factor affecting project success. In order to verify hypothesis H1, an attempt was made to identify the components of Industry 4.0 (from amongst its 7 main components) that showed the strongest relations with project success (independent variables). Identification was made with the use of regression analysis, referring to all the components of Industry 4.0. Two approaches to modelling were employed: multiple regression (backward elimination method) and logistic regression (backward elimination method: likelihood ratio).

In the model using multiple regression, the final project result as adopted as the independent variable (aggregate approach to project success). The obtained results lead to a conclusion that three out of seven studied components in the created model demonstrated statistical significance of less than 0.05 ($p < 0.05$). The results are shown in Table 8.

The model comprised the following components: data management (dm), decentralisation (dec) and virtualisation (vir); all of them were presented in Formula 2 below. The value of collinearity test (VIF) for variables in the model points to the occurrence of minor collinearity of predictors ($1 < VIF < 10$), in might therefore be assumed that the problem of collinearity is at an acceptable level.

Formula 2. Project success model I – aggregate form

$$S_p = 10.318 + 0.805\ dm + 1.159\ dec + 0.396\ vir$$

From all of the above-listed components, the one having the strongest impact on project success (S_p) was decentralisation ($B = 1.159$). Data management ($B = 0.805$) and virtualisation ($B = 0.396$) are also a part of the model, but their contribution is visibly smaller. The value of determination coefficient ($R^2 = 0.776$) within the obtained model proves that the model of dependencies between components of Industry 4.0 and project success is adequate.

The formula presented above allows a partial conclusion to be made that the increase in aggregate level of the aforementioned components affects the increase in aggregate level of project success.

Table 8
Results of linear regression.

Model	Non-standardised coefficients		Standardised coefficients	t	Significance	Collinearity statistics	
	B	Standard error	Beta			Tolerance	VIF
(Constant)	10.318	0.855		12.068	0.000		
dm	0.805	0.063	0.558	12.846	0.000	0.325	3.077
dec	1.159	0.199	0.228	5.819	0.000	0.401	2.497
vir	0.396	0.112	0.164	3.550	0.000	0.286	3.495

Source: own study. $N = 370$.

Furthermore, an analysis of logistic regression was performed, as part of which both project success (dependant variable) and all independent variables assumed the binary format of 0–1. The following components were part of the model ($logit\ P = -1.844 + 1.085VIR + 4,628DM$): virtualisation (VIR) and data management (DM) – Table 9. The detailed form of the model is presented in Formula 3.

Formula 3. Project success model II – aggregate form

$$P(X) = \frac{1}{1 + e^{-(-1.844+1.085\ VIR+4.628\ DM)}}$$

The model presented above indicates project success or failure with great accuracy (total% of correct classifications – 89.6; see Table 10). On the basis of the information in binary format (0–1) concerning virtualisation and data management, it is possible to predict the result of a project (success or failure) with 90% accuracy.

Table 11 presents further calculations of the value of project success indicator depending on different values of independent variables. For the value of success to be higher than the limit value 0.5, the following components are necessary: data management and virtualisation in combination or just virtualisation (value 1).

Theoretical and practical implications

Theoretical implications

Individual components of Industry 4.0 should be considered not only in the context of measurement or calculation, but also in terms of understanding the essence of its creation and development. The conducted analyses have demonstrated that Industry 4.0 is largely a process of sharing and stabilizing (structuring) knowledge within a company. This value cannot be managed directly, only through corporate culture that is conducive to its effective application. Effective enterprise management implies effective management of Industry 4.0 as a resource (Shaykhulova & Selivanov, 2021). Therefore, effective Industry 4.0 management shall be construed as effective management of Industry 4.0 components, leading to enhancement of profit generation, building competitive advantage and ultimately market stability. Such approach fosters innovation and the formation of atmosphere of trust which all constitute fundamental factors of providing better goods and services to consumers. By promoting market fairness, the system of intellectual property rights benefits users, consumers and society at large by fostering innovative, better products and spreading the development of knowledge that contributes to a higher quality of life around the world.

Table 9
Results of logistic regression.

Variables	B	Standard error	Wald	df	Significance	Exp(B)
DM	4.628	0.690	44.958	1	0.000	102.334
VIR	1.085	0.444	5.988	1	0.014	2.960
(Constant)	−1.844	0.228	65.324	1	0.000	0.158

Source: own study. $N = 370$.

Managerial implications

The result of the project where respondents indicated the presence or absence of Industry 4.0 solutions was presented in Fig. 3. In both cases, the data on the vertical axis was presented in an aggregate form, while the data on the horizontal axis used the values obtained after the conversion of the sum of points under approach 0 (condition unmet) and 1 (condition met).

Outlying and extreme values have been reported for the presence of Industry 4.0. These measurements have been identified below the lower scope of non-outlying values, which means that the project failed despite the implementation of Industry 4.0 solutions, (however, these were rare cases). From the opposite perspective, the solutions of Industry 4.0 were broadly applied to projects which proved to be successful (median 97 pts, mean 90 pts). For the projects that failed, the median was merely 38 pts, while the mean was 45 pts. Outlying values have been identified for project failure. These measurements have been identified above the higher range of non-outlying values, which means that despite broad implementation of Industry 4.0 solutions, the project failed. Outlying and extreme values have been reported for project success. These measurements have been identified below the lower scope of non-outlying values, which means that despite insufficient implementation of Industry 4.0 solutions, a project succeeded. In both cases, however, these measurements were rare.

Breakdowns presented in Fig. 3 clearly show that strong dependencies exist between the application of Industry 4.0 and project success from two perspectives. It has been shown that: (1) broad application of Industry 4.0 solutions increases the chance for a project to succeed; (2) project success occurs in the enterprises where Industry 4.0 solutions have been extensively applied.

Table 10
Classification of model II.

Observed		Predicted		
		Success		Per cent value of correct classifications
		0	1	
Success	0	161	3	98.2
	1	32	140	81.4
% in total				89.6

Source: own study. $N = 370$.

Table 11
Project success values $P(X)$ depending on *DM* and VIR.

No.	DM	VIR	P(X)
1	0	0	0.137
2	0	1	0.942
3	1	0	0.313
4	1	1	0.980

Source: own study.

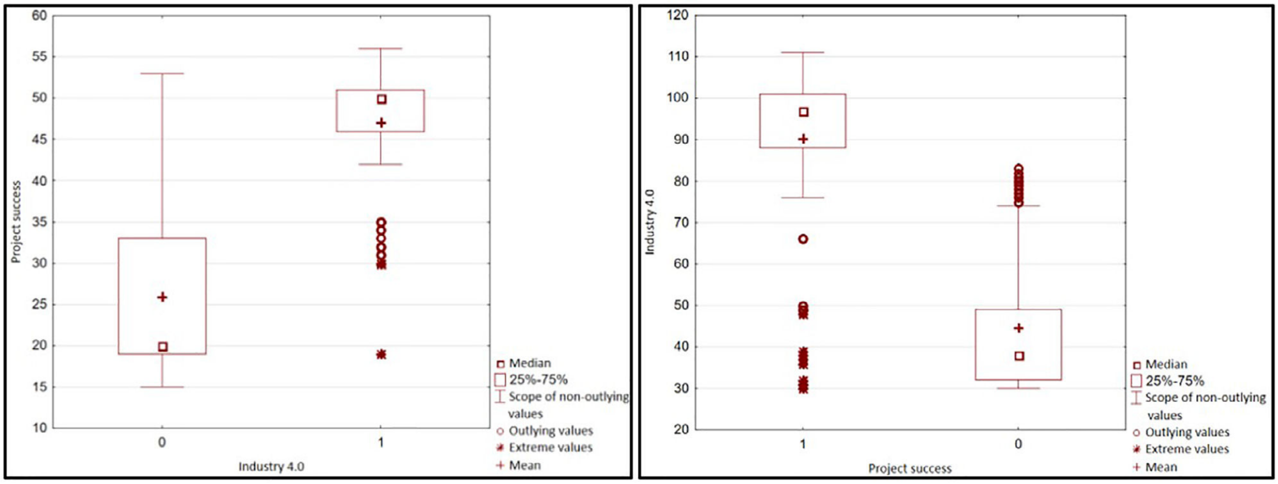

Fig. 3. Result for the project vs. Industry 4.0. Source: own study. *N* = 370.

Discussion of results

The purpose of the study was to identify the factors determining project success from the perspective of identified components of Industry 4.0 approach. The factors were discussed in detail in the first part of the paper. Each factor was evaluated separately, based on its significance during the performance of tasks. Further part of the paper focuses on analysing the correlations between the factors and project success components both individually and in an aggregate form.

Positive verification of hypothesis H1.1 has shown that projects succeed more frequently with the application of Industry 4.0 (median 50 pts, mean 47 pts) than with insufficient application of Industry 4.0 (median 20 pts, mean 26 pts) – see Fig. 3.

Moreover, verification of hypothesis H1.2 allows the conclusion that over 45% of respondents who indicated the presence of Industry 4.0 solutions in their enterprises also reported project success – see Table 7.

Finally, using regression analysis it was proven that for the success value to be higher than the limit value (50%), the following components are indispensable: data management and virtualisation combined or just virtualisation – see Table 11. Thus, certain **conclusions and recommendations** concerning project success can be drawn:

1. *Data management* affects project success. The chance for a project to succeed in an organisation that applies Industry 4.0 solution is significantly higher than in an organisation that has not applied it ($e^{4.628}$ $(1-0) = 102.309$).
2. *Virtualisation* affects project success. The chance for a project to succeed in an organisation that applies Industry 4.0 solution is significantly higher than in an organisation that has not applied it ($e^{1.085}$ $(1-0) = 2.959$).

In conclusion, positive verification of supporting hypotheses (H1.1 and H1.2) as well as the entire research material and its analyses allow an **unambiguous positive verification of H1**, which means that choosing the right configuration of Industry 4.0 components is the essential condition for successful project completion. The analysed correlation presented above clearly proved the occurrence of dependencies between the application of Industry 4.0 solutions and project success. Its impact was recorded both with reference to individual success components and in an aggregate form. It means that Industry 4.0 is an indispensable component (prerequisite) guaranteeing project success.

The research conducted and the results obtained complement the research gap identified in the literature on the subject of project success from the perspective of the fourth industrial revolution (Vrchota et al., 2020). Research to date has mainly focused on demonstrating the overall relationship between project success and Industry 4.0, with lesser focus on identifying the relationship between the individual components of both success and industry. The literature review indicates both the critical factors for the successful implementation of Industry 4.0 (Sony & Naik, 2019) and the key determinants of success in project ventures (Salem et al., 2022), but the juxtaposition of these elements and the search for mutual correlations is a direction for further research. The indicated relationship that data management and virtualization affect the success of implemented tasks is a practical guideline that can serve as a basis for developing innovative management strategies focused on maximizing the probability of project success (Ruoslahti, 2020). This fact becomes particularly apparent in the case of advanced IT solutions, to which undoubtedly Industry 4.0 solutions (Ali et al., 2022) are applicable. It is also a promising direction for further research in the increasingly popular Industry 5.0 solutions (Javaid & Haleem, 2020).

Limitations and future research

The study described in this paper provides a better understanding of the relationships between project success and individual components of Industry 4.0.

In view of extensive literature review, the authors' own research and their practical experience, it should be noted that both the components of project success and Industry 4.0 are constantly evolving; hence, it is necessary to conduct further research taking into account the newly emerging components.

However, it should be emphasized that the research was limited to technology, electromechanical and light industry. Despite a multifaceted analysis of the issue, the research should be continued, especially in other disciplines. A detailed analysis of individual cases, particularly the projects characterised by great complexity and high budget, seems particularly interesting. Investigation of this phenomenon and an attempt to bridge this gap should be a challenge for both scientists, as well as business.

The set of limitations includes the arbitrary method of determining the conversion of data obtained from the questionnaires into binary (0–1) format (presence or absence of a given factor). For the purpose of the analyses, a threshold of 3n was adopted (min. 1n; max. 5n). Determining the exact transition point between 0 and 1 could be the subject of further research, investigating e.g. the items that received the lowest scores or aimed at obtaining even more accurate regression models.

As the conducted study concerns *post factum* observation of projects, there might have been a situation where, during project execution, managers would change the management style,on account of subjective evaluation of the probability of project success (they might adopt a more rigid management style if failure is predicted, and be less willing to apply the solutions of Industry 4.0).

However, it should be noted that each variable may have a potential impact on another one. For instance, the duration of a company can affect the application of Industry 4.0 (older companies are likely to be less apt to use these solutions), agility may affect project team's satisfaction or vice versa: a satisfied team is more eager to work in an agile manner. In order to verify the collinearity of variables, *VIF* (Variance Inflation Factor) coefficients were calculated. The results of the *V IF* test prove the occurrence of insignificant collinearity of predictors, which allows the conclusion that the observed correlations and dependencies found in models still provide a useful picture of the impact of applying the Industry 4.0 solutions on project success.

Conclusions

The research objective was the identification of individual components of Industry 4.0 as project success factors. The factors were evaluated based on their impact on and significance to actual completion of a project according to nine criteria. Survey respondents evaluated those factors in terms of their impact and frequency. Statistical methods, such as contingency tables, correlation analysis, regression analysis or statistical tests, were employed in the analyses of survey results. A novel formula for determining the values of indicators (W) of meeting the specified criteria was also developed.

The analysis of results allowed the principal research objective to be met, which was identification of the conditions and factors affecting the success of projects. It particularly concerns the identification of relationships between the selected components of Industry 4.0 and project success components. Identification of these relationships made it possible to develop recommendations or solutions and attitudes increasing the chances of project success. In should be noted that the Industry 4.0 solutions demonstrate strong correlations with all project success components (apart from charging contractual penalties); therefore, it might be stated that the occurrence and broad application of Industry 4.0 is conducive to successful completion of projects.

Positive verification of the hypothesis adopted in the beginning confirmed the existence of strong dependencies between Industry 4.0 and successful execution of tasks. However, it should be noted that project succeeds to the greater extent when the Industry 4.0 solutions are broadly applied. A multi-faceted study of project success allowed the following conclusion to be formulated: application of advanced project management solutions is a necessary, but insufficient condition for project success. The crucial success factor is the extensive application of Industry 4.0 components to support the actions carried out as part of a project. Particular attention is drawn to two components: data management and virtualisation, as they are of key significance for positive evaluation of actions within the project. The presence of these two components increases the likelihood of project success . Responses to individual questions, positive verification of adopted assumptions and the analyses of collected research material can serve as a basis for validation of the above conclusion. It should be emphasized that the final success of a project is not a result of meeting merely one of the described conditions. The greater the synergy between individual components of Industry 4.0, the more likely the project is to succeed.

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