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Intellectual Capital: A New Predictive Indicator for Project Management Improvement

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Abstract: Effective project management has contributed to successful operations and process management. The goal of this article is to look at the link between a project's success (PS) and the amount of intellectual capital (IC) an organization has. Instead of being reactive to measuring the cost, timeliness, and quality (customer requirements), a more predictive indicator of a project's success is needed. Nearly 300 people who work in the field of digital (information and communication) technology took part in the survey research. The survey contains 88 questions. Several statistical techniques are utilized for the data analysis. Based on the comprehensive surveys, the findings show the strong possibility for IC to be adapted as a predictor of the success of investment projects, especially for digital upgrade and improvement. IC plays a key role in assuring the effective (and successful) project management. The study highlights the impacts of effective project management on industrial and organizational operations. This highlight is based on the attempt to determine whether IC contributes to a PS. In this study, in addition to the three traditional factors of cost, timeliness, and quality (or requirements), IC should be considered as a prediction for the project management's success. The survey was addressed to selected companies from the ICT industry (IT projects). The sample selection is based on non-probability sampling. The author's method of converting the respondents' answers into binary form was adopted.

Keywords: intellectual capital; project success; human capital; project management; business process improvement; relationship value

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1. Introduction

Value creation in modern organizations is primarily achieved through intangible factors, including intellectual capital (IC), which is based on the so-called knowledge assets. The views and values of the society are being remodeled. Building the competitive advantage of enterprises is determined mainly by intangible resources. Moreover, a significant increase in the importance of project undertakings is observed. According to P. Drucker, following the industrial and production revolutions, currently we are in the third phase of the economic evolution, i.e., the so-called management revolution in which organizations use the resources they possess to create enterprise value, owing to the effective implementation of project tasks [1,2]. Taking the above into account, it is important to note that project management in modern organizations revolves around activities directed towards the best use of various IC components, in order to efficiently and effectively achieve the set project objectives [3,4]. To this end, it is important not only to understand the relationship between various components of IC and project success, but also to be able to use tools, technologies and concepts that support the use of IC for project purposes. This should lead to synergies resulting from the ability to combine individual IC elements and methodologies to support the project management [5–7]. This paper explores the relationship between individual IC resources and project success in the ICT industry.

A success in implementing a project could be possibly derived from the maturity and learning capability of a project team [8–10]. In general, a project team consists of a diverse group of individuals, with different backgrounds and experience, and possibly from different functional areas within an organization. With this diversity, an effective project team depends on human learning, which transforms into human capital [11–13]. Project management has a special role in industrial management. Project members are often selected from functional departments (production, marketing, and finance). They are expected to work within an ad hoc project which will later be dissolved when a project is completed [14–16].

Often, a large functional unit, such as production, is required to continuously improve its performance through a series of project investments, especially in the areas of digital (information and communication) technology. A project team(s) is established to ensure cohesive work. Implementing a project under the member diversity and the business pressure (i.e., timeliness, cost management, and quality and compliance) highlights the need to focus on learning among these members [17–20]. This learning capability plays a crucial role in strengthening IC. IC is viewed as one of the competitive advantages in industrial operations and management today [18,21–26].

According to Joslin and Müller [27–29], project success (PS) remains a great challenge for managers, given the risk and uncertainty (e.g., complex scope of work, reliance on subcontractors, regulatory compliance, team diversity, etc.). According to a conventional classification of a firm's assets, resources of an enterprise are usually understood as the physical resources defined as material assets, such as fixed assets, equipment, land and monetary resources (cash and receivables), while key competences include knowledge resources dispersed in an organization, i.e., IC [30–34].

IC represents the intangible value of a company which can contribute to its business and operational success [35,36]. A high level of IC is deemed to be a potential contributor to high performance, which includes PS [37,38]. The issue of the influence of IC on PS is present in recent research in the context of information technology (IT) projects [39–42]. The analysis of the results of these studies supports the thesis on a strong correlation existing between IC and PS. It has also been demonstrated that IC has a positive impact on project success and can therefore be a good predictor of future project performance [43–46]. More importantly, the authors found an important intermediary role of the structural capital in the application of human and relational capital in project success [47–50]. The survey described in this paper goes a step further than what has been achieved so far and shows the dependencies of the constituent components of IC on the individual elements of PS. Ultimately, they also show the overall (in aggregate form) impact of IC on the PS.

The attempt to define IC and to classify its main components (dimensions) is not straightforward. Authors classify the different components depending on the criterion adopted [51,52]. The perception of IC has also changed over the years [53–55]. There is no universal and comprehensive approach for both classifying and measuring the IC. The approach depends both on the researcher, the nature and the detail of the research conducted, but above all is specific to the industry under study. Based on the extensive literature review as well as the practical experience, the authors have attempted to classify key aspects of IC from the perspective of the ICT industry [56–59]. The industry is specific in terms of the IC application. For the purpose of the present study, the classification adopted was the most common approach specifying: human capital, relationship capital (client capital, cooperation capital), organizational capital and structural capital. Human capital consists of the knowledge, skills, and health that people invest in and accumulate throughout their lives, enabling them to realize their potential as productive members of society [60]. The 'term human capital' is often discussed as one of the key components of IC [12,32,34]. Relationship capital is the sum of an organization's connectivity to the marketplace, both directly and indirectly [61]. Organizational capital is the information/knowledge embodied in employees [62]. Structural capital consists of the supportive infrastructure, processes, and databases of the organization that enables the human capital to operate [63].

2. Materials and Methods

2.1. Research Objective

Due to the significance of project management in operations and despite some adjustment in monitoring the criteria (e.g., satisfaction of team members within a project), the learning capability within a project has been constantly brought up as a possible criterion to help prevent a repeated failure [64–67]. Many executives have called for proactive criteria (i.e., more predictive to the future) for project management, as existing criteria are viewed as reactive (i.e., information from the past to the present) [68–71].

The primary objectives of the research are to evaluate the suitability of IC as a possible monitoring criterion for project management and the interrelationships between IC and a PS. The consideration into IC is based on the importance of a speed of human learning in a complex business environment during the implementation of a project remains a challenge for many manufacturing and service firms, especially when dealing with project investments to increase their long-term competitiveness [35,72]. In addition, the recent trend on the shortened project duration renews the need to examine the roles of IC in project management [73,74]. IC consists of human capital, relational capital, and organizational capital [75–77]. It should be noted that the significant number of studies focuses on demonstrating the relationship between intellectual capital commonly understood and the success of project ventures [61,78–82]. The relationship between IC and its dimensions and the various elements of an organization's success (performance) is not a frequent subject of research and scientific analysis [83–85]. Consequently, the primary objective of this paper is, first of all, an attempt to show partial (individual) dependencies between individual IC and PS components and further in an aggregated form, as well as building a model that identifies those elements of the IC that are of crucial importance to project success. On the basis of the identified research problem, the following main research hypothesis was developed:

Hypothesis 1 (H1). *A relationship exists between intellectual capital and project success [the successful implementation of a project].*

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

Hypothesis 1.1 (H1.1). *Significant interdependencies exist between IC components and PS components.*

Hypothesis 1.2 (H1.2). *Choosing the right configuration of IC components is the key condition for successful project completion.*

2.2. Data and Methods

The methodology consists of the development of a questionnaire, the analysis and interpretation of the results, and the discussion with the research's implications. In this study, a questionnaire with the 5-point Likert scale was to be developed to help identify possible key factors of PS from the viewpoint of IC. This scale is a bipolar interval scale which allows to measure attitude and belief of the participants. For the scale's interpretation, it is as follows: 1 = strongly disagree, 2 = rather disagree, 3 = neutral, 4 = rather agree, 5 = strongly agree. The questionnaire consists of five sections with a total of 88 questions and 155 variables.

Inference was based on selected descriptive statistics of PS and IC components (mean, median, mode, standard deviation, skewness, kurtosis). Further, for the purpose of the analyses, correlations (Spearman's rank correlation analysis) between the PS and IC components and between PS and "clustered" IC were applied. Additionally, cross-tabulations and a model-based approach—i.e., multivariate and logistic regression were used.

For each data set, Cronbach's alpha coefficient (AC) was estimated, testing each time the internal consistency of the survey tool (AC > 0.6). The analyses were based on data

obtained directly from a survey (survey data—SurD) and converted to 0–1 form using the formula below (Formula (1); converted data—ConD).

Formula (1) is the general formula for determining the (*W*) indicator

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

where: *W*—set indicator, *n*—number of elements (considered in the indicator), *i*—the consecutive number of the response (assessment) analysed, x_i—the value of the response (assessment), expressed by the respondent for the i-th object forming the indicator, $x_i \in \{1, 2, 3, 4, 5\}$. The resulting *W* index was interpreted as follows:

- 0—means the value of the indicator for the sum of points smaller than 3*n*—was 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 3*n*,
- 1—means the value of the indicator for the sum of points above 3*n*, interpreted as fulfilling the condition.

As a limit of the positive verification of each determined indicator, a middle value was adopted (3*n*) between the minimum (*n*) and maximum (5*n*) value of the obtained points for each determined indicator, was assumed. 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 a 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 the five-point Likert scale).

With the use of the processed data, an attempt was made at developing a model (analysis of logistic regression) of the project success's dependency on the identified components of intellectual capital. The research and statistical methods adopted, models used, indicators and their interpretations are recommended for management science and qualitology [86,87].

2.3. Research Model

This section presents the details of the data collection which consists of the profiles of the companies or enterprises and the participants, and the data analysis. The data analysis primarily focuses on the interrelationships between IC and a PS. The details are as follows. The adopted research model (see Figure 1) included the stage of defining the research problem and formulating the research objective (Stage I), four intermediate steps related to the implementation of the research (Stage II) and the stage of discussing the results, together with developing application recommendations (Stage III).

In stage two, the first step was to identify the key elements of the PS and the most important components of IC. The second step consisted in collecting, aggregating and validating the data obtained. The results were also interpreted, especially those concerning the assessment of key PS components. The third step was a key research stage in which the verification of the relationship between the PS and IC was performed, using several statistical methods. The fourth and the last step was the interpretation of the results of the conducted survey; particularly the determination of the relations between IC and PS. The effect of this step was a set of developed recommendations for application.

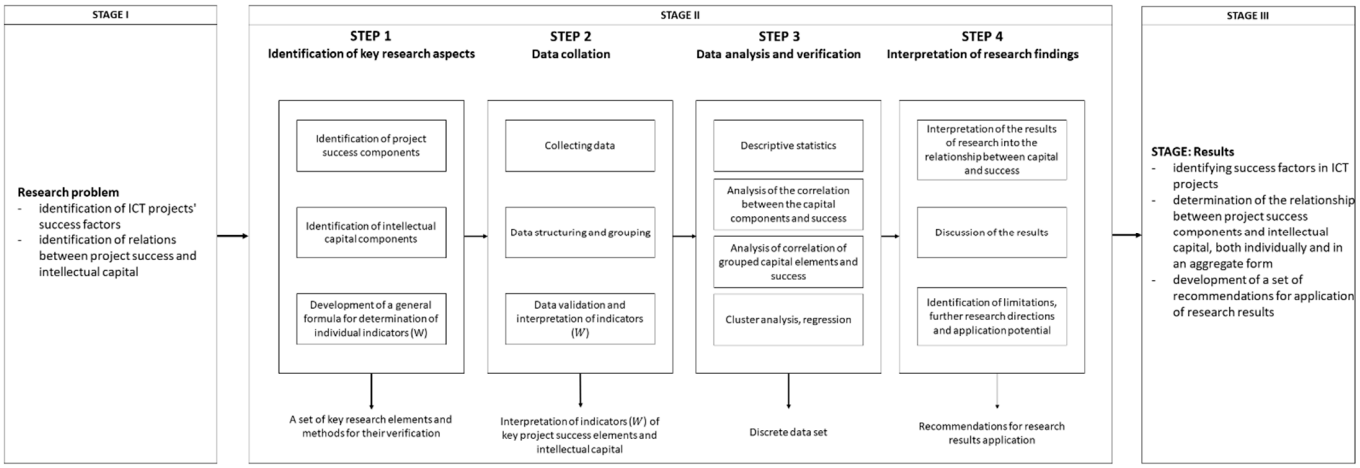


Figure 1. Diagram of the research model.

3. Results

3.1. Profiles of Participating Companies and Participants

The methodology adopted for the survey consisted in the development of a questionnaire, analysis and interpretation of the results, and a discussion of the research implications. Survey respondents were selected, based on purposive sampling. The participants were required to have the experience in managing large-scale investment projects, as well as in the creation of corporate standards on project management practice (representatives of company management, product managers, project managers and users). The survey covered persons participating in project implementation in the ICT area in the broad sense, and providing advisory and consulting services in this field, in particular external experts and contract engineers. The scope of the research included an analysis of the role of the ordering party/investor and the contractor/supplier in the project. On the part of the contractor, respondents included project managers, product managers and company executives. The group of respondents on the part of the investor covered project managers and management representatives. With the above assumptions in mind, the survey questionnaire was addressed to employees in the ICT industry, mainly to public companies. The survey was conducted in enterprises with their registered office or branches in Poland, which implemented projects on the international, mainly European market. The basic criterion for qualifying a company to participate in the survey was its entry in the major industry report in Poland, i.e., 'Computerworld Top 200' 2021 [88]. The report ranks the leaders of the Polish ICT market, both consumers and suppliers of IT solutions and services in various sectors, including: industry, manufacturing, construction, agriculture, processing, public administration, finance, insurance and others. The questionnaire was addressed to all 367 companies included in the report. Respondents' participation in the survey was voluntary. A total of 288 complete questionnaires were returned. The survey was carried out with the use of the LimeSurvey online tool, while the statistical analyses were performed with the use of IBM SPSS Statistics (version 28.0.1.0(142), IBM Corporation, Armonk, NY, USA) and StatSoft Statistica software (Version 13, TIBCO Software Inc., Palo Alto, CA, USA). Respondents completed the survey in an electronic format, following the instructions provided on the website. In the cases analyzed, 15% of the respondents represented the role of the ordering party, whereas the role of the contractor was represented by 85% of the respondents. The majority of respondents represented medium-size enterprises, accounting for 70%. It should be noted that 84% of survey respondents were employed in enterprises operating longer than five years on the market. Over 54% of respondents indicated IT as their leading discipline, and over 23% indicated the telecommunications industry. This means that nearly 80% of the respondents participating in the survey, work in the ICT industry. 68% of respondents were between 36 and 50 years old. The most numerous group of respondents constituted project managers—31%. Seventy percent of survey participants

were experienced employees with over six years of professional background, of whom 21% had over 10 years of experience in project management. The analysis of the survey results indicated that 55% of respondents participated in projects involving between 11 and 50 people. The participation in projects carried out by more than 50 people was declared by 26% of respondents. A brief summary of the survey sample characteristics is presented in Table 1.

Table 1. Characteristics of the survey sample.

Characteristics of the Enterprises Represented by the Survey Respondents	
Role of enterprises in project implementation	
Contractor	85%
Employer	15%
Categories of the surveyed enterprises by size	
Small	17%
Medium	70%
Large	13%
Period of operation of the company on the market	
Up to 1 year	2%
Between 1 and 5 years	14%
Between 6 and 10 years	62%
Over 10 years	22%
Discipline	
IT	54%
Telecommunications	23%
Energy	10.7%
Industry	4%
Financial services	2%
Marketing and advertising	2%
Construction	0.3%
Other (medical, military)	4%
Characteristics of the respondents participating in the survey	
Age of respondents	
Up to 25 years	4%
Between 26 and 35 years	24%
Between 36 and 50 years	68%
Over 50 years	4%
Characteristics of the respondents' jobs	
Product user	4%
Project team member	12%
Project manager	31%
Lower/middle level manager	18%
High-level manager	28%
President/Member of the Board	7%
Respondents' professional experience	
Less than 1 year	6%
Between 2 and 5 years	24%
Between 6 and 10 years	49%
Over 10 years	21%
Territorial area of the implemented projects	
Nationwide projects	30%
International projects	70%
Number of people involved in the implementation of a single project	
From 1 to 10 persons	19%
From 11 to 50 persons	55%
From 51 to 100 persons	22%
More than 100 people	4%
Complexity of the projects	
Simple projects	4%
Moderately complex projects	21%
Complex projects	62%
Highly complex projects	13%

Source: own study. N = 288.

3.1.1. Characteristics of the PS Components

In the first place, the components of the PS [project success] were analyzed (SurD). The respondents were asked nine questions assessing the relevance of the components for a PS. The Cronbach Alpha value ($AC = 0.931$) indicates that the assumed variables for the determination of the PS were correctly selected. The statistical results of the PS are presented in Table 2.

Table 2. Results of the individual components of the project's success.

Components of the Project Success	Mean	Median	Mode	Standard Deviation	Skewness	Kurtosis
Compliance with the set budget	3.56	4.00	4.00	1.413	−0.647	−1.047
Compliance with the schedule	3.43	4.00	4.00	1.398	−0.553	−1.143
Ensuring functionality	3.32	4.00	4.00	1.400	−0.493	−1.224
Client satisfaction	3.58	4.00	5.00	1.489	−0.669	−1.107
Project team members' satisfaction	3.35	4.00	4.00	1.484	−0.477	−1.313
Ensuring benefits for the project products' users	3.50	4.00	4.00	1.374	−0.628	−1.021
Ensuring technical, organizational, social, political and business benefits	3.53	4.00	4.00	1.448	−0.656	−1.068
Achieving the company's strategic objectives	3.46	4.00	5.00	1.502	−0.416	−1.427
Full achievement of all project objectives	2.86	2.00	1.00	2.471	0.134	−1.616

Source: Own study. N = 288.

The mean values of the compliance with the set budget, compliance with the schedule, ensuring functionality, client satisfaction, project team members' satisfaction, ensuring benefits for the project products' users, ensuring technical, organizational, social, political and business benefits, achieving the company's strategic objectives are from 3.32 to 3.58. Only one variable (full achievement of all project objectives) is below the mean value of 3.0. The obtained results show that, in most of the examined cases, a project can be evaluated as successful with the majority of the listed criteria being fulfilled.

A vast majority of PS components demonstrates similar levels of mean, median and mode values. The only component which scored clearly standing out values is the full achievement of all project objectives.

3.1.2. Characteristics of the IC Components

- Component 1: Human capital

Human capital is a collection of the potential of individual employees that is their physical, mental, intellectual and moral capacity developed by skills, knowledge, talents, predispositions and the health determinants they possess. The perception of these determinants among the respondents was identified using seven questions ($AC = 0.902$) focused on the particular assets of human capital. The obtained results are presented in Table 3.

Table 3. Statistical results of the intellectual capital components.

Components of Intellectual Capital	Mean	Median	Mode	Standard Deviation	Skewness	Kurtosis
Human capital assets						
Attitude: Ability to talk to a colleague with whom one has fallen out	3.17	4.00	4.00	1.502	−0.336	−1.456
Attitude: Interested in social relations in different departments of the company	3.50	4.00	4.00	1.426	−0.529	−1.210
Attitude: Promotion of teamwork, including the willingness to share knowledge	3.37	4.00	4.00	1.452	−0.482	−1.279
Attitude: Promotion of innovation, creativity, ability to transform theory into practice	3.36	4.00	4.00	1.456	−0.517	−1.238
Skills: High level of skills (intellectual abilities) of project team members	3.44	4.00	4.00	1.442	−0.586	−1.149

Table 3. *Cont.*

Components of Intellectual Capital	Mean	Median	Mode	Standard Deviation	Skewness	Kurtosis
Knowledge: High level of knowledge and education of project team members	3.23	4.00	4.00	1.518	−0.351	−1.459
Experience: Sufficiently high level of experience of project team members in the implementation of their duties	3.22	4.00	4.00	1.507	−0.260	−1.507
Client capital						
Functioning of efficient client retention mechanisms	3.28	4.00	4.00	1.480	−0.370	−1.402
Participation in trade fairs, conferences or other forms of promotion	3.42	4.00	5.00	1.507	−0.451	−1.370
Functioning of a professional client relationship management system	3.45	4.00	4.00	1.436	−0.699	−0.997
Cooperation capital						
Exclusive agreements	2.14	2.00	2.00	1.297	1.092	−0.061
Strategic alliances	2.15	2.00	1.00	1.347	1.018	−0.322
Long-term agreements with distribution and sales channels	3.23	4.00	4.00	1.520	−0.369	−1.448
Franchise agreements	2.01	2.00	1.00	1.262	−1.112	−0.070
Letters of intent or other forms of cooperation e.g., knowledge transfer	3.38	4.00	4.00	1.493	−0.465	−1.330
Organizational capital						
Intellectual property rights: Copyright	2.99	2.00	2.00	1.553	0.018	−1.616
Intellectual property rights: Patent rights	2.47	2.00	1.00	1.484	0.557	−1.245
Intellectual property rights: Trademarks	2.81	2.00	2.00	1.495	0.185	−1.529
Legally unprotected intellectual assets: Implementation and execution of ISO, AQUAP, other procedures	3.76	4.00	4.00	1.286	−0.941	−0.365
Legally unprotected intellectual assets: Free access to documentation, including project, technical, service, training materials, knowledge bases, etc.	3.52	4.00	4.00	1.429	−0.630	−1.078
Structural capital						
Organizational support: Proper setting and decomposition of project objectives, resources and key parameters	3.39	4.00	4.00	1.482	−0.393	−1.398
Organizational support: Proper management of work organization, taking into account defined project constraints, such as project scope, time, costs and quality	3.07	4.00	4.00	1.480	−0.146	−1.535
Organizational support: Correctly defined circulation and clarity of information transfer	3.10	4.00	4.00	1.481	−0.194	−1.508
Infrastructural support: Proper provision of the infrastructural support necessary to achieve the project objectives	3.45	4.00	4.00	1.440	−0.600	−1.123
Capacity to utilize intellectual capital resources: Attention to building, accumulation and use of intellectual capital resources, including human and social capital	3.30	4.00	4.00	1.465	−0.388	−1.370

Source: Own study. N = 288.

Based on the presented indicators, the human capital is highly valued in an enterprise (SurD). Each of the examined components has a score higher than 3.0. The remaining indicators (median, dominant, standard deviation, skewness, kurtosis) were comparable. The social relations across various departments in an enterprise is viewed to be the most significance.

- Component 2: Relationship capital

Client capital is defined as the sum of the following assets: exchange of knowledge with the environment through the participation in fairs or conferences, client loyalty expressed in the number of signed framework agreements, effective management of the client base, or maintaining long-term relationships with clients using loyalty programs, as well as repeated sales of products and services to the same client. The level of perception of the elements of the client capital was verified by means of three questions ($n = 3$; $AC = 0.842$). The obtained results are presented in Table 3.

Based on the presented results, the client capital is highly valued by an enterprise. Each of the examined elements has a mean score higher than 3.0. The lowest rating is given to the functioning of efficient client retention mechanisms (3.28). The remaining elements are rated at a similar level, and the mean scores are 3.42 and 3.45 for participation in fairs, conferences or other forms of promotion and functioning of a professional client relationship management, respectively.

Cooperation capital is defined as the ability to establish long-term and close relations with business partners, by reaching commercial agreements, franchise agreements, establishing strategic alliances and long-term agreements with distribution and sales channels. The degree of involvement of individual assets of the cooperation capital was identified using five questions ($n = 5$; $AC = 0.716$). The obtained results are presented in Table 3.

The results show that three types of assets [exclusive commercial agreements (2.14), strategic alliances (2.15), franchise agreements (2.01)] scored mean values below 3.0. This shows that there is little interest in entering into such commitments by enterprises. A higher rating i.e., with a mean value 3.0 scored two cooperation capital assets, namely concluding the long-term agreements with distribution and sales channels (3.23) and letters of intent or other forms of expressing willingness to cooperate in e.g., knowledge or technology transfer (3.38).

- Component 3: Organizational and structural capital

Intellectual property rights (copyrights, trademarks, patents) and legally unprotected intangible assets (documentation, procedures, instructions, training materials, databases) are perceived as the organizational capital. The analysis of individual assets is based on the responses to six questions ($n = 6$; $AC = 0.809$). The obtained results are presented in Table 3.

The initial findings reveal that the respondents showed little interest in or minimal care for intellectual property rights. Three examined elements [copyrights (2.99), patent rights (2.47), trademarks (2.88)] were rated at a mean value below 3.0. The mean score of legally unprotected intellectual assets [implementation and execution of ISO, AQUAP procedures, other] (3.76), free access to documentation, including project, technical, services, training materials, knowledge bases, etc., (3.52), access to knowledge necessary for making strategic decisions in the company (3.43), was above 3.0.

Structural capital focuses on the organizational and infrastructural support and the ability to store and utilize IC. Individual assets of structural capital were analyzed using five questions ($n = 5$; $AC = 0.890$). The obtained results are presented in Table 3.

The analysis of the above indicators (mean values) implies that all components of the structural capital exceeded the value of 3.0. The highest mean value (3.45) obtained for the infrastructural support indicates that an enterprise focuses on equipping their employees with proper tools and devices necessary for the implementation of project tasks.

A vast majority of IC components demonstrate similar levels of mean, median and mode values. The areas where the selected values clearly stand out include cooperation capital and organizational capital.

3.2. Interrelations between IC and PS

3.2.1. Elements of PS and IC—Calculation

From the above results, a formula for determining the value of the (W) indicators representing the level of fulfilment of the set criteria was developed (Formula (1)). These indicators (human capital, relationship capital, client capital, cooperation capital, organizational capital, structural capital, IC and PS components) were used to determine the degree of implementation of the selected aspects of PS and to assess the impact of the individual elements of IC on the ultimate PS (ConD).

Using Formula (1), the indicators for the individual elements of PS were determined. The analysis allowed for the positive verification of all success components (0—unfulfilled, 1—fulfilled): compliance with the budget (0—32%, 1—68%), compliance with the schedule (0—34%, 1—36%), ensuring functionality (0—36%, 1—64%), customer satisfaction (0—32%, 1—68%), satisfaction of the project team members (0—36%, 1—64%), ensuring benefits for the recipients of the project products (0—32%, 1—68%), ensuring technical, organizational, social, political and business benefits (0—35%, 1—65%), achieving the company's strategic objectives (0—32%, 1—68%), full achievement of all project objectives (0—46%, 1, 54%).

Using formula (1), the verification of the PS was based on ($n = 9$) questions concerning the evaluation of the elements forming the indicator ($PS\min \sum_{i=1}^{9} x_i = 9$, $PSmax \sum_{i=1}^{9} x_i = 45$). The adopted criterion was verified by the frequency of PS vs. project failure. The analysis shows that 67% of respondents indicated that the projects they implemented succeeded more frequently than failed. The opposite situation was indicated by 33% of respondents. The direct advantage of it is the fact that survey participants are people who succeeded in project implementation, thus providing reliable insight in the actual conditions of PS.

The analyses of the IC components allowed for the positive verification of the following indicators (0—not fulfilled, 1—fulfilled): human capital (0—32%, 1—68%), client capital (0—33%, 1—67%), organizational capital (0—34%, 1—66%), structural capital (0—34%, 1—66%). The relevance of the cooperation capital was verified negatively (0—51%, 1—49%).

For the purpose of the analysis of the relationship between the PS and IC, the following premise was made. Success of the project is interrelated with the level of IC in the company. To determine the strength of the assumed correlation between these elements, Spearman's rank correlation coefficient was used. First, the correlation of the individual elements of IC with the factors of the PS was investigated. The results are presented in Table 4, indicating statistically significant coefficients only.

As regards the H1.1 hypothesis, in the course of the analyses, the existence of statistically significant interdependencies between the IC and PS components was confirmed. The only areas where interdependence was not statistically significant are the franchise agreements and strategic alliances. Therefore, the H1.1 hypothesis may be considered supported.

In the further part of the paper, the PS factors and components of IC were grouped and the correlation of these (grouped) components was examined.

3.2.2. PS vs. Human Capital

The analysis reveals that the attitude of project stakeholders is highly correlated with the schedule (0.527), satisfaction of project team members (0.522) and the benefits for the company (0.509). Attitude correlates moderately with other components of the PS. The skills of the project team members are strongly correlated (0.501) with the project schedule. The strongest correlation for knowledge was identified with the benefits for the product recipients (0.572), and the weakest with the general project goals (0.264). The experience of the project team members does not show strong correlations with any element of PS. The weakest correlations were identified for the project budget (0.279), functionality of

the project products (0.292), strategic objectives of the company (0.281) and the overall project objectives (0.231). For other elements, the correlations are moderate. The results are presented in Table 4.

3.2.3. PS vs. Relationship Capital

The correlation between the assets of the client capital and individual elements of PS was analyzed. Knowledge exchange between the company and the environment strongly correlates with the satisfaction of the project team members (0.508). In the remaining cases, the correlation was moderate. The correlation between the construction and functioning of the client base in three cases (required functionalities, benefits for the company and fulfilment of all project objectives) was weak or poor (<0.3). In the remaining cases, the correlation was moderate.

The correlation of the cooperation capital assets and the individual elements of the PS was analyzed. The assessment of individual assets of cooperation capital was verified by means of a various number of questions, depending on the examined features (see Table 4). The correlation between the long-term agreements with distribution and sales channels with each element of PS is moderate. The correlation with other elements of PS was generally moderate. For the strategic alliances and franchise agreements within the cooperation capital, the correlation with elements of PS was weak (<0.3), and in several instances without any statistical significance. The area of exclusive agreements is not presented in Table 4, due to the absence of the statistically significant correlations with any PS component. Table 4 presents the results obtained.

3.2.4. PS vs. Organizational and Structural Capital

From Table 4, intellectual property rights proved a weak correlation (<0.3) with the six components of the PS (implementation in accordance with the budget, providing the required functionality, ensuring client satisfaction and benefits for product recipients, meeting strategic objectives and all project objectives). In the remaining three cases (schedule, satisfaction of the project team members and benefit for the company) the correlation was moderate. Legally unprotected intellectual assets correlate weakly only with the fulfilment of all project objectives (0.249). In the remaining eight cases, the correlation is moderate. There was no strong correlation identified for the organizational capital assets with elements of PS.

The last examined area was the interrelationship between the structural capital and a PS. See Table 4. The overall result indicates the moderate correlation between individual assets of the structural capital and elements of the PS.

3.3. Interdependence of the Components of the PS and the Aggregated Elements of IC

The analyses carried out so far have examined, in detail, the interdependencies of the individual (fundamental) assets of IC and the components of PS. In the further part of the analysis, the correlation of the grouped assets of IC was generalized and scrutinized in the following arrangement: human, clients, cooperation, structural and an organization with individual components of PS (ConD). The results obtained are presented in Table 5.

Table 6 presents the correlations of IC in an aggregate form with the individual elements of PS ($n = 27$ questions; ConD). IC strongly correlates with almost all elements of PS, including: project schedule (0.737), budget (0.558), functionalities (0.587), client satisfaction (0.721), satisfaction of the project team members (0.755), ensuring benefits for the recipients of the products (0.583), ensuring benefits for the company (0.738) and meeting strategic objectives of the company (0.559). In one case (meeting all project objectives), the correlation was moderate and amounted to 0.342.

Table 4. Spearman's rank correlation results—Intellectual capital elements/Project success elements.

Intellectual Capital Elements/Project Success Elements	Project Success								
	Schedule	**Budget**	**Functionality**	**Client's Satisfaction**	**Project Team's Satisfaction**	**Benefits for the Product Recipients**	**Benefits for the Company**	**Strategic Objectives**	**All Project Objectives**
Human capital									
Attitude	0.527 **	0.412 **	0.474 **	0.492 **	0.522 **	0.466 **	0.509 **	0.426 **	0.322 **
Skills	0.501 **	0.375 **	0.344 **	0.454 **	0.372 **	0.446 **	0.422 **	0.399 **	0.335 **
Knowledge	0.407 **	0.365 **	0.336 **	0.396 **	0.364 **	0.572 **	0.350 **	0.327 **	0.264 **
Experience	0.304 **	0.279 **	0.292 **	0.324 **	0.320 **	0.347 **	0.370 **	0.281 **	0.231 **
Client capital									
Exchange of knowledge with the environment	0.486 **	.409 **	0.478 **	0.471 **	0.508 **	0.433 **	0.497 **	0.456 **	0.329 **
Recurring clients	0.559 **	0.494 **	0.482 **	0.559 **	0.576 **	0.519 **	0.543 **	0.524 **	0.427 **
Building and maintaining client base	0.351 **	0.327 **	0.255 **	0.360 **	0.348 **	0.322 **	0.279 **	0.316 **	0.222 **
Cooperation capital									
Strategic alliances		0.126 *	0.174 **		0.167 **				0.133 *
Long-term agreements with distribution and sales channels	0.387 **	0.375 **	0.406 **	0.436 **	0.465 **	0.429 **	0.452 **	0.380 **	0.319 **
Franchise agreements			0.140 *						0.148 *
Letters of intent or other forms of cooperation e.g., knowledge transfer	0.464 **	0.450 **	0.394 **	0.513 **	0.515 **	0.412 **	0.435 **	0.417 **	0.374 **
Organizational capital									
Intellectual property rights	0.323 **	0.246 **	0.289 **	0.278 **	0.312 **	0.268 **	0.322 **	0.270 **	0.252 **
Legally unprotected intellectual assets	0.336 **	0.334 **	0.336 **	0.369 **	0.376 **	0.383 **	0.352 **	0.301 **	0.249 **
Structural capital									
Organizational support	0.495 **	0.433 **	0.479 **	0.465 **	0.509 **	0.474 **	0.495 **	0.406 **	0.338 **
Infrastructural support	0.530 **	0.417 **	0.492 **	0.545 **	0.491 **	0.474 **	0.497 **	0.426 **	0.286 **
Capacity to utilize intellectual capital resources	0.495 **	0.454 **	0.454 **	0.454 **	0.459 **	0.477 **	0.500 **	0.397 **	0.368 **

Note(s): ** Correlation significance level 0.01 (two-tailed). * Correlation significance level 0.05 (two-tailed). N = 288 (missing data were deleted in pairs).

Table 5. Spearman's rank correlation results—IC (main areas) and PS.

Intellectual Capital	Project Success								
	Schedule	**Budget**	**Functionality**	**Client's Satisfaction**	**Project Team's Satisfaction**	**Benefits for the Product Recipients**	**Benefits for the Company**	**Strategic Objectives**	**All Project Objectives**
Human capital	0.461 **	0.377 **	0.424 **	0.545 **	0.469 **	0.433 **	0.441 **	0.405 **	0.297 **
Client capital	0.500 **	0.516 **	0.544 **	0.467 **	0.509 **	0.460 **	0.481 **	0.547 **	0.334 **
Cooperation capital	0.303 **	0.287 **	0.298 **	0.271 **	0.357 **	0.216 **	0.287 **	0.323 **	0.237 **
Organizational capital	0.473 **	0.409 **	0.405 **	0.458 **	0.449 **	0.450 **	0.441 **	0.385 **	0.299 **
Structural capital	0.521 **	0.442 **	0.437 **	0.511 **	0.481 **	0.507 **	0.522 **	0.417 **	0.314 **

Note(s): ** Correlation significance level 0.01 (two-tailed). N = 288 (missing data were deleted in pairs).

Table 6. Spearman's rank correlation results—IC/PS.

Intellectual Capital	Project Success								
	Schedule	**Budget**	**Functionality**	**Client's Satisfaction**	**Project Team's Satisfaction**	**Benefits for the Product Recipients**	**Benefits for the Company**	**Strategic Objectives**	**All Project Objectives**
Intellectual capital	0.737 **	0.558 **	0.587 **	0.721 **	0.755 **	0.583 **	0.738 **	0.559 **	0.343 **

Note(s): ** Correlation significance level 0.01 (two-tailed). N = 288.

4. Discussion

The survey conducted and the results obtained complement the research gap identified in the literature on the subject of project success, from the perspective of the project success, from the perspective of the application of the intellectual capital. Research to date has mainly focused on demonstrating the overall relationship between project success and an organization's intellectual capital, with lesser focus on identifying the relationship between the individual components of both success and capital [19,74,89–94]. The literature review undertaken identifies both the critical factors for the successful implementation and management of the intellectual capital and the key determinants of the success in project ventures, but nevertheless the juxtaposition of these components and the search for intercorrelations shall be a direction for further research. Clearly, based on the findings, a PS could be attributed by the IC. This finding is consistent with the premise of the IC's potential benefits for operation management [18,21,95,96].

On the basis of all of the responses provided by respondents (SurD) a comparison (Figure 2) of PS (vertical axis; range <9, 45>) and IC (horizontal axis; range <27, 135>) was made. The horizontal dividing line (for PS) results from a demarcation value of 27 points, and the set above it represents PS, while the area below illustrates failure. The vertical dividing line (for IC) results from a demarcation value of 81 points, and the set on the left represents the absence of IC, while the area on the right represents the presence of IC.

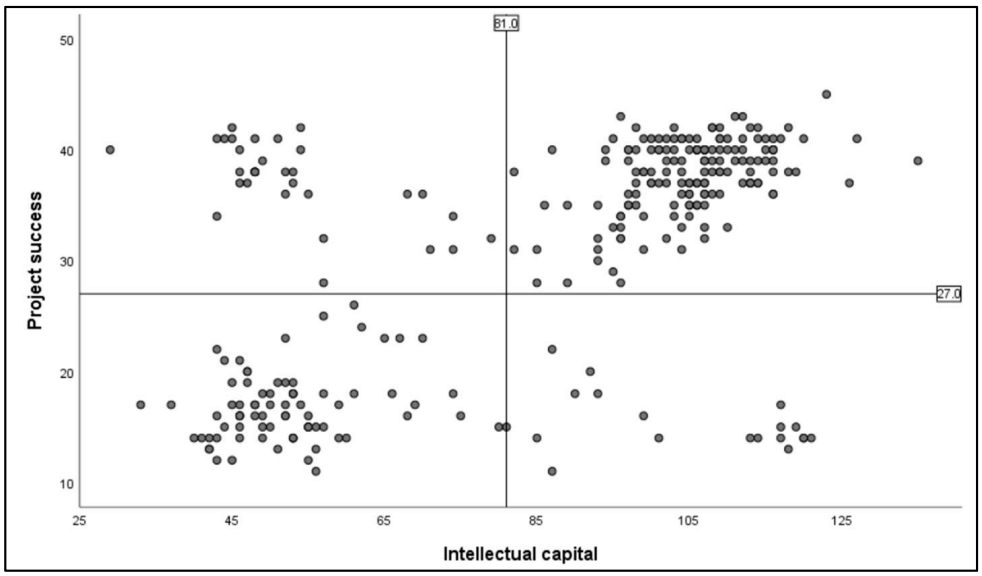


Figure 2. Scatter chart for IC and PS. Source: own study, based on the survey. N = 286.

The scatter chart presents the evident clusters which include: the presence of intellectual capital (IC > 81) and project success (PS > 27) and the absence of intellectual capital (IC < 81) and project failure (PS < 27). Hence, it may serve as evidence that those areas are interrelated.

More importantly, Table 7 shows the frequency of PS or failure (in %), within the context of a company's IC. The presence of IC was verified by means of a total of 27 questions ($n = 27$, $\min \sum_{i=1}^{27} x_i = 27$, $max \sum_{i=1}^{27} x_i = 135$). The threshold value below which, 0 was assumed (lack of resources), and above which, was 1 (presence of resources was set at 81. PS was also determined using the value after converting the obtained sum of points (0—failure and 1—success). The analysis clearly confirms that the positive perception of IC increases the probability of succeeding in the final project implementation.

In 58% of cases, PS coincided with IC (ConD). Another large group (25%) was the set characterized by the absence of IC and project failure. There are also two additional groups where, with the presence of IC, no [expected] outcome of the project was reported (8%) and also where PS occurred, despite the estimated absence of IC (9%).

Table 7. Project result and IC.

		Project Result		SUM
		Failure	**Success**	
Intellectual capital	Absent	25%	9%	34%
	Present	8%	58%	66%
SUM		33%	67%	100%

Source: Own study, based on surveys. N = 287.

An additional set of analyses was also performed for the above chart. All of the results obtained are statistically significant ($p < 0.05$). The value of the chi-squared test ($\chi^2 = 107.067$; $p < 0.001$) indicates that there is a relationship between the positive perception of IC by the employees of the company and the success of the project. The ϕ value ($\varphi = 0.611$; $p < 0.001$) and Cramer's V value ($V\ Cramera = 0.611$; $p < 0.001$) and Spearman's rank correlation coefficient ($\rho_S = 0.611$; $p < 0.001$) prove a significant correlation between the examined elements.

The study also assessed the relationship of the individual IC elements with PS. For this purpose, a logistic regression (backward elimination method: likelihood ratio) were used.

The following components were qualified for the model ($logit\ P = -0.883 + 1.547MUK + 1.763KAP$): customer retention mechanisms (MUK) and IC resource utilization capabilities (KAP). Details of the model are presented in Formula (2).

Formula (2) explains the project success model

$$P(X) = \frac{1}{1 + e^{-(-0.883 + 1.547MUK + 1.763KAP)}} \quad (2)$$

The presented model also indicates the project success or failure with a high accuracy (percentage of the total correct qualifications—81.6; see Table 8).

Table 8. Qualification table for the model.

Observed		**Expected**		
		Success (0–1)		**Percentage of Correct Qualifications**
		0	**1**	
Success (0–1)	0	61	26	70.1
	1	25	165	86.8
Total percentage				81.6

Source: own study. N = 288.

Conclusion: Having only the aggregate information on the assessment of customer retention mechanisms and IC resource utilization capabilities, it is possible to indicate the project outcome (success or failure) with more than an 80 percent accuracy.

Table 9 presents the calculation of the PS index values depending on the different values of the independent variables. In order for the success value to be greater than the 50% threshold value, it is necessary (value 1) to have customer retention mechanisms (MUK) in place or IC resource utilization capacity (KAP).

Table 9. Project success values $P(X)$ depending on MUK and KAP.

#	***MUK***	***KAP***	***P(X)***
1	0	0	0.293
2	0	1	0.707
3	1	0	0.660
4	1	1	0.912

Source: own study.

Based on this model, several conclusions about PS can be drawn.

1. PS is influenced by customer retention mechanisms, including loyalty programs, framework agreements, etc. The chance of PS in an organization with such mechanisms in place is significantly higher than in an organization without such mechanisms ($e^{1.547\ (1-0)} = 4.697$).
2. PS is influenced by the organization's IC resource utilization capabilities. The chance of PS in an organization in which the aforementioned behaviors are present is significantly higher than in an organization in which such behaviors were not found ($e^{1.763\ (1-0)} = 5.829$).

As regards H1.2—it is possible to build models demonstrating the influence of the selected IC elements on PS, which means that choosing the right configuration of IC components is the essential condition for a successful project completion. The conducted analysis indicated two key elements of the IC: customer retention mechanisms, including loyalty programs, and framework agreements resulting in company's ability (capability) to utilize IC resources. The identified interdependence of customer retention mechanisms result in a nearly 5-fold increase in the probability of success (4.697) and the company's ability (capability) to utilize IC resources (a nearly 6-fold increase—5.829), have a decisive impact on the success of the tasks performed. In particular, the presence of these two elements increases the probability of PS (by 90%). Therefore, hypothesis H1.2 should be considered confirmed (supported).

Limitations and Future Work

The presented survey allowed for a better understanding of the relationship between the PS factors and the individual assets of IC. It should be clearly stressed that the research was limited to the ICT industry, using purposive sampling and random selection. The arbitrary method of determining the conversion of the data collected by means of questionnaires into the 0–1 form (presence or absence of the factor/effect) can be added to the set of such limitations. For the purpose of the analysis, the delimitation was set at $3n$ (min. $1n$; max. $5n$). The determination of the exact point of transition between 0 and 1 could be the subject to further research.

Further analysis could also address the elements that were rated by the respondents the lowest, e.g.,: full achievement of all project goals, components of cooperation capital and organizational capital (also in the context of the absence of statistically significant correlations). Further research could also be aimed at obtaining even more accurate regression models.

It should also be noted that project success was partly assessed on the basis of the perception/view of the respondents, as well as on the basis of the objective project success criteria which can partly be biased and affect the results. However, the respondents were professional project managers holding senior positions in organizations and persons with extensive experience in the companies surveyed, which significantly limits the subjectivity or randomness of their answers.

The authors point out that the classification of the various components of IC depends both on the researcher, the nature and detail of the survey conducted, but above all is contingent on the analyzed industry. The ICT industry is notorious for its specificity in terms of IC. Therefore, the authors adopted the most common IC systematics/classification for ICT, with a proviso that other studies may be based on different characteristics of IC and its components.

Despite the multi-faceted analysis of the issue, the research needs to be continued, especially to cover other industries and business branches. A detailed analysis of the individual cases (case study), mainly covering projects of high complexity and very high budget—the so-called mega-projects—seems to be extremely promising. The conducted research has also highlighted the relatively weak relationship between the scientific and business environment. The analysis of this phenomenon and an attempt to reduce this gap should be a challenge for both the academics and the business community.

5. Conclusions

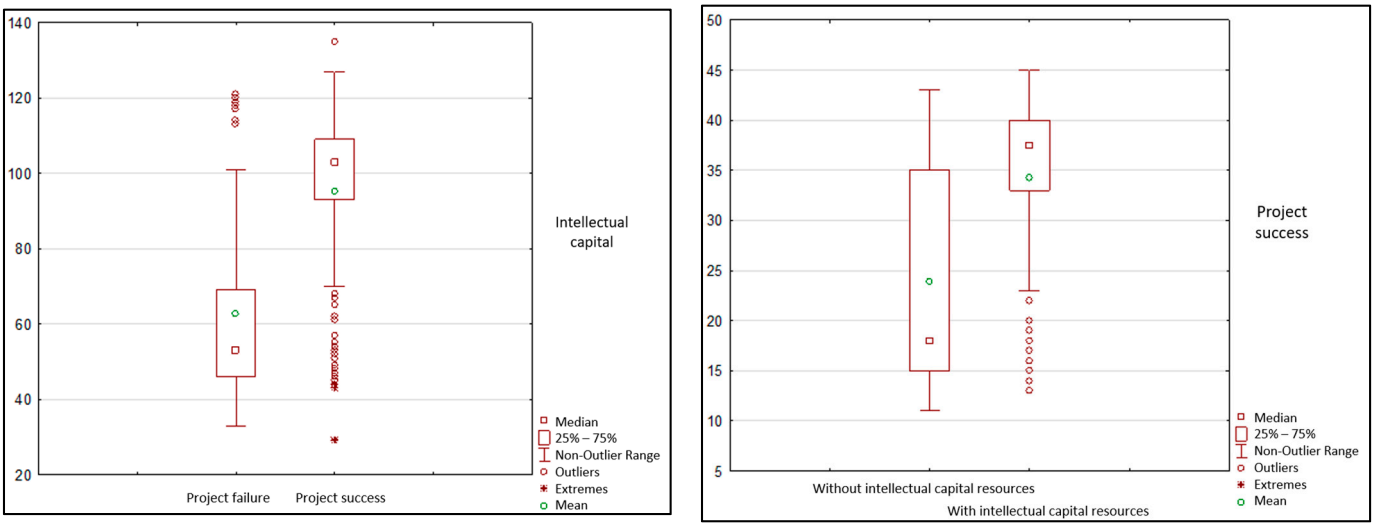
In conclusion, the positive verification of the supporting hypotheses (H1.1,H1.2), as well as the entire research material and its analyses, allow an unambiguous positive verification of H1, which proves the existence of a strong dependency between intellectual capital and the successful implementation of the project. Its impact was recorded both with reference to the individual success components, and in an aggregate form. It means that IC is an indispensable component (prerequisite) guaranteeing project success.

First, on the basis of the conducted literature research (see Introduction), the key elementary components of PS (nine elements) and IC (16 elements) were identified, and their individual relationships were examined using the Spearman's rank correlation (see Table 4). Subsequently, the individual elements of the OI (human capital, client capital, cooperation capital, organizational capital, structural capital) were grouped, and the relationship beteween these grouped elements and the individual PS components was shown (see Table 5). Then, the relationship of the aggregate IC with the basic PS is shown (see Table 6). The research results have shown that strong relationships exist between the selected items. The detailed characteristics of the identified dependencies are described in Section 3.2. Interrelations between IC and PS. The final conclusion is that a relationship between PS and IC depends on the presence (or absence) of IC in the organization. In 58% of cases, PS coincided with IC. Another large group (25%) of cases was the set characterized by the absence of IC and project failure (see Table 7). The Spearman's rank correlation coefficient ($\rho_S = 0.611; p < 0.001$) revealed a significant correlation between the examined (grouped) elements, indicating that the research results are significant. Due to the existence of a significant correlation between PS and IC, an attempt was made to identify the IC elements of the particular relevance to PS. For this purpose, the logistic regression (backward elimination method: likelihood ratio) was used. The conducted analysis indicated two key elements of the IC: customer retention mechanisms, including loyalty programs and framework agreements resulting in a company's ability (capability) to utilize IC resources. The presence of these two elements increases the probability of the project success's achievement (by 90%) (see Table 9).

The detailed results of the study confirm that PS is achieved to a greater extent in the organizations with a high IC (median 37.5 points, mean 34 points) than in those with a low IC (median 17.5 points, mean 24 points). From an opposite perspective, successful projects recorded high levels of IC (median 103 points, mean 95 points). For projects that failed, the median was only 53 points and the mean 62 points (see Figure 3). In both cases, the data on the vertical axis (SurD) were presented in a cumulative form, whereas on the horizontal axis, ranging from 0 (condition not met) and 1 (condition met) (ConD). Thus, the conducted research confirms the close correlation between IC and PS.

The study of the PS is important for industrial and business operations alike. The impacts of a project's failure has been well documented (in terms of delays, financial penalty, loss of reputation, etc.). This failure contributes to an organization's performance and long-term competitiveness. The responses to individual questions through vigorous statistical analyses point to the need to essentially integrate IC into project management (from the planning and design until the implementation stage). This integration is viewed as an important contributor to a PS.

In 58% of cases, PS coincided with IC (ConD). Another large group (25%) was the set characterized by the absence of IC and project failure. There are also two additional groups where, with the presence of IC, no [expected] outcome of the project was reported (8%) and also where PS occurred, despite the estimated absence of IC (9%).



(**a**) (**b**)

Figure 3. Project result and company IC: (**a**)—in relation to the success of the project, (**b**)—in relation to the intellectual capital. Source: own study. N = 288.

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Informed Consent Statement: Informed consent was obtained from all subjects involved in the study.

Data Availability Statement: The data presented in this study are available on request from the corresponding author.

Conflicts of Interest: The authors declare no conflict of interest.

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