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ORIGINAL RESEARCH

Identification and Evaluation of Success Criteria and Critical Success Factors in Project Success

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Abstract *Project success is one of the widely discussed issues inside Project Management field in the last decades. Success criteria (SC) and critical success factors (CSFs) constitute the two fundamental components of project success. The aim of this paper is the identification and evaluation of the SC as well as the CSFs in project success in theory and practice. A detailed literature review and content analysis are used to identify the frequency of reference of SC and CSFs, while an extensive questionnaire survey in individuals and organizations with experience in construction projects in Greece is performed to investigate their importance in project success. Regarding the relative importance, according to respondents' perceptions, cost/budget, time/schedule, client/user satisfaction, and quality and technical performance are the most important SC, while project finance/funding and economics, project team/team members ability/competence and effectiveness, and project manager/team leader ability/competence and relative/past experience are the most important CSFs. The first four SC present similarities in terms of citation frequency in the literature review and relative importance provided by the respondents, while the ranking of the rest SC and CSFs presents several deviations. The Spearman correlation coefficient is used to investigate the possible relationships among the SC and the CSFs. 5 out of 17 SC and 11 out of 26 CSFs present low or moderate correlations ($rs < 0.5$) respectively. The present research can serve as the basis for developing either a mathematical model or performance index for evaluating success of construction projects.*

Keywords Critical success factors · Project management · Project success · Project success assessment · Project success evaluation · Success criteria

Introduction

Project success has been widely discussed topics in academic and business research over the last few decades. The subject of what characteristics define a successful project has been much debated in the Project Management field, with no consensus on a definition emerging until recently (Baccarini, 1999; Judgev & Müller, 2012; Pinto & Slevin, 1988a). According to the findings of Albert et al. (2017) and Davis (2014), there is no universal definition of project success. Significant differences and deviations between the various considerations and approaches can be distinguished from a scientific standpoint in terms of how success can be practically attributed to a project. The different perspectives of the main stakeholders/participants (owner, contractor, project manager, project team, client, user/end-user, community) should be used to interpret project success; as a result, a project may be regarded as a success for some parties and a failure for others. Davis (2017) found significant differences in perceptions of project success among senior management, project core team, and project recipient stakeholder groups, highlighting the need for a more participatory approach based on collaboration among the stakeholders involved in determining a project's success or failure. The distinction in the perception of project success is given by Freeman and Beale (1992, p.8):

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"*success means different things for different people. An architect may consider success in terms of aesthetic appearance, an engineer in terms of technical competence, and a human resources manager in terms of employee satisfaction*." Also, Lim and Mohamed (1999, p.244) highlight that project success is considered as the accomplishment of some predetermined project goals, which frequently include multiple parameters.

The Success Criteria (SC) and the Critical Success Factors (CSFs) are widely accepted as two fundamental components of project success in general. The SC are used to assess project success and to provide either principles or standards for judging project success (Alashwal et al., 2017), whilst the CSFs can contribute to achieving project success in a variety of ways (Ika, 2009; Judgev & Müller, 2012; Lim & Mohamed, 1999; Turner, 2009). The emphasis placed on the main project criteria, such as cost, time, quality, performance, or safety, can cause project success criteria to vary (Lester, 2021). Although several studies can be found in the literature on SC, Castro et al. (2019) pointed out that there is still a gap in how to measure project success because some suggested measures have either not been tested in reliable empirical research or have been tested in a specific industry or sector but not in a broad sense.

This paper aims to identify and assess the most cited SC and CSFs in project success. The emphasis of this paper is placed on providing an answer to the following research question: how do engineers in the construction sector evaluate project success? Although the idea of this paper might not be new, this paper contributes as the first attempt to examine the perceived project SC and CSFs from the engineers' perspective within the Greek construction industry. To the authors' knowledge, this paper presents the most comprehensive list of SC and CSFs relevant to project success. In addition, this study investigates SC and CSFs in the context of the Greek construction industry to develop a perspective of project success. This would address the gap in the literature, which currently includes several studies focusing on understanding how to measure success using either SC or/and CSFs.

Section 2 provides a detailed literature review on SC and CSFs organized in two distinct subsections, while Sect. 3 briefly describes the adopted research methodology of this paper. Subsequently, in Sect. 4 the most cited SC and CSFs in the considered literature are presented (quantitatively and qualitatively), and the empirical data of the structured questionnaire survey are analyzed through different statistical methods. Finally, Sect. 5 concludes with some useful findings and remarks of this paper.

Literature Review on Success Criteria (SC) and Critical Success Factors (CSFs)

The Success Criteria (SC)

One of the most important aspects of project success is the SC. The traditional method of assessing project success is based on a simplified scheme of the three basic SC (time, cost, and quality/performance), also known as the "Iron Triangle," "Golden Triangle," or "Triangle of Virtue" in the scientific community (Atkinson, 1999; Ika, 2009; Westerveld, 2003). Many researchers have adopted additional SC over the years to address the increasing need to broaden the concept of success. The following SC are included in the traditional framework of project success evaluation (Ika, 2009; Pinto & Slevin, 1988a): (a) Budget–cost, (b) Time–schedule, (c) Quality–performance, and (d) Client satisfaction. Depending on the different goals and objectives of the various project types, the SC may differ and several new criteria for evaluating project success have been proposed by various researchers over the last few decades.

Pinto and Slevin (1988a) present an accurate and comprehensive model of project success evaluation that separates the SC into two areas: the project (time, cost, performance), and the client (use, satisfaction, effectiveness). Subsequently, Freeman and Beale (1992) cite the most important and common SC in the literature as follows: technical performance, efficiency of project execution, managerial and organizational implications, personal growth, project termination, technical innovativeness, and manufacturability and business performance. In the early 2000s, Westerveld (2003) introduces the "Project Excellence Model" which classifies the SC (labeled as result areas) in six general categories: project results (budget, schedule, quality), appreciation by the client, appreciation by project personnel, appreciation by users, appreciation by contracting partners, and appreciation by stakeholders. However, Nelson (2005) regards that the evaluation of project success should include specific criteria relating to the process (time, cost, product) and the outcome (use, learning, value) of a project.

Chan and Chan (2004) propose a framework for the assessment of construction projects' success which consists of the following basic criteria: time, cost, value and profit, health and safety, environmental performance, quality, functionality, user expectation, and satisfaction, and participants' satisfaction. Turner (2009) presents the concentrated list of SC, derived from previous research of Turner and Müller (2006), as follows: end-user satisfaction, supplier satisfaction, team satisfaction, other stakeholders' satisfaction, performance in terms of time–cost–quality,

meeting user requirements, the project achieves purpose, customer satisfaction, reoccurring business. Moreover, the proposed framework of Al-Tmeemy et al. (2011) demonstrates three dimensions of project success evaluation, namely the project management success (quality targets, schedule, budget), the product success (customer satisfaction, functional requirements, technical specifications), and the market success (revenue and profit, market share, reputation, competitive advantage), considering the project development period, the different stakeholders' perspectives, as well as the project impact on the organization, respectively.

According to the proposed evaluation framework of Wai et al. (2012), the SC are embedded into five dimensions of project success: the company success (company growth, personnel training, experience and knowledge gain, improvement of management, developer–contractor relation, capital gain), the profitability success (sales of product, product market share, project profitability), the primary product success (quality, durability, complete within time, complete within allocated budget), the secondary product success (sustainability, environmental effect, project safety, life cycle cost), and the branding success (customer confidence on product, developer reputation, customer satisfaction). Furthermore, Nguyen et al. (2013) proposed a framework for evaluating the success of construction projects including the following SC: quality, project cost, project time, project safety, technical performance/specifications, functionality, project stakeholders' satisfaction, environmental sustainability, project communication, productivity, and conflict, litigation, and dispute. More recently, Silva et al. (2016a) conduct an extensive literature review and formulate a framework for the evaluation of project success in the construction sector which classifies a wide range of SC into the short-term dimension of efficiency (cost–budget, time–schedule, quality, safety, cash-flow management) and the long-term dimension of effectiveness (client–customer satisfaction, employee–project staff satisfaction, profitability, environmental impact, learning, and development), respectively.

Alashwal et al. (2017) conduct a literature review to investigate the SC and CSFs for international construction projects in Malaysia. The results of the Principal Component Analysis indicate that the construction project success can be assessed using three components, the management success (quality, time, revenue and profit, safety, cost, reputation, benefit to stakeholders), the functional success (functional requirement, customer satisfaction, scope), and the organization success (competitive advantages, market share). Albert et al. (2017) attempt to identify the common SC used in different fields/industries to examine the possible existence of specific patterns in the selection of SC. The findings of the literature review show that the identified SC can be separated into hard criteria (time, cost, performance, quality, economic success) and soft criteria (company satisfaction, line-manager satisfaction, project-member satisfaction, customer satisfaction, end-user satisfaction, supplier satisfaction), respectively.

According to Adabre and Chan (2019), a common set of SC for the assessment of project success cannot be recognized in the corresponding literature. The systematic literature review uncovers 20 distinct SC, which is incorporated into a conceptual framework for measuring project success in affordable housing projects. The SC of sustainable housing projects can be analyzed in terms of project management success (cost performance, quality performance, safety performance, productivity/efficiency, environmental performance, schedule performance, reduced litigations and disputes, risk containment, technology transfer, project team satisfaction), product success (household satisfaction, functionality, technical specification, reduced project life cycle cost, price of housing (related to income), rental costs (related to income), cost of transport (related to income) take up-rate of the facility), and project success (waiting time of candidates earlier than being allotted a housing unit).

The Critical Success Factors (CSFs)

The CSFs, or more simply the success factors, concentrate an extremely wide range of scientific and academic research due to their high contribution and impact on the possibility/likelihood of project success accomplishment. Since 1960, several researchers have attempted to examine and identify, in a theoretical and empirical manner, the factors that could significantly affect the success or failure of a project (Avots, 1969; Baker et al., 1983; Boynton & Zmud, 1984; Cleland & King, 1983; Lock, 1984; Martin, 1976; Morris & Hough, 1987; Murphy et al., 1974; Queiroz & Mendes, 2020; Tiwari & Suresha, 2021; Vishvakarma et al., 2021). However, it is not possible to distinguish a generalized framework with wide acceptance and universal application.

The first systematic and empirical attempt for the categorization of the CSFs originates from Slevin and Pinto (1986) and Pinto and Slevin (1987, 1988b, 1989), who develop and present the popular "Project Implementation Profile" (PIP). This conceptual model encloses the following ten generic critical factors that contribute to the successful execution of a project: project mission, top management support, project schedule/plan, client consultation, personnel, technical tasks, client acceptance, monitoring and feedback, communication, and trouble-shooting (Pinto & Slevin, 1987; Slevin & Pinto, 1986). Subsequently, Pinto and Slevin (1988b) distinguish a wide range of critical factors or forces that can significantly contribute

to the success of a project providing the administrator/manager useful assistance in terms of proper project management. They also add four external factors to the "Project Implementation Profile" that extend beyond the narrow control limits of a project, namely the characteristics of the project team leader, the power and politics, the environmental events, and the urgency. De Wit (1988) conveys the results of a previous extensive literature survey on project success and failure (Morris & Hough, 1987), which classifies the most important success factors into ten categories/areas: project definition, planning, and design, politics, schedule duration, schedule urgency, finance, legal agreements, contracting, project management, and human factors. It is highlighted that the CSFs can serve to the analysis of the individual issues of project success/failure, but they cannot be applied for the measurement or evaluation of project success (De Wit, 1988).

The contribution of Belassi and Tukel (1996) to the studied field is considered extremely crucial, as they conduct complicated research and review of all the CSFs available in the international literature. Particularly, Belassi and Tukel (1996) separate all available studies into theoretical and empirical and propose a framework that indicates general categories/areas of factors based on their relation to the project, the project manager and the team members, the organization, and the external environment. Baccarini and Collins (2003) conduct a major questionnaire survey that attributes the following generalized categories of success factors: project understanding, competent project team, communication, realistic cost and time estimates, adequate project control, client involvement, risk management, resources, teamwork, project planning, top management support, stakeholder involvement, project manager authority, external factors, and problem-solving.

Westerveld (2003) introduces the "Project Excellence Model" which classifies the CSFs (labeled as organizational areas) in six general categories, namely the leadership and team, the policy and strategy, the stakeholder management, the resources, the contracting, and the project management (scheduling, budget, organization, quality, information, risks). However, the external factors that should be seriously considered and may vary between projects are the project manager and team members, the project, the parent organization, and the external environment (Westerveld 2003). In particular, remarkable research originates from Chan et al. (2004) who examine the success of construction projects and concentrate on the CSFs that are necessary to improve their effectiveness. Chan et al. (2004) examine seven prominent scientific journals in respect to project management and finally develop a conceptual framework of factors influencing the success of construction projects with the following basic components: project management actions, project procedures, project-related factors, human-related factors, and external environment. The positive performance of the proposed categories of factors is considered to contribute to the success of the construction projects individually or collectively (Chan et al. 2004). Fortune and White (2006) suggest the model of a robust system named as "Formal System Model" that includes all the success factors within the considered literature and assorts them into the main components or the key elements of a project as follows: goals and objectives, performance monitoring, decision making, transformations, communication, environment, boundaries, resources, continuity, and implicit factors.

From the viewpoint of Toor and Ogunlana (2009), the CSFs constitute the necessary aspects of a project that can significantly contribute to its successful achievement. However, the different main stakeholders adopt their own goals and expectations for each project, as a consequence, it is extremely difficult to formulate a commonly acceptable and comprehensive list of success factors. Also, the projects have different goals and objectives, which require specialized sets of success factors depending on the circumstances. It is noted that the research on CSFs is covering many scientific fields and is being developed in various countries. Toor and Ogunlana (2008, 2009), carry out a combined survey to identify the CSFs of large-scale construction projects from the perspective of the construction professionals. Specifically, the twenty more important success factors are grouped via factor analysis into four appropriate categories (4 COMs): comprehension, competence, commitment, and communication.

Tabish and Jha (2011) thoroughly examine the relative literature and finally distinguish through survey and statistical analysis the four main components of success factors: rules and regulations awareness and compliance, effective partnering among project participants, pre-project planning, and scope clarity, and external monitoring and control. Moreover, Sudhakar (2012) focuses his research interest on interpreting the success of software development projects and presents a conceptual model that encloses seven distinct categories of factors: communication, technical, organizational, environmental, product, team, project management.

Shahu et al. (2012) investigate the role of flexibility in reducing risk and increasing project success. Their paper focuses on the traditional critical success factors in construction project management and tries to figure out the role of flexibility. To identify the scope of flexibility as one of the critical success factors of construction projects, the authors conducted interviews with 60 project managers from the construction industry in the Nagpur region of India. The findings show that project success is strongly linked to flexibility, which is one of the project success factors.

Wai et al. (2013) concentrate on the successful performance of social infrastructure projects and propose a framework of success factors that consists of the following general categories based on the project life cycle: pre-construction factor, construction factor, post-construction factor, organization factor, information management factor, change management factor. Subsequently, Gudienė et al. (2013, 2014) investigate in detail the CSFs that affect the execution of the construction projects in their country through a general survey and an evaluation process. The proposed conceptual framework for the success of construction projects includes seven distinct categories of factors based on their relation to the project, project management/team, project manager, client, contractor, as well as external and institutional factors (Gudienė et al. 2013, 2014).

Recently, Yong and Mustaffa (2017) updated their previous research work (Yong & Mustaffa 2012, 2013) aiming at the re-evaluation of the CSFs of the construction projects. Based on the literature review, they formulate a concentrated framework of CSFs for the construction projects, which encloses eight basic categories of factors related to the project, the project planning and management, the project stakeholders (client, project team leader, project consultant, contractors), the project procurement, and the external environment (Yong & Mustaffa 2017).

Critical success factors (CSFs) that are required for the adoption of public–private partnerships (PPP) models in Indian urban metros are investigated by Kulshreshtha et al. (2017). In a pilot study, eighteen CSFs identified through a literature review were validated using a structured questionnaire and classified into seven macro-factors using hierarchical cluster analysis. The seven CSFs include as follows: socio-political environment, stable macro-economics and institutional, legal, framework, government support, good governance, effective procurement, well-structured PPP project, and PPP implementation processes.

Alashwal et al. (2017) conduct a literature review to investigate the SC and SFs for international construction projects in Malaysia. The results of the Principal Component Analysis show that the most important SFs of the international projects can be categorized into the following components: power and skills of the project team, resource availability, external environment, organization capability, project support, and project organization.

Mathar et al. (2020) examine the CSFs that influence the success of large building construction projects in Saudi Arabia. Following a thorough literature review, 91 CSFs were identified and clustered into eight general categories based on previous studies and common characteristics of the following factors: project characteristics, contractual arrangement, project participants, interactive processes and communication, financial attributes, management and technical attributes, experience and resource attributes, and risk attribute.

Gunduz and Almuajebh (2020) aim at the identification and evaluation of the different CSFs that conduce to the construction project's success. The extensive literature review indicates a list of 40 CSFs that are appropriately prioritized in seven general categories based on the distinct characteristics of the factors related to: the project, the business and work environment, the client, the project management, the design team, the contractor, and the project manager.

Research Methodology

This paper's methodological framework consists of four stages (Fig. 1).

The first stage of the research methodology (Stage 1) outlines the initial search of databases and references (e.g.,

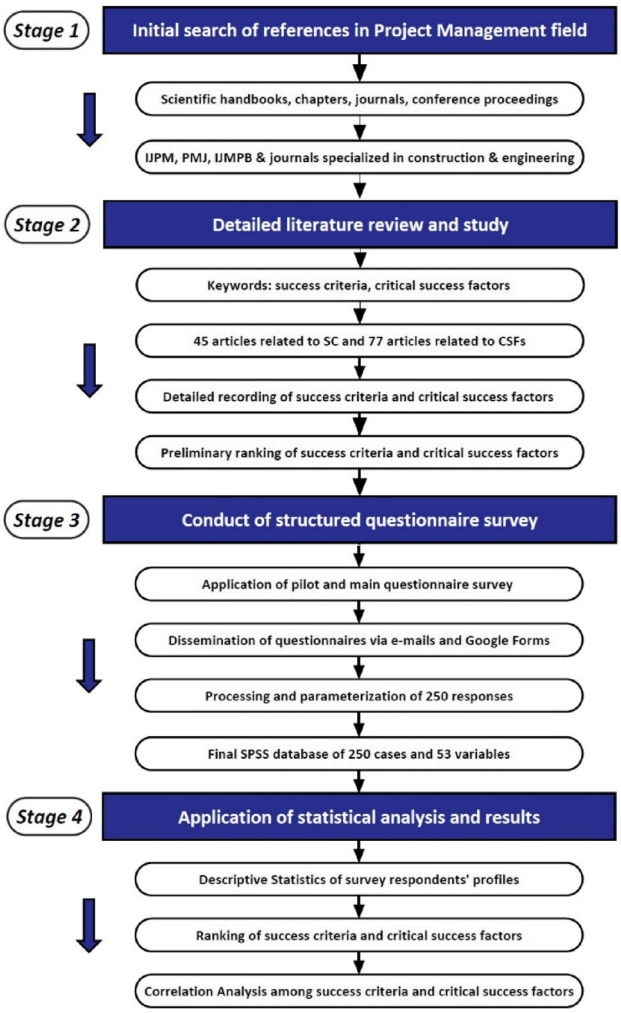

Fig. 1 The adopted research methodology

Google Scholar, Microsoft Academic, Mendeley, Scopus, Science Direct, Springer Link, Wiley Online, Emerald Insight, Taylor and Francis Online, etc.) that deal with the major research subjects (project success, success criteria, critical success factors) and collate books, handbooks, chapters, journals, etc. Thus, the output of this search includes various journals such as the International Journal of Project Management (IJPM), the Project Management Journal (PMJ), the International Journal of Managing Projects in Business (IJMPB) as well as books, handbooks, and conference proceedings.

The second research stage (Stage 2) is an extensive study and review of the most apposite scientific handbooks, chapters, articles, and standard references collected in Stage 1. Figure 2 briefly describes searching for references and the selection approach of articles referring to the SC and the CSFs. The literature review focuses on the important theoretical and empirical studies about the components of project success under consideration in this study (success criteria and critical success factors), and special emphasis is given to the reasoning and methodology adopted by related case studies and proposed models and frameworks. In addition, Stage 2 includes a content analysis on the references we studied to systematically record the different SC and CSFs. This research stage is completed a preliminary quantitative evaluation of the degree of significance of the recorded SC and CSFs using the frequency of reference and occurrence in the literature as an indicator.

The third research stage (Stage 3) includes an extensive questionnaire survey (pilot and main questionnaire survey) intended to examine the importance of both fundamental components of project success. The participants in the questionnaire survey are mainly individuals and organizations with proven experience in the management and execution of construction and technical projects in Greece.

Specifically, a structured questionnaire survey was designed and organized electronically in Google Forms. This consisted of two separate sections with 12 open-ended and closed questions, respectively. The first section of questions (1–9) included the personal/demographic profiles of the respondents, while the second section of questions (10–11) evaluated the relative importance (Likert scale 1 to 5) of the 17 success criteria and 26 critical success factors extracted from the literature review (Stage 2). It should be noted that the 5-point Likert measurement scale has been used in several case studies in the literature of SC and CSFs (e.g., Gudienė et al., 2014; Toor & Ogunlana, 2008; Toor & Ogunlana, 2009; Wai et al., 2012; Wai et al., 2013) and the value "1" represented the lowest degree of importance,

Fig. 2 The literature review process

while the value "5" represented the highest. Additionally, a general question was added at the end (12) to evaluate the overall perceived success (in percentage form) of the projects in which the respondents have participated or been involved. It should be noted that the questionnaire was simple and specific to reduce the ambiguity of the questions. In addition, all definitions of SC and CSFs were provided to avoid any misunderstanding of the terms participants were unfamiliar with. The main aim of the questionnaire survey was the collection of sufficient empirical data to be contrasted with the theoretical data which could form the basis for the formulation of the proposed methodological model and framework.

The questionnaire survey consisted of two implementation phases. Firstly, the pilot application was carried out (December 2018) with 17 academics with a research interest in project management and 20 major construction companies in Greece to check the degree of accuracy of the questionnaire and identify any potential deficiencies and omissions. Subsequently, the main application of the questionnaire survey was conducted between January 2019 and April 2019 with a specially selected pool of potential respondents (all of whom were engineers). The authors tried to include all the databases of engineers in Greece when choosing the respondents. The potential respondents of the questionnaire survey included (i) 214 construction companies in Greece, (ii) 438 construction/technical company members of the Greek Association of Technical Companies, (iii) 17 regional departments of the Technical Chamber of Greece, iv) graduates of MSc programs in project management, (v) associations of graduate engineers of Greece, and (vi) the authors' personal contact lists. The respondents' contact information was obtained through Internet searches and authors' contacts with the appropriate Greek authorities. However, there was a low responsiveness from the potential respondents during the main application of the questionnaire survey. As a result, the duration of the main questionnaire survey was extended by two months (May–June 2019) to allow the collection of enough full responses. The 250 responses were then checked in terms of their completeness and validity.

The final methodological stage (Stage 4) describes the statistical analysis of the empirical data obtained from the questionnaire survey. After checking the completeness and validity of the electronic questionnaire survey, there was a total of 250 complete responses. The respondents' replies were recorded, codified, parameterized and organized in a database to be used for further processing and analysis. The statistical analysis of the data includes the methods of descriptive statistics, the correlation analysis and some other statistical tests, which were expected to lead to useful research and scientific results and findings. Additionally, the statistical analysis was performed using IBM SPSS Statistics v.25 and other appropriate data processing software.

Results

The Most Cited Success Criteria (SC) and Critical Success Factors (CSFs)

The collection of references (scientific handbooks, chapters, scientific papers and proceedings in international conferences) with a proven contribution to research evolution was a result of the successful completion of the first two methodological stages. Many theoretical and empirical aspects of project success and its fundamental components (SC and CSFs) were discovered after a comprehensive review and study of these sources, which were organized and recorded through content analysis. The SC and CSFs are then separated and recorded in Tables 1 and 2, summarizing the most significant and cited SC and CSFs in the literature (45 and 77 references, respectively).

It should be noted that in the case of CSFs, the review and study of the references resulted in a high number of records (more than 400 separate CSFs). Some CSFs with the same or similar meaning, wording, content, and function were merged and incorporated into generic categories to reduce the range of registers and produce a more effective summary table.

The time/schedule (SC1), cost/budget (SC2) and quality and technical performance (SC3) represent the most common (cited) success criteria for evaluation project success followed by client/user/end-user satisfaction (SC4) and business and commercial performance (SC5), in descending order. Effectiveness (SC16) and suppliers' satisfaction (SC17) are ranked as the least cited success criteria.

The top five choices of CSFs in the corresponding literature, in decreasing order, are project mission and project goals and objectives (CSF1), top/senior management support (CSF2), the success factors of project communication (CSF3), project planning/monitoring/control (CSF4) and project manager/leader competence and experience (CSF5), whereas external factors, such as natural environment (CSF24) and leadership issues (CSF25), represent two of the least cited CSFs in the relevant literature. A detailed discussion of the above results is presented in Lamprou and Vagiona (2018).

Statistical Analysis of the Questionnaire Survey Data

The final number of respondents that participated in the extensive questionnaire survey was 250. The respondents stated their personal information (respondents' profile) in

Table 1 The most common SC in the corresponding literature

Success criteria (SC)	Percentage (%)	Success criteria (SC)	Percentage (%)
Time/Schedule (SC1)	87	Strategic Goals/objectives and Competitiveness (SC9)	36
Cost/Budget (SC2)	87	Use–Utilization (SC10)	31
Quality/Technical Performance (SC3)	67	Health and Safety (SC11)	31
Client/user/end-user Satisfaction (SC4)	67	Project Team/personnel Satisfaction (SC12)	27
Business and Commercial Performance (SC5)	53	Contractor's Satisfaction (SC13)	27
Other Stakeholders' Satisfaction (SC6)	44	Future Perspective (SC14)	27
Technical Specifications and Requirements (SC7)	42	Environmental Impact (SC15)	22
Functionality (SC8)	36	Effectiveness (SC16)	18
		Suppliers' Satisfaction (SC17)	4

Table 2 The most common CSFs in the corresponding literature

Critical success factors (CSFs)	Percentage (%)	Critical success factors (CSFs)	Percentage (%)
Project mission, project goals and objectives, project scope, project definition/perception, project vision (CSF1)	62	Project team/team members ability/competence and effectiveness (CSF14)	26
Top/senior management support, top/senior management commitment (CSF2)	55	Project personnel, project personnel ability/quality, adequate/skilled project personnel, project personnel issues (CSF15)	25
Project communication, communication/information systems/channels/procedures, internal project communication (CSF3)	48	Project size/value/type/uniqueness/complexity, project duration, project characteristics (CSF16)	25
Project planning/monitoring/control, monitoring & control, project monitoring/control mechanisms/ systems/procedures (CSF4)	47	Project plan/program, strong/detailed/up-to-date/ comprehensible project plan, project plan/program updating (CSF17)	23
Project manager/team leader ability/competence & relative/past experience (CSF5)	43	Project problems confrontation/solving, problems confrontation/solving abilities (CSF18)	23
Technological environment, modern/advanced/ appropriate technology, automatization, technology knowledge/transfer, knowledge & expertise utilization/support, technology level/availability, technological advancement (CSF6)	34	Effective project quality assurance program implementation, project quality control/management, project quality issues (CSF19)	23
Project finance/funding, project economics/budget, adequate/guaranteed project funding, reliable funding source, project cash-flows (CSF7)	32	Adequate project resources, project resources allocation/management, skilled/competent project resources (CSF20)	22
Political environment, political stability/instability, political risks, political factors, political influences (CSF8)	31	Project urgency/emergency, project results/outcomes urgency/emergency (CSF21)	21
Social environment, social factors, social support (CSF9)	31	Project client, project client size/type/nature/ characteristics, project client contribution and experience/knowledge, project client participation/ involvement (CSF22)	21
Monitoring and feedback, feedback abilities (CSF10)	30	Effective/regular/frequent project meetings, review/ progress/control/ performance evaluation project meetings, project progress reports (CSF23)	19
Risk identification/analysis/ evaluation/confrontation, project risk management, project risk management training, project risks (CSF11)	27	Nature, natural/ecological environment, natural factors (CSF24)	18
Project organizational structure, project organization structure, organizational policy/philosophy (CSF12)	26	Leadership and project team, project leadership quality, effective/good project leadership (CSF25)	18
Economic environment, economic factors/risks, national economy (CSF13)	26	Realistic/accurate/reliable/detailed project time/cost estimates (CSF26)	18

Table 3 Respondents' information and details

Gender breakdown	Percentage (%)
Men	64.00
Women	36.00
Age of respondents	
$\leq$ 30 years	12.61
31–45 years	56.76
46–60 years	24.77
$\geq$ 61 years	5.86
Academic background	
BSc qualification	40.80
MSc qualification	51.20
PhD qualification	7.60
Profession/specialty of respondents	
Civil Engineer	54.80
Mechanical Engineer	13.20
Electrical Engineer	10.40
Architect Engineer	8.80
Urban and Spatial Planning Engineer	5.20
Rural and Surveying Engineer	3.20
Other Engineers	4.40
Business activity sector	
Private sector	67.60
Public sector	32.40
Experience of respondents	
0–10 years	44.72
11–20 years	30.49
21–30 years	17.07
$\geq$ 31 years	7.72

Table 4 Types and number of projects the respondents have participated in

Types of projects	Percentage (%)
Building projects	32.87
Road construction projects	9.75
Hydraulic projects	8.36
Industrial/energy projects	6.96
Electrical/mechanical projects	6.13
Other projects	35.93
Number of projects	
0–25 projects	48.15
26–50 projects	16.87
51–75 projects	4.94
76–100 projects	10.29
$\geq$ 101 projects	19.75

the first nine open-ended and close-ended questions and provided their evaluation scores under a predefined scale in the questions regarding SC and CSFs. They were also asked to estimate the overall perceived success of the projects (in percentage form) in which they have participated or have been involved. The responses of the participants of the questionnaire survey were recorded, processed and parameterized into a form to create a database. All the processed data were imported into an SPSS database (in IBM SPSS Statistics v.25), which consisted of 250 cases (number of respondents) and 53 variables (elements of questions). The incorporated variables of the SPSS database referred to the respondents' profiles (9 variables), the evaluation scores of the examined SC (17 variables) and CSFs (26 variables) and to the perceived success of the projects that the respondents have participated in (one variable). It is also notable that the statistical analysis process used in this study encompassed descriptive statistics, correlation analysis and some other more specialized statistical tests, as presented in detail below.

Descriptive Statistics

For the first step, the statistical analysis process of the data of the complete responses of the questionnaire survey included a method of descriptive statistics. We used a widespread range of statistical techniques and procedures applied for the systematic organization, simplification, interpretation and presentation of the accurate data obtained from a questionnaire survey. Generally, the results of the research (in percentage form) were based on a sample of all 250 respondents.

Data regarding the respondents' profile are presented in Table 3. In terms of the gender breakdown (question 1), 64% of the respondents were male and 36% were female, noting that all the respondents of the survey responded to this question. Regarding the age of the respondents (question 2), most of them (56.76%) were between 31 and 45 years, whereas a significant portion of the respondents was between 46 and 60 years (24.77%). The remaining respondents were either under 30 years old (12.61%) or older than 60 years old (5.86%). In general, it can be inferred that mostly relatively young engineers (31 to 45 years old) participated in this questionnaire survey.

One feature of the respondents' profiles was their academic background (question 3). Approximately, half of the respondents (51.20%) held a postgraduate studies degree (specifically an MSc), while a large proportion of the rest (40.80%) were undergraduates (BSc) of the universities or technical schools in Greece. Analyzing the previous question further, the questionnaire survey also focused on the profession/specialty of the respondents. Generally, most (about 95%) were engineering graduates. More

specifically, the largest group was civil engineers (54.80%) and another 13.20% was made up of mechanical engineers, 10.40% electrical engineers, 8.80% architectural engineers, 5.20% urban and spatial planning Engineers, 3.20% rural and surveying engineers and 'other engineers' constituted 4.40%. Referring to the respondents' main form of employment (question 5), the highest percentage of the respondents (about 70%) owned their own technical office, company or business (38.00%) or worked in a private technical office, construction company or business (31.60%). The rest of the participants of the survey operated as partners (permanent or temporary) in a technical office, construction company or business (17.60%) and as employees in the public sector (12.00%). Separating the previous answers into the two main business activity sectors (question 6), most respondents worked in the private sector (67.60%) compared to those working in the public sector (32.40%).

Subsequently, the questionnaire survey focused on the experience of the respondents in the execution or management of technical or construction projects (question 7) (Table 4). In particular, approximately half of the respondents stated they had experience of up to 10 years (44.72%), while a sizable number of them indicated previous experience of between 11 and 20 years (30.49%). The participants in the questionnaire survey with previous experience of 21 to 30 years in the execution or management of technical and construction projects follow in the final ranking (17.07%), while some of them answered that their experience exceeded 31 years (7.72%). In addition to the previous experience in the execution or management of such projects, the questionnaire survey asked for the main types of projects and the approximate number of projects in which the respondents had participated or had been involved (Table 4). In terms of the categories of projects (question 8), most respondents stated that they had mainly participated in building projects (32.87%), road construction projects (9.75%), hydraulic projects (8.36%) and industrial and energy projects (6.96%). However, the biggest portion of the answers could be classified as 'other projects' (34.26%) due to specialist projects (e.g., research/development/educational projects, infrastructure projects, management projects, sports/cultural projects, environmental projects, information technology projects and project studies/plans/certificates). Regarding the number of projects (question 9), the largest percentage of the respondents mentioned that they had participated in up to 25 projects (48.15%), while a significant part of them had participated in over 100 projects (19.75%) and from 26 to 50 projects (16.87%). Moreover, several respondents reported that they had been actively involved in between 76 and 100 projects (10.29%) and a few of them who had been involved in from 51 to 75 projects (4.94%).

In summary, most of the respondents in the questionnaire survey were engineers, who were of a relatively young age (31 to 45 years), with little to moderate previous experience (up to 20 years) and had had active involvement in a comparatively low number of projects (up to 25 projects).

The second section of the questionnaire survey (questions 10–11) encompassed the evaluation of the relative importance, under a predefined scale (Likert scale 1–5), of the 17 success criteria (SC) and the 26 critical success factors (CSFs) found in the literature review. Tables 5 and 6 present the descriptive statistics referring to the relative importance of the listed SC and CSFs, ranked in descending order based on the mean scores.

According to Table 5, the relative importance of the 17 SC examined, ranging from 3.20 to 4.60, indicated that most success criteria were considered quite important or even very important by the respondents. Specifically, the three most important SC of a project, based on their mean evaluation score, were cost/budget (SC2), time/schedule (SC1) and customer/user/end-user satisfaction (SC4). Also, the five most important success criteria in the final rankings also included quality/technical performance (SC3) and effectiveness (SC16). In contrast, the three least important project SC were regarded as contractor satisfaction (SC13), project team/personnel satisfaction (SC12) and supplier satisfaction (SC17).

Comparing the results of the statistical analysis of the questionnaire survey data (Stage 4) and the preliminary quantitative evaluation (Stage 2), in respect to the importance degree of the success criteria examined, there was a relatively high correspondence between the first and final positions of the final rankings. In other words, the literature review and the questionnaire survey converged significantly on two or three of the most and least important project SC. Moreover, the appreciable increase in the criteria of effectiveness (SC16) and future perspective (SC14), as well as the decrease in the criteria of stakeholders' satisfaction (SC6) and business and commercial performance (SC5) were notable in terms of their degree of relative importance.

Referring to the evaluation of the 26 CSFs (Table 6), their relative importance degree ranged from 3.40 to 4.50, again implying that most of the success factors were regarded as quite important or even very important by the respondents. According to the final ranking based on their evaluation mean score, the top five most important success factors were project finance/funding and economics (CSF7), project team/team member ability/competence and effectiveness (CSF14), project manager/team leader ability/competence and relative/past experience (CSF5), project problem confrontation/solving (CSF18) and project planning/monitoring/control (CSF4). On the contrary,

Table 5 Final ranking of the success criteria based on the mean scores

Ranking	Success Criteria (SC)	Minimum	Maximum	Mean
1	SC2	1.00	5.00	4.604
2	SC1	2.00	5.00	4.428
3	SC4	1.00	5.00	4.424
4	SC3	1.00	5.00	4.400
5	SC16	2.00	5.00	4.240
6	SC7	3.00	5.00	4.220
7	SC8	3.00	5.00	4.208
8	SC11	2.00	5.00	4.180
9	SC14	1.00	5.00	3.920
10	SC5	2.00	5.00	3.912
11	SC10	1.00	5.00	3.888
12	SC15	1.00	5.00	3.880
13	SC6	1.00	5.00	3.784
14	SC9	1.00	5.00	3.776
15	SC13	2.00	5.00	3.700
16	SC12	1.00	5.00	3.696
17	SC17	1.00	5.00	3.252

nature and natural/ecological environment (CSF24), social environment and social factors (CSF9) and monitoring and feedback (CSF10) were ranked (in descending order) as the three least important success factors of a project.

Comparing the results of the statistical analysis of the questionnaire survey data (Stage 4) and the preliminary quantitative evaluation (Stage 2) relating to the importance degree of the examined CSFs, some remarkable differences at the theoretical and empirical levels can be identified. On the one hand, there was a significant increase in the success factors of project personnel and project personnel ability/quality/issues (CSF15), project resources and project resources allocation/management (CSF20), realistic/accurate/reliable/ detailed project time/cost estimates (CSF26) and leadership and project team (CSF25). On the other hand, the success factors of project mission/goals/objectives/scope/vision (CSF1), project communication and information (CSF3), top/senior management support and commitment (CSF2) and political environment and political risks/factors (CSF8) received a relatively low evaluation by the questionnaire survey respondents.

To conclude, it is important to briefly present the results in respect to the perceived success of the projects in which the respondents had participated (question 12). In detail, more than half of the respondents (59.68%) regarded 76% to 100% of the projects in which they had participated as successful. Also a sizable percentage (33.06%) assessed 51% to 75% of the projects as successful, and most of the respondents (about 93%) estimated that more than half of the projects in which they had participated were eventually successful.

Correlation Analysis

The correlation analysis is a statistical method used for the measurement and interpretation of the possible relationship between two variables, as observed in their natural environment. The correlation between two variables expresses the relationship between them and does not explain the way they are related. Consequently, the correlation cannot indicate the causal relationship between any two variables. Because the correlation of two variables does not necessarily reflect the causality between them, there may be a need for further examination. The complete interpretation of the correlation between two or more variables often presupposes the use of additional coefficients or measures of determination (Gravetter & Wallnau, 2017; Pallant, 2016).

Considering all the theoretical data, the application of the bivariate correlation was selected for the 17 SC and the 26 CSFs to identify the existence of possible correlations between them. The correlation analysis was conducted with the aid of IBM SPSS Statistics v.25 and the Spearman correlation coefficient (Spearman's rho-r_s) was selected as the considered variables contain nominal data (evaluation categories 1–5).

Firstly, it should be noted that most of the correlations between the 17 SC and the 26 CSFs presented high statistical significance ($p < 0.05$, two-tailed), while the

Table 6 Final ranking of the critical success factors based on the mean scores

Ranking	Critical Success Factors (CSFs)	Minimum	Maximum	Mean
1	CSF7	2.00	5.00	4.500
2	CSF14	2.00	5.00	4.308
3	CSF5	2.00	5.00	4.304
4	CSF18	3.00	5.00	4.300
5	CSF4	2.00	5.00	4.220
6	CSF15	2.00	5.00	4.216
7	CSF20	2.00	5.00	4.184
8	CSF26	1.00	5.00	4.148
9	CSF17	2.00	5.00	4.124
10	CSF25	1.00	5.00	4.104
11	CSF1	2.00	5.00	4.052
12	CSF3	2.00	5.00	3.932
13	CSF6	2.00	5.00	3.932
14	CSF11	1.00	5.00	3.932
15	CSF13	1.00	5.00	3.924
16	CSF16	1.00	5.00	3.884
17	CSF2	1.00	5.00	3.760
18	CSF12	2.00	5.00	3.760
19	CSF19	2.00	5.00	3.736
20	CSF8	1.00	5.00	3.696
21	CSF21	2.00	5.00	3.592
22	CSF22	1.00	5.00	3.592
23	CSF23	1.00	5.00	3.586
24	CSF24	1.00	5.00	3.440
25	CSF9	1.00	5.00	3.436
26	CSF10	1.00	5.00	3.404

correlation coefficients (r_s) generally ranged from 0.1 to 0.6, and from 0.2 to 0.7, respectively. Pallant (2016), following on from Cohen (1988, pp. 79–81), referred to the strength gradation of the correlation between two variables. A correlation coefficient of up to 0.5 ($r_s < 0.5$) indicates low to moderate correlation, whereas a correlation coefficient of greater than 0.5 ($r_s > 0.5$) indicates moderate to high correlation. Based on the previous data, the correlations among the 17 SC and the 26 CSFs that showed a coefficient greater than 0.5 ($r_s \geq 0.5$) were set for further investigation (Tables 7 and 8).

The highest pairwise correlations were observed between the SC of project team/personnel satisfaction (SC12) and contractor satisfaction (SC13) and the SC of contractor satisfaction (SC13) and supplier satisfaction (SC17). These bivariate relationships demonstrated the general dependence of project success on the individual perspectives of some of the main project stakeholders. A similar type of dependence was indicated by the relatively high correlation among the criteria of project team/personnel satisfaction (SC12) and stakeholder satisfaction (SC6). Moreover, the same interpretive context included the positive pairwise correlations between the SC of project team/personnel satisfaction (SC12) and supplier satisfaction (SC17), as well as stakeholder satisfaction (SC6) and contractor satisfaction (SC13). Generally, it can be considered that the highest correlations in this research concern the main project stakeholders and participants, who actively participate in the execution or management of a project and determine its degree of success based on their opinions.

Two equally significant positive correlations were detected among the SC of environmental impact (SC15) and effectiveness (SC16), as well as environmental impact (SC15) and health and safety (SC11). These pairwise correlations highlight the importance of the concepts of environment and health and safety for a project, which constitute quite important success criteria and key parameters during its design, execution and management. Regarding the other bivariate relationships, the positive

Table 7 Bivariate Correlation analysis of the examined success criteria ($r_s \geq 0.5$)

Success criteria (SC)	SC6	SC7	SC8	SC9	SC10	SC11	SC12	SC13	SC14	SC15	SC16	SC17
SC6	1.00						0.576	0.508				
SC7		1.00										
SC8			1.00									
SC9				1.00	0.513							
SC10				0.513	1.00							
SC11						1.00	0.504			0.523		
SC12	0.576					0.504	1.00	0.635				0.524
SC13	0.508						0.635	1.00				0.597
SC14									1.00	0.511	0.507	
SC15						0.523			0.511	1.00	0.552	
SC16									0.507	0.552	1.00	
SC17							0.524	0.597				1.00

Table 8 Bivariate Correlation analysis of the examined critical success factors ($r_s \geq 0.5$)

Critical success factors (CSFs)	CSF1	CSF2	CSF3	CSF4	CSF8	CSF9	CSF 10	CSF 11	CSF 12	CSF 13	CSF 14	CSF 15	CSF 21	CSF 22	CSF 24
CSF1	1.00	0.555													
CSF2	0.555	1.00													
CSF3			1.00	0.573											
CSF4			0.573	1.00											
CSF8					1.00	0.575				0.546					
CSF9					0.575	1.00									0.620
CSF10							1.00	0.600							
CSF11							0.600	1.00	0.614						
CSF12								0.614	1.00						
CSF13					0.546					1.00					
CSF14											1.00	0.744			
CSF15											0.744	1.00			
CSF21													1.00	0.575	
CSF22													0.575	1.00	
CSF24						0.620									1.00

correlations between the SC of future perspective (SC14) and environmental impact (SC15), as well as future perspective (SC14) and functionality (SC16), should be noted. The future perspective of a project is a long-term dimension of success, which has been proven to be highly dependent on, and possibly influenced by, the functionality and the environmental impact of a project throughout its function and operation. Another conclusion can be deduced from the positive correlation between the criteria of strategic goals/objectives and competitiveness (SC9) and the use/utilization (SC10) of a project. Specifically, a project is considered to have fulfilled the strategic goals and objectives for which it was designed and implemented, and is only regarded as being competitive, if it is properly used or utilized and serves the needs of the client or end-user. Also, it is advantageous to highlight the relatively high correlation between the SC of project team/personnel satisfaction (SC12) and health and safety (SC11), reflecting the extremely high significance and necessity of creating a healthy and safe working environment for each project. Therefore, it can be concluded that a healthy and safe working environment can positively affect and satisfy a project team, in combination with its other needs and requirements.

Analyzing Table 8, the highest positive pairwise correlation was between the CSFs of project team/team member ability/competence and effectiveness (CSF14) and project personnel and project personnel ability/quality/issues

(CSF15). A project's team is very important and its effectiveness depends on the ability, competence, and quality of its individual members. Also, three relatively strong correlations were present among the CSFs of social environment and social factors (CSF9) and nature and natural/ecological environment (CSF24), social environment and social factors (CSF9) and political environment and political risks/factors (CSF8), as well as political environment and political risks/factors (CSF8) and economic environment and economic factors/risks (CSF13). The economic, social, political and natural environment constitute fundamental components of the so-called external environment, which may influence or change the planned development route of a project at different stages of its life cycle. The relationship between them is significantly and positively dependent, while all four main components should be examined and analyzed in detail during the initial planning phase of a project.

Furthermore, the CSF of risk identification/analysis/evaluation/management/confrontation and project risks (CSF11) was highly correlated with the CSFs of monitoring and feedback (CSF10) and project organizational structure and project organizational philosophy/policy (CSF12). Generally, the identification, analysis and management of project risks are a major issue that should be seriously examined in the early stages of its development. The project organizational structure depends on the nature and importance of the risks that may emerge as a project progresses, while the monitoring and feedback conditions contribute to the prompt identification and analysis of these risks. From the other standout bivariate relationships, the positive correlation between the CSFs of project urgency/emergency and project outcomes/results urgency/emergency (CSF21) and project client and project client size/type/nature/characteristics and project client participation/involvement (CSF22) deserve special mention. The client or user of a project is regarded as one of the most important stakeholders to whom the original idea for its execution or implementation belongs. Therefore, the needs and requirements of the project client largely determine the urgency of the execution and implementation of a project or the urgency of its outcomes.

Moreover, the pairwise correlations between the CSFs of project communication and information (CSF3) and project planning/monitoring/control (CSF4) and project mission/goals/objectives/scope/vision (CSF1) and top/senior management support and commitment (CSF2) were also relatively high. The complete and continuous communication between the teams involved in a project is a basic precondition for its successful execution and implementation. The constant communication through the appropriate systems or processes is directly related to the monitoring and control of each phase of the life cycle, which allow proper briefings about the progress of a project to take place. Also, after the clarification of the mission, scope, goals and objectives of a project have been decided, the support and commitment from the senior management is critical for the project to acquire necessary feasibility and importance. Finally, the senior management support and commitment is maybe one of the few factors based on which project success can be assessed and predicted in the early stages of project development.

Discussion

Implications for Theory

This paper presented a comprehensive list of SC and CSFs that are relevant to project success and could be used to develop a mathematical model or performance index for assessing project success. Furthermore, it adds to the literature from the perspective of engineers.

Implications for Practice

The framework developed here could be used by organizations, companies and enterprises to measure success in project delivery. Therefore, it can assist managers in focusing on critical success elements (SC and CSFs) in measuring the level of success achieved by their construction projects.

Limitations of the Study and Future Research Directions

One limitation of this study is that the SC and CSFs were only evaluated by engineers and organizations with experience in construction projects (experts and practitioners) in Greece. Future research should focus on different project stakeholder categories (e.g., client, owner, contractor) to gain an overview of construction project success. Moreover, the most important SC and CSFs could be appropriately classified into the main phases of the project life cycle to evaluate project success in different periods of a project's progress. Selected SC and CSFs can be used in future research to develop a more complete understanding of the relative contribution of each one to influencing project success. In addition, future research could include an in-depth analysis of success criteria and success factors based on respondents' profiles (e.g., profession, experience) and project type, to examine if they differ based on the above variables. This way, a precise guideline that is applicable to various types of projects can be provided.

Conclusions

Project success is, without a doubt, one of the most debated topics in the scientific field of project management, with a lot of research being focused on it. However, until recently, there has not been a widely accepted definition of the concept of project success in the academic community. Generally, SC and CSFs are the two most important aspects of a project's success. SC are dependent variables that are used to assess and measure the success of a project, whereas CSFs are independent variables that can influence and increase the likelihood of a project achieving success (Ika, 2009; Judgev & Müller, 2012; Lim & Mohamed, 1999; Turner, 2009). Through extensive academic research in the context of project success, the current paper aimed to study, record and assess project success criteria (SC) and critical success factors (CSFs) in a systematic manner.

In the first instance, the different SC and CSFs were identified through content analysis on the examined references. The quantitative index of frequency of reference and occurrence was used for the preliminary evaluation of the relative importance of the recorded SC and CSFs. The most cited SC in the corresponding literature were time/schedule, cost/budget, quality/technical performance and client/user satisfaction. Similarly, the most cited or common CSFs were project mission/goals/objectives/scope/vision, top/senior management support and commitment, project communication and the project planning/monitoring/control. Moreover, the external environment and its distinct components were regarded as significant success factors that should be considered and analyzed in the early stages of the project development.

Secondly, the most cited SC and CSFs were enclosed in a structured questionnaire survey to Greek engineers and technical/construction companies to evaluate their perceived relative importance. Specifically, the most important SC were cost/budget, time/schedule and client/user satisfaction, and the most important CSFs are project finance/funding and economics, project team/team member ability/competence and effectiveness, and project manager/team leader ability/competence and relative/past experience. Referring to the perceived project success, most of the respondents regarded more than half of the projects in which they have participated as being eventually successful.

The correlation analysis indicated that most SC and CSFs correlated from moderately to highly with each other. The highest pairwise correlations were observed among the criteria of project team/personnel satisfaction and contractor satisfaction and the criteria of contractor satisfaction and supplier satisfaction. Similarly, the highest pairwise correlation was detected between the factors of project team member ability, competence and effectiveness and project personnel and project personnel ability, quality and issues and the factors of social environment and social factors and nature and natural environment.

This paper contributes to the academic field of project management by presenting a comprehensive and systematic method for identifying and evaluating SC and CSFs based on theoretical and empirical data. To the authors' knowledge, this paper presents the most comprehensive list of SC and CSFs relevant to project success. Considering this list, professionals in project management can select the criteria that are appropriate for their projects on a project-by-project basis.

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Declarations

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