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Management of industrial service projects developed by Brazilian companies and their relationship with critical success factors

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RESUMO

Objetivo – Este estudo tem como objetivo analisar a gestão de projetos de serviços industriais desenvolvidos por empresas brasileiras e sua relação com os Fatores Críticos de Sucesso.
Referencial teórico – Por meio de uma análise de conteúdo, foi realizado um alinhamento dos Fatores Críticos de Sucesso para a gestão de serviços industriais e as diretrizes de gestão de projetos do PMBOK.
Desenho/Metodologia/Abordagem – Para desenvolver a pesquisa, foi realizado um levantamento sobre gestão de projetos de serviços industriais com profissionais de serviços industriais. Os dados da pesquisa foram analisados por meio de distribuição de frequência e classificados pela técnica TOPSIS.
Resultados – Os resultados mostraram que as empresas citadas utilizam as diretrizes do PMBOK, porém há possibilidades de melhorias. Comparativamente, destaca-se a gestão do cronograma do projeto; os 5 FCS considerados mais relevantes estão relacionados ao escopo, cronograma, custos, integração, comunicação e gestão de recursos.
Pesquisa, Implicações práticas e teóricas – Os resultados fornecem insights para as práticas organizacionais e orientam para a melhoria da gestão, mostrando as principais oportunidades de melhoria para as empresas analisadas.
Originalidade/Valor – A literatura falha em fornecer análises das empresas brasileiras de serviços industriais. Nesse sentido, esta pesquisa traz uma valiosa contribuição para a área.
Palavras-chave: Gestão de Serviços Industriais; Fatores críticos de sucesso; Gerenciamento de projetos; Brasil.

ABSTRACT

Purpose *– This study aims to analyze the project management of industrial services developed by Brazilian companies and their relationship with Critical Success Factors.*
Theoretical framework – Through a content analysis, Critical Success Factors were aligned to industrial service management and PMBOK project management guidelines.
Design/methodology/approach *– To develop the study, a survey on industrial service project management was carried out on industrial service professionals. Survey data were analyzed through frequency distribution and ranked using the TOPSIS technique.*
Findings *– The results showed that the companies mentioned use PMBOK guidelines, however, they can be improved. Comparatively, the project schedule management is highlighted; the five CSFs that are considered more relevant are related to the scope, schedule, costs, integration, communications and resource management.*
Research, Practical & Social implications *– The results provide insights for organizational practices and guide management improvements, showing the main opportunities for improvement in the companies analyzed.*
Originality/value *– The literature fails to provide an analysis of Brazilian industrial service companies. In this sense, this study provides a valuable contribution to the field.*
Keywords*: Industrial Services Management; Critical Success Factors; Project Management; Brazil.*

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1. INTRODUCTION

According to the Brazilian Institute of Geography and Statistics (IBGE, 2017), Brazil has about 4.6 million active companies, and 1,286,621 of them operate in the services sector. This sector has been prominent in Brazil and developed nations, contributing to income generation and job creation through its expressive growth (ERKOYUNCU; DURUGBO; ROY, 2013; MCLAUGHLIN; PANNESI; KATHURIA, 1991; RUST; HUANG, 2014).

Analysing this sector, it is possible to identify the industrial services (IS) segment, which also presented a high relevance for the economy and has been growing in recent decades (BONAMIGO *et al*., 2020; KOHTAMÄKI; HELO, 2015; PRAJOGO, 2006). This specific type of service interacts with the industrial sector in different ways and can be characterized as a mean to support products or to create solutions to support industrial processes and activities (RABETINO *et al*., 2015; STORMI *et al*., 2018; TRENTO *et al*., 2016). By presenting a specific deadline for its achievement and well-defined objective, industrial services can be understood as projects (PMI, 2017); additionally, stakeholders can benefit from project management guidelines disseminated by various institutions. As it is exposed by Ferreira *et al.* (2019), Mahmood *et al.* (2019) and Severo *et al.* (2019), project management practices are necessary for project success, adding advantages to organizations, such as greater financial return, efficiency in processes, and customer satisfaction. For this, barriers should be overcome (ALEKSIC *et al*., 2017; URTON; MURRAY, 2021).

According to PMI (2017), the use of project management guidelines for industrial services management increases the chances of success, minimizes risk factors and contributes to the satisfaction of all stakeholders. In PMBOK (PMI, 2017), recognized as a relevant project management knowledge source (WEI; PRYBUTOK; SAUSER, 2021), project management guidelines are presented in 10 knowledge areas: integration management, scope management, schedule management, cost management, quality management, resource management, communications management, risk management, procurement management and project stakeholder management.

Industrial services management is complex and the use of critical success factors (CSF) may contribute substantially to its management (KOHTAMÄKI; HELO, 2015; PINTO; JOHNSTON, 2004; SPRING; ARAUJO, 2009). In their research, Machado et al.

(2020) studied the CSF for Industrial Service management, and showed the need for more studies about this theme.

In this context, the objective of this article is to analyse the management of industrial services projects developed by Brazilian companies and their relationship with the CSF presented by Machado *et al*. (2020). To reach this goal, the following guiding questions were established: 1) based on the opinion of experienced professionals, what are the most relevant CSF to the management of the industrial services? 2) in these professionals' opinion, are the Brazilian companies that work in the aforementioned segment based on the guidelines disseminated by PMBOK when they perform their projects? 3) Is it possible to identify relationships between the most relevant CSF and the application degree of PMBOK guidelines in industrial services management? It is worth mentioning once again that the present study uses the findings of Machado *et al.* (2020) as a framework for analysis. The present study combines project management and industrial services areas to enhance the knowledge to enhance the knowledge in this interface, which is scarce, as pointed out in the literature (COLQUITT; GEORGE, 2011; MÜLLER; KLEIN, 2019). Next section presents the theoretical background.

2. THEORETICAL FOUNDATION

2.1 Project management

The literature provides definitions about projects, but these concepts have been refined towards a common sense on the subject. According to PMI (2017), project is a temporary effort to create a product, service or unique result. This temporary nature demonstrates that projects present well-defined beginning, middle and end. Additionally, projects are responsible for adding value to an organization, generating changes and improvements. In addition, the ISO 21500 Standard states that projects consist of a set of processes composed by activities control and coordination, to achieve a specific goal. These activities present well-defined start and end dates and to be reached, the deadlines requires provision of deliveries aligned to specific needs and limitations (ISO, 2012).

As it is exposed by Tereso *et al.* (2019), Souza Pereira *et al.* (2022), Corchak and Gasques (2020) and Severo *et al.* (2019), project management practices are necessary project success, adding advantages to organizations, such as greater financial return, efficiency in

processes, and customer satisfaction. This management addresses the application of knowledge, skills, tools and techniques to project activities in order to comply effectively and efficiently with requirements established. Thus, it includes stages of planning, organization, supervision and control of all aspects of a project in a continuous way (ISO, 2012). According to PMBOK, the structure of project management is based on its life cycle. As explained by Bomfin *et al.* (2012), the project lifecycle is typically composed of 5 basic steps, which are also known as project management Process Group (PMI, 2017) that cover the initiating, planning, execution, monitoring and controlling and closing. These process groups are categorized into knowledge areas, which can be understood as a set of processes associated with a specific project management theme, and are described considering process terms that compose them, such as practices, inputs, outputs, tools and techniques (PMI, 2017).

Regarding the 10 knowledge areas of project management, in project integration management, processes that seek to identify, define, combine, unify, interrelate and coordinate different processes and activities of project management are considered, throughout the project (PMI, 2017).

At the same time, scope management encompasses the processes necessary to ensure that project includes the work ordered for project success. Schedule management covers processes necessary for project to end punctually (PMI, 2017). For this area, time is one of the biggest obstacles to project success (JITPAIBOON; SMITH; GU, 2019).

Cost management area is related to how necessary resources will be acquired to complete project activities and it needs to be related to planning, budgets, financial and cost control, in order to ensure the project execution within the required budget. Quality management consists of a set of processes that seeks to incorporate the company's quality policy into the project to meet stakeholders' requirements and expectations (PMI, 2017; WILLIAMS *et al*., 2019).

Resource management includes processes that identify, acquire, and manage the resources needed to complete the project based on stipulated assumptions. These processes seek to ensure that needed resources will be available at the right time, location, and quantity. Communication management seeks to ensure that needs of project information and stakeholders are made available and exchanged effectively. This management should ensure the development and implementation of an effective communication strategy with stakeholders (PMI, 2017).

Project risk management encompasses processes that seek to ensure the implementation of responses and risk monitoring of the project, to boost the likelihood and impact of positive risks and reduce the chances and impacts of negative risks, thus enabling greater chances of success in the project. In parallel, the procurement management is a set of processes seeking to acquire the products and services necessary for project execution, being responsible for the development and administration of contracts, purchase orders and other documents related to purchasing (PMI, 2017).

Finally, stakeholder management includes processes that identify people, groups and/or organizations that impact or may be impacted by the project. The expectations of these parties are reviewed and strategies are developed to engage stakeholders throughout project's life cycle (PMI, 2017).

2.2 Industrial services and its CSF

When addressing the services sector, it is hard to identify a homogeneous treatment of all modalities that compose it, due to its magnitude (MELO *et al.*, 1998). According to Baines *et al*. (2009), it is understood by service any economic activity that can be performed but not produced.

From a contemporary perspective, it is identified that activities in this sector can be classified into two categories: intermediary services, which are those related to the development of industrial and business activities and services aimed at individual and collective use such as: leisure, entertainment, safety, health, education, etc. (MEIRELLES, 2006). However, there is no unanimity in the literature regarding services classification (MELO *et al.*, 1998).

Specifically focusing on industrial services, it is possible to identify as presented by Mathieu (2001), Huaccho Huatuco *et al.* (2019) and Rabetino *et al.* (2015), two capable categories of representing them: services that support products, such as post-sales and services that support customer processes and their activities (EGGERT e*t al*., 2014).

The first category presented includes the combination of product-service (KOWALKOWSKI; KINDSTRÖM; BREHMER, 2011; SUH, 2019). This concept addresses an evolution to product development approaches incorporating services to achieve sustainable development (SHOKOHYAR; MANSOUR; KARIMI, 2014). It is a new type of business model where companies can maintain their level of competitiveness, satisfy consumers and

cause fewer environmental impacts than traditional business models (GRÄSSLE; POTTEBAUM, 2021; LI; JIANG, 2013). Thus, it is noted that there is a tendency for manufacturing companies to also incorporate services into their system of activity. This trend is enabled and supported by the rapid advance of smart technologies (e.g. Cyber-Physical System (CPS), Internet-of-Things (IoT), and Artificial Intelligence (AI) (CHEN *et al*., 2020).

Notably, Product-service systems are part of the industrial services sector (KOWALKOWSKI; KINDSTRÖM; BREHMER, 2011), with the specificity that these companies are primordially manufacturing companies - they are not usually managed as project organizations, facing challenges especially at the customer interaction side (SJÖDIN *et al*., 2020). The movement from product manufacturer to service and project-oriented is not simple; it is challenging (NAOR; DRUEHL; BERNARDES, 2018). The combination between this challenge with the high opportunities that surrounds product-service systems for emerging economies (RETAMAL, 2017), emphasizes the relevance of deepening the studies on CSF.

In parallel, second category reinforces the importance of understanding processes and operation of each customer, in order to provide services appropriate to meet stakeholders expectations (ERKOYUNCU; DURUGBO; ROY, 2013; MATHIEU, 2001). In this sense, it is possible to verify a wide variety of classifications about industrial services which shows its heterogeneity and complexity (KOHTAMÄKI *et al*., 2015).

The success in providing industrial services is related to CSF. CSF are key areas that can improve organization competitiveness due to a positive performance, being directly related to its success (BULLEN; ROCKART, 1981). These elements should be the focus of managers and are characterized as activities that enhance organizations' results (MATTHYSSENS; VANDENBEMPT, 1998). As presented by Jitpaiboon *et al.* (JITPAIBOON; SMITH; GU, 2019), the success factors of a project originate from stakeholders expectations and must be intrinsic in company's strategy.

This article uses the work of Machado *et al.* (2020) that lists the CSF for the management of industrial services as basis to develop the current research. These CSF are presented in Table 1.

TABLE 1 - Critical Success Factors for management of industrial services.

Item	Critical Success Factors for management of industrial services
CSF1	Alignment between organization strategies and types of services to be offered, focusing on allocating resources (technological, logistical, human) effectively.
CSF2	Focus on understanding market needs to identify and comply with key specifications of the service and its process.
CSF3	Accurate management of service execution focusing on scope, cost and time.
CSF4	Accurate definition of key performance indicators to be used to evaluate the progress of service execution as well as its post-conclusion compliance, due to the diversity of services.
CSF5	Use of technological resources aimed at integrated management and better quality to the services provided (identification of problems and critical indicator, opportunities for improvements, etc.).
CSF6	Client co-participation in the execution of all phases of offered services, allowing necessary adjustments in key elements in the pursuit of full satisfaction.
CSF7	Continuous training of collaborators involved in the provision of service (trainings, qualification, etc.) aimed at better interaction with the customer, development of innovations and differentiations in the services.
CSF8	Effective management of demand and forecast mechanisms due to the intangibility of the services.
CSF9	Efficient communication throughout the entire execution, including intra and extra company information.
CSF10	Use of modular services concept, allowing its combination to enable greater offer of services to customers more quickly and with lower costs.
CSF11	Customization of industrial services in order to provide an individual solution for each customer.
CSF12	Consolidation of a solid company image in terms of quality and commitment, seeking the development and prospection of new clients/projects
SF13	Critical analysis of the projects after their execution to establish the lessons learned in order to be used in future projects.

Source: (adapted from Machado et al., 2020).

It is possible to verify – based on Table 1 extracted from the work of Machado *et al.* (2020) – that CSF approach enable the alignment of industrial service with organization strategy, reinforcing aspects such as brand image, performance indicators and modularization systems that relate to the plans and tactics of each company. In addition, the focus on understanding market needs is also covered, highlighting the importance of customer

engagement during industrial service provision, which must be customized for value aggregation.

In parallel, internal factors to the process of managing industrial service provision are considered as CSF, such as: administration of scope, cost and time of service delivery, communications management, demand management, development of human resources and technological resources, beside others.

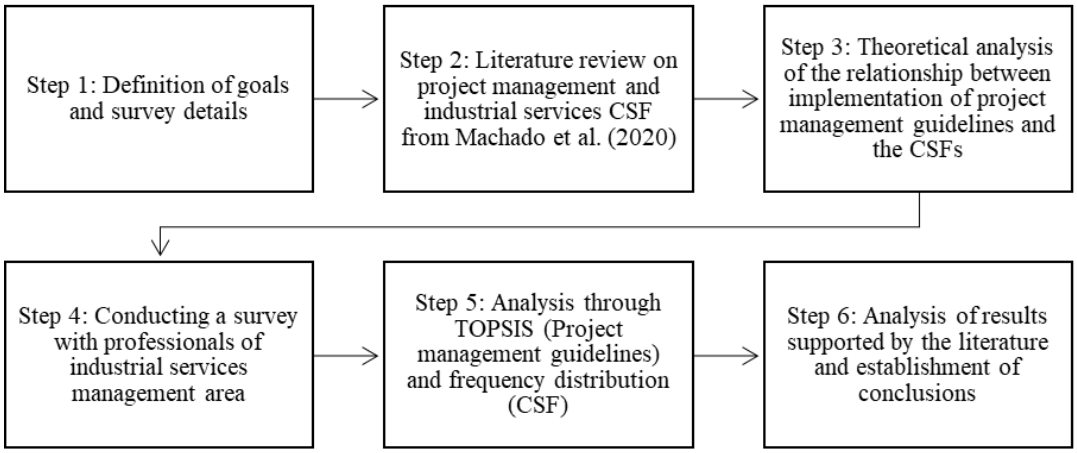
Although, the CSF presented correspond specifically to the IS management, it is possible to verify, as highlighted by Jitpaiboon *et al.* (2019), the alignment of CSF with project management, such as: definition of specific goals, availability of adequate resources, good communication, customer engagement and schedule management.

The CSF presented here will be deepen and related to the PMBOK Project management guidelines in section 4 of this article.

3. METHODOLOGICAL PROCEDURES

To conduct this research, it was performed bibliographic research and a survey. The article was undertaken based on phases presented in Figure 1.

FIGURE 1 - Phases of survey's execution.



Source: Adapted from (FORZA, 2002).

To elaborate the bibliographic review, a selection of books and scientific articles was used. This selection was made based on criterion of inclusion and exclusion of words, using

the key terms: "industrial service", "service", "critical success factors", "project", "project management", and "PMBOK". It is noteworthy that this article aimed to deepen the research of Machado *et al.* (2020) in relation to the theme CSF for industrial services management. For this, the results from Machado *et al*. (2020) were used to elaborate the bibliographic review of this research, which supported the results of this research.

After bibliographic review, a correlation analysis of CSF for industrial services management indicated by Machado *et al.* (2020) and PMBOK knowledge areas was conducted. For this, content analysis technique – for a critical unveiling – was applied (SANTOS, 2012). As stated by Bardin (1979), this method can be understood as a set of communication analysis techniques that uses systematic and objective procedures to describe text content. This technique can be used not only in content description, but in teaching possible to be obtained after its treatment.

In pre-analysis stage, reading allowed the identification and understanding of articles and books about CSF and PMBOK knowledge areas. Then, the objective of relating these CSF with the PMBOK was established. It is noteworthy that, as presented by Bardin (1979), some analyses can be performed without definitions and pre-defined hypotheses. This research did not establish hypotheses for its accomplishment. Finally, excerpts from analysed texts were obtained to use them as indicators of this correlation.

The analysed material was explored and relationships between the explicit and latent contents of the CSF and the PMBOK knowledge areas were identified and established, considering the knowledge from this material. Finally, results analysis enabled a critical and reflective analysis of the inferred content, allowing Table 2 development.

Subsequently, a questionnaire was conducted considering PMBOK ten knowledge areas. For each area, a question was developed to understand application level of these processes in the organizations studied. In parallel, a question was elaborated to identify among the thirteen CSF presented by Machado *et al.* (2020), the most relevant ones. Professionals of key job positions, such as CEOs, directors, managers and coordinators of companies operating in the field of industrial services were invited to participate in this survey.

Data collected was treated through TOPSIS (Technique for order Preference by Similarity to Ideal Solution) which is characterized as a multicriteria decision technique. This

technique allows to identify a performance ranking, considering the weights attributed to each criterion presented (KROHLING; SOUZA, 2011; SINGH *et al*., 2016).

The first step is to develop a decision matrix that considers the alternatives proposed for the problem (A1, A2..., Am) and the established criteria (C1, C2,..., Cn). This matrix (Equation 1) is composed of xij elements, which indicate the performance of alternative i according to criterion j, in which i = 1, 2, (...), m and j = 1, 2, (...), n. It is important to emphasize that this work uses the mathematical representation proposed by Singh et al. (2016). For this study, the alternatives corresponded to the ten major areas of PMBOK for project management and the criteria corresponded to the averages measured by respondent groups, divided according to their professional experience. Group 1: Professionals with less than 10 years of experience industrial services management; Group 2: Professionals with experience between 11 and 20 years in the industrial services management; Group 3: Professionals with experience over 21 years in the industrial services management.

Subsequently, the normalized matrix is calculated with the Rij elements through the formula $Rij = \frac{xij}{\sqrt{\sum_{i=1}^{n} xij^2}}$ (Equation 2), in which i = 1, 2, (...), m and j = 1, 2, (...), n (SINGH *et al*., 2016).

$$D = \begin{pmatrix} x_{11} & x_{12} & \cdots & x_{1n} \\ x_{21} & x_{22} & \cdots & x_{2n} \\ \cdots & \cdots & \cdots & \cdots \\ x_{m1} & x_{m1} & \cdots & x_{mn} \end{pmatrix} \quad \text{Equation 1} \qquad R = \begin{pmatrix} r_{11} & r_{12} & \cdots & r_{1n} \\ r_{21} & r_{22} & \cdots & r_{2n} \\ \cdots & \cdots & \cdots & \cdots \\ r_{m1} & r_{m1} & \cdots & r_{mn} \end{pmatrix} \quad \text{Equation 2}$$

Next, the normalized matrix V (Equation 5) is elaborated considering the weights attributed to each criterion. This matrix is composed by elements $Vij = WjxRij$ (SINGH et al., 2016). The weights adopted by the authors of this article were: 20% for group 1 of respondents; 30% for group 2 of respondents and, finally, 50% for group 3.

$$V = \begin{pmatrix} v_{11} & v_{12} & \cdots & v_{1n} \\ v_{21} & v_{22} & \cdots & v_{2n} \\ \cdots & \cdots & \cdots & \cdots \\ v_{m1} & v_{m1} & \cdots & v_{mn} \end{pmatrix} \quad \text{Equation 3}$$

From normalized matrix V, it is possible to identify the ideal positive solution Vi+ and the negative Vi-, through the maximum and minimum values of elements (SINGH *et al.*, 2016). Successively, it is calculated the Euclidean distance of each alternative in relation to positive ideal solution (Si*) (Equation 4) and negative ideal solution (Si') (Equation 5), according to the following formulas (SINGH e*t al*., 2016).

$$Si^* = \left[\sum_j \left(v_{ij}^* - v_j^+\right)^2\right]^{\frac{1}{2}} \quad Equation\ 4 \qquad Si' = \left[\sum_j \left(v_{ij}' - v_j^-\right)^2\right]^{\frac{1}{2}}, \quad \text{Equation 5}$$

in which i = 1,2, (...), m and j = 1,2, (...), n.

Finally, the calculation of the relative distance for the ideal solution Ci* is performed by the following formula (Equation 6) (SINGH *et al*., 2016):

$$Ci^* = \frac{s_i'}{(s_i^* + s_i')} \text{ in which: } 0 \leq Ci^* \leq 1 \qquad \text{Equation 6}$$

Alternatives ranking is classified according to the proximity of Ci*, in which the element that presents the shortest distance in relation to the ideal positive solution is the best classified and the element with the highest distance is the worst classified (SINGH *et al*., 2016).

In parallel, in order to perform a quantitative analysis of the most relevant CSF for industrial services, frequency distribution technique was used, which performs an analysis through the number of repetitions of a given phenomenon (CORREA, 2003). The application of this technique seeks to identify among the 13 CSF identified by Machado *et al*. (2020) the 5 with the highest number of repetitions, based on the answers, characterizing the most relevant ones.

4. RESULTS AND DISCUSSIONS

4.1 Relation among areas of PMBOK and CSF studied by Machado et al. (2020)

Based on the knowledge acquired in theoretical foundation and using content analysis technique, it was possible to develop Table 2 that presents the relationships between CSF

presented by Machado *et al*. (2020) and PMBOK knowledge areas. Subsequently, more details about these relations are presented.

TABLE 2 - Relations between CSF studied by Machado et al. (2020) and the knowledge areas of PMBOK.

CSF	PMBOK knowledge areas
1	Integration Management
2	Scope Management
3	Scope Management, Schedule Management and Costs Management
4	Integration Management
5	Resources Management
6	Stakeholders Management
7	Resources Management
8	Integration Management, Resources Management
9	Communications Management
10	Scope Management
11	Scope Management
12	Integration Management
13	Integration Management

Source: Authors, based on Machado *et al.* (2020) and PMI (PMI, 2017).

4.1.1 CSF 1 and integration management

When analysing CSF 1, it is important to consider enterprise environmental factors (EEFs) and organizational process assets (OPAs). EEFs are internal and external conditions to organization that have direct and indirect influence on projects, such as: organizational culture and governance, infrastructure, software, resource availability, market conditions, legal constraints, governmental standards, among others. In parallel, OPAs are composed by plans, policies, procedures and knowledge bases used by the company. The projects are executed within constraints presented in the organization, based on its structure and governance. This governance is related to organizational arrangements of all levels includes rules, policies, procedures, standards, among others, and influences the way that performance is optimized, objectives are defined, risks are monitored and evaluated, and, in general, how strategies are traced (PMI, 2017).

Thus, it is evident, that services to be performed need to be aligned with company's strategy for project management success, once strategies present a strong influence on the way that project will be conducted. In this sense, it is suggested that CSF 1 is strongly linked to project integration management. In this stage, it considers EEFs, OPAs, business documents, among other information, to elaborate the term of project opening, management plan, knowledge management and other activities (PMI, 2017).

Finally, according to PMBOK (6th Edition), project chart development establishes a direct link between project and organization strategic objectives, in order to demonstrate organization's commitment (PMI, 2017).

4.1.2 CSF 2 and scope management

CSF 2 discusses the definition and understanding of service key specifications, to enable the achievement of results expected by the market, which can be understood as a stakeholder (MACHADO *et al.*, 2020). In parallel, as explained by PMI (2017), project scope can be understood as the work that must be carried out to deliver a service/result with the specified characteristics and functions.

One of the activities of this process is related to gathering stakeholders' requirements to determine the documents and manage their needs to fulfill expected objectives. Therefore, this understanding of market demands has as output requirements documentation and its traceability matrix, which are used as raw material to define the project scope (PMI, 2017).

In this sense, scope management includes processes capable of identifying market requirements and stakeholders, aiming to determine the specifications and processes of the service, which would comprise project scope (PMI, 2017).

4.1.3 CSF 3 and scope, schedule and costs management

CSF 3 presents a broad characteristic when addressing critical topics such as understanding scope, cost management and time management (MACHADO *et al.*, 2020). In this sense, it is verified that this CSF is related to more than one of PMBOK knowledge area. Considering the understanding of scope, it is evident the relationship with scope management area, which presents the definition of what is and what is not included in the project. When addressing costs, it is verified the alignment of this activity with cost management area, which encompasses the processes responsible for ensuring that project execution fits stipulated

budget. Finally, when addressing time management, there is a relationship with schedule management area, which is responsible for the development of processes that enable punctual conclusion of the project (PMI, 2017).

4.1.4 CSF 4 and integration management

Performance metrics related to scope, schedule, costs, quality, among others, are defined at the beginning of the project as part of project management plan. The development of this plan is a process carried out within integration management area and aims to define a comprehensive document that establishes the entire work base of the project to be developed. In parallel, the performance data is collected based on work execution, through processes control, and compared with metrics established in the project management plan (PMI, 2017).

Therefore, CSF 4 is aligned with integration management area, since this area covers activities such as: development of project management plan, in which performance indicators are defined; execution of activities necessary to complete the project deliveries; and the stage in which performance data is collected and communicated to control processes (PMI, 2017).

4.1.5 CSF 5 and resources management

The availability of technological resources within a project is made possible through resources management, which encompasses the processes necessary to identify, acquire and manage them, in order to ensure the successful completion of project. These resources can be human or physical, such as materials, facilities, infrastructure and equipment (PMI, 2017).

An example of an important technological resource for project management is the Project Management Information System (PMIS), which provides access to information technology software tools such as timeline tools, information collection and distribution, key indicators report, among others. PMIS cooperates with planning, management and optimization of resources (PMI, 2017).

4.1.6 CSF 6 and stakeholders management

The project customer can be understood as a stakeholder, and their satisfaction must be identified and managed as a project objective. Stakeholders management contemplates the processes that seek to identify the groups that impact or can be impacted by the project, study their expectations and develop strategies for their engagement during the project execution.

To achieve this, these processes should develop approaches to involve stakeholders to enable an effective interaction (PMI, 2017). Communication and co-participation in work execution to meet expectations of stakeholders enable an effective management of customer engagement mentioned in CSF 6, considering the features mentioned by Machado *et al.* (2020).

4.1.7 CSF 7 and resources management

Resource management knowledge area is responsible for managing physical and team resources, which refers to personnel to be allocated in the project. This team consists of individuals with defined roles and responsibilities that work together to achieve a pre-established goal (PMI, 2017).

One of the processes that compose this stage is the team development, which seeks to improve competencies, interaction and overall environment of the team, in order to improve project's performance. Trainings, performance evaluation, recognition and rewards are among tools and techniques used in this process (PMI, 2017).

4.1.8 CSF 8 and integration management and resources management

Integration management is the process that encompasses the unification, communication, and inter-management of several project management processes, presenting as one of its activities the analysis and balancing of demand, providing information about allocation and resource needs of the project, among others. The demand is identified and documented by integration management area, to subsequently be used as input for resource management which is the stage responsible for providing such needs for project execution (PMI, 2017).

Thus, the present work highlights the alignment of CSF 8 (MACHADO *et al*., 2020) in two knowledge areas of PMBOK: integration management, a stage in which market demand will be analyzed and aligned to project strategy; and project resources management, a phase in which, after identifying the demands, it is conducted the resource management needed to meet the demands.

4.1.9 CSF 9 and communication management

The efficient communication in the project is a critical factor administered by communication management area, which includes processes necessary to ensure that

stakeholder information demands are met. This process consists in the development and implementation of a strategy that aims to ensure an effective communication (PMI, 2017). Therefore, it is suggested that CSF 9 is related to the communication management.

4.1.10 CSF 10 and scope management

The concept of modular services is characterized by decomposition process and combination of a project different activities, in order to present different configurations and, consequently, variations that may present lower cost and/or greater agility (RADDATS, 2011; SANDBACKA; NÄTTI; TÄHTINEN, 2013). Thus, when considering that project's scope management area analyzes processes and activities required to perform the work, it is possible to verify an alignment with the CSF 10. This area contemplates processes that seek to establish how scope will be defined, developed, monitored and controlled. This step can contemplate the analysis of validation of possible opportunities for modularization, which can be influenced by different project variables, such as: infrastructure, market conditions, organization culture, policies, procedures, lessons learned reports, among others (PMI, 2017).

In addition, another process carried out by this knowledge area is the elaboration of work breakdown structure (WBS), a document responsible for decomposing project activities into smaller and more easily manageable components, providing a vision of what must be delivered. This decomposition of activities can be characterized as favorable to identify opportunities for modularization, since it enables the definition of work packages that are used to group activities (PMI, 2017).

4.1.11 CSF 11 and scope management

Customization of the service project aims to offer to stakeholders a result that is appropriate to what is individually understood as a value, and can characterize the project as unique (MACHADO *et al*., 2020). Thus, for the project to be customized and perfectly suited to customer or other stakeholder, it is necessary to have a good analysis and understanding of the scope.

Scope management includes the process of gathering the requirements of stakeholders, activity that determines, documents and manages the needs of these parties, in order to meet the proposed objectives (PMI, 2017). This process is aligned with service customization to provide an individual solution.

4.1.12 CSF 12 and integration management

Company image can be understood as a key factor of choice when considering industrial services, since when addressing these services some perceptions associated with tangible items cannot be judged (MACHADO *et al*., 2020). In this case, the perspective of integration management, that includes process that coordinate and unify activities throughout the project, can help results combination, bringing an overview of the project (PMI, 2017), enabling greater robustness of the brand image.

Thus, activity performed in this phase enables a better perception of service, greater attendance to stakeholder's expectations and, consequently, strengthening the image of organization (PMI, 2017).

4.1.13 CSF 13 and integration management

The record of lessons learned, as discussed by CSF 13 (MACHADO *et al*., 2020), is managed by integration management area through the process named project knowledge management. This process is responsible for using existing knowledge and creating new knowledge to achieve project objective and develop organizational learning. The main benefit of this process is the use of previous knowledge to improve project results and the development of new knowledge for application in future projects. Although lessons learned are managed through knowledge management, they are generated and used by other processes throughout the project (PMI, 2017).

4.2 Data analysis via TOPSIS and frequency distribution

4.2.1 Averages measured by respondents according to degree of experience

Based on the responses obtained, it was possible to calculate the averages for each group of respondents, structuring Matrix D. From these data and the application of the formula $Rij = \frac{Xij}{\sqrt{\sum_{i=1}^{n} Xij^2}}$, it was possible to obtain matrix R. Then, based on weights attributed to each group, the normalized matrix V was elaborated, considering $Vij = WjxRij$ elements. Tables 3 and 4 show the calculations performed.

TABLE 3 - Initial Structure of data for analysis via TOPSIS.

Area	Description	Group 1: 20% Under (≤) 10 years	Xij^2	Group 2: 30% Between 11 and 20 years	Xij^2	Group 3: 50% Over (≥) 21 years	Xij^2
KA_1	Integration Management	7.50	56.25	7.62	57.99	7.11	50.57
KA_2	Scope Management	8.50	72.25	8.31	69.02	8.28	68.52
KA_3	Schedule Management	9.50	90.25	8.62	74.22	8.67	75.11
KA_4	Costs Management	9.50	90.25	8.62	74.22	8.50	72.25
KA_5	Quality Management	8.00	64.00	7.15	51.18	7.89	62.23
KA_6	Resources Management	8.75	76.56	8.31	69.02	8.44	71.31
KA_7	Communication Management	7.25	52.56	7.31	53.40	7.78	60.49
KA_8	Risks Management	8.00	64.00	6.77	45.82	7.22	52.16
KA_9	Acquisitions Management	9.25	85.56	8.08	65.24	8.22	67.60
KA_10	Stakeholders Management	8.75	76.56	7.00	49.00	6.83	46.69
		$\sqrt{\sum_{i=1}^{n} Xij^2}$	26.99	$\sqrt{\sum_{i=1}^{n} Xij^2}$	24.68	$\sqrt{\sum_{i=1}^{n} Xij^2}$	25.04

Source: Authors.

TABLE 4 - Structure of matrix Rij and weighting for the matrix Vij.

	MATRIX Rij			MATRIX Vij		
	Group 1: Under 10 years	Group 2: Between 11 and 20 years	Group 3: Over 21 years	Group 1: Under 10 years	Group 2: Between 11 and 20 years	Group 3: Over 21 years
Área	Rij	Rij	Rij	Rij * 0.2	Rij * 0.3	Rij * 0.5
KA_1	0.2779	0.3086	0.2840	0.0556	0.0926	0.1420
KA_2	0.3150	0.3366	0.3306	0.0630	0.1010	0.1653
KA_3	0.3520	0.3491	0.3461	0.0704	0.1047	0.1731
KA_4	0.3520	0.3491	0.3395	0.0704	0.1047	0.1697
KA_5	0.2964	0.2899	0.3151	0.0593	0.0870	0.1575
KA_6	0.3242	0.3366	0.3373	0.0648	0.1010	0.1686
KA_7	0.2687	0.2961	0.3106	0.0537	0.0888	0.1553
KA_8	0.2964	0.2743	0.2884	0.0593	0.0823	0.1442
KA_9	0.3428	0.3273	0.3284	0.0686	0.0982	0.1642
KA_10	0.3242	0.2836	0.2710	0.0648	0.0851	0.1365

Source: Authors.

From normalized Vij matrix, we found the ideal positive solution (Vi+) and the ideal negative solution (Vi-), through the maximum and minimum values found. Table 5 shows these values.

TABLE 5 - Ideal Positive Solution and Ideal Negative Solution.

Ideal Positive Solution		
Group 1: Under 10 years	Group 2: Between 11 and 20 years	Group 3: Over 21 years
0.0704	0.1047	0.1731
Ideal Negative Solution		
Group 1: Under 10 years	Group 2: Between 11 and 20 years	Group 3: Over 21 years
0.0537	0.0823	0.1365

Source: Authors.

In the sequence, we calculated the Euclidean distance of each alternative in relation to the ideal solution (Si*) positive and negative (Si') and, finally, the relative distance calculation was performed for the ideal solution Ci*, as evidenced in Table 6.

TABLE 6 - Calculation of Euclidean distance and Ci* indicator.

Area	**Si***	**Si'**	**Ci***
KA_1	0.036501423	0.011831735	0.244795411
KA_2	0.011367528	0.035602142	0.757981516
KA_3	0.0000	0.046064318	1
KA_4	0.003328152	0.043466227	0.928877098
KA_5	0.026084962	0.022294567	0.460826458
KA_6	0.008035938	0.03883742	0.828560644
KA_7	0.029082649	0.019963013	0.407029123
KA_8	0.038198806	0.009549968	0.200004469
KA_9	0.011182123	0.035236087	0.75910052
KA_10	0.0419133	0.011465274	0.214791693

Source: Authors.

Based on the results of Ci*, it was possible to obtain the ranking of application level of the knowledge areas in companies that provides industrial services, as presented in Table 7.

TABLE 7 - Final ordering of the areas through Ci* indicator.

Ranking	Ci	Code
1°	1.0000	KA_3
2°	0.9289	KA_4
3°	0.8286	KA_6
4°	0.7591	KA_9
5°	0.7580	KA_2
6°	0.4608	KA_5
7°	0.4070	KA_7
8°	0.2448	KA_1
9°	0.2148	KA_10
10°	0.2000	KA_8

Source: Authors.

4.2.2 Related results to CSF ranking

The application of frequency distribution technique was aimed at analyzing the number of times that the CSF was chosen. From this, it was possible to identify the 5 most relevant CSF for IS management, among the 13 presented by Machado *et al*. (2020). The result of the application of this technique can be identified in Table 8. The column 2 (Quantity of responses) indicates the number of times the CSF were selected among the total responses, while column 3 (%) indicates the percentage of respondents who chose each CSF.

TABLE 8 - Ranking of the most relevant CSF according to respondents.

CSF	Quantity of responses	%
CSF 3	25	71.4
CSF 7	20	57.1
CSF 9	20	57.1
CSF 1	19	54.3
CSF 4	18	51.4
CSF 12	17	48.6
CSF 13	16	45.7
CSF 6	11	31.4
CSF 5	10	28.6
CSF 11	8	22.9
CSF 2	6	17.1
CSF 10	4	11.4
CSF 8	2	5.7

Source: Authors.

Based on of the relation presented between CSF and PMBOK knowledge areas (KA), it is possible to observe that the five most relevant CSF for industrial services management are connected with the following areas: scope management, schedule management, costs

management, integration management, communications management, and resources management. It is observed, however, that, although the 5 most relevant CSF are related to 6 different knowledge areas, integration management is the most mentioned KA. The relevance of this KA is not exclusive for industrial service sector. As argued by Demirkesen and Ozorhon (2017) and Al-Kuhail *et al.* (2021), it also plays a key role in projects of the construction industry.

It is possible to check that the schedule management, besides being the most developed KA, is related to the most relevant CSF among the 13 presented, which demonstrates a satisfactory result for companies in industrial services sector. The same happens with cost management area, which, as the result obtained by TOPSIS shows, is classified as the second most developed KA in these companies, also related to the most relevant CSF for industrial services management. There are studies about project management focusing on different sectors that highlight the relationship between schedule and costs management (ADOKO; MAZZUCHI; SARKANI, 2015; CHATERINE; A. SIMANJUNTAK, 2020). In this sense, the proximity between these two KA regarding their development can be explained.

However, when considering project scope management, KA that is also related to CSF 3, it is verified that this is the fifth most developed among the 10 presented by PMBOK. Based on this relationship, it is identified that, although this KA is related to the most relevant CSF among the 13 surveyed, it is not the best developed in industrial service companies, which can cause difficulties and management problems. It is, therefore, an improvement opportunity to improve the industrial service management carried out.

It is tied in second place, CSF 9, together with the CSF 7. It addresses the continuous training of employees related to service provision and related to the project resources management. This KA, based on the ordering obtained with the application of TOPSIS, is the third most well developed, which presents a positive result, once the Euclidean distance to the ideal solution is relatively low, as shown in Table 7.

The CSF 9 refers to efficient communication over the project and it is related to communication management, the KA placed at 7th position in the ranking and presented a Ci* of 0.4070. It is identified, based on the Ci* obtained, that distance of ideal positive solution is relatively high, which indicates that this KA has a lower level of development compared with other KAs, such as: cost management, schedule, resources and others. Therefore, a non-

satisfactory result is verified, since one of the most relevant CSF is aligned with a knowledge area with the possibility of improvement, when compared with the other areas.

In parallel, when analyzing the CSF 1 and 4, which were allocated respectively in 4th and 5th positions, it is observed that they are related to project integration management, which obtained the 8th position in the ranking of the KAs level of development. It is observed, however, that the distance from this KA to ideal positive solution is relatively high, since Ci* was 0.2448.

Based on the results obtained and considering the relation of the 5 CSF of greater relevance and the ranking of PMBOK KAs, it is possible to identify 3 points of attention that can generate negative impact in industrial service management. The first point of attention refers to the relationship between CSF 3, considered the most relevant, and scope management KA, which presents Ci* of 0.7580, the 5th KA most developed in the analyzed companies. The relevance of CSF 3 can be also connected with arguments presented in the literature (JITPAIBOON; SMITH; GU, 2019), according to which time is a major issue in project management.

In parallel, the integration management KA that relates to two of the five most relevant CSF, present, when compared with the others, a high distance with the ideal solution, characterizing a second point of attention. Finally, the relationship between the CSF 9 (4th position) and communication management also stands out as a warning factor for companies, since this KA, when compared with the others, fits as one of the least developed in organizations considered in this study.

Finally, this analysis allows the identification of opportunities for improvement that are related, but not limited, to the better development of integration management, scope management and communication management of project, which will enable the improvement of factors such as: strategic alignment between project and organization, monitoring of industrial service through the best performance indicators, dissemination of information, data and knowledge along the chain, project scope management, among others.

6. CONCLUSION

The objective of this work was to analyze the application degree of project management guidelines in Brazilian companies that provides industrial services and their relationship with the most relevant CSF, based on the opinion of professionals with experience in this segment. Initially, it was possible to observe based on the averages of the grades measured by the professionals allocated in groups according to experience that the project management guidelines are contemplated by the studied companies, however with improvement opportunities, since the averages ranged from 6 to 9.5. It is reflected that no knowledge area is neglected, but there is a favorable condition for improvement in relation to the formalization of procedures and dissemination of the knowledge generated

This factor demonstrates that, although TOPSIS presents to some knowledge areas a low Ci*, which indicates a greater distance from each factor to the ideal positive solution, no guideline is ignored or not developed in the companies. It is only a comparison between areas which allows the establishment of the application and development ranking of each guideline in the organizations that provide industrial services.

Considering TOPSIS application, it was possible to establish the ranking of each KA application, being the schedule management the most developed KA and risk management least implemented. In parallel, the application of frequency distribution technique allowed the identification of the 5 most relevant CSF. The use of these techniques combined with content analysis development allowed the verification of application degree of the project management guidelines in Brazilian companies that provides IS, and the relationship of these guidelines with the most relevant CSF, which demonstrates the fulfillment of proposed objective. The TOPSIS analysis enabled to consider the level of experiences of the respondents to weight their answers accordingly. Companies can replicate the method presented here to obtain the analysis of their own reality.

Content analysis technique application led to a wider survey of industrial services, since it allowed the identification of an alignment of its CSF with the knowledge areas of the PMBOK, seeking to contribute with debates about these factors. This characteristic of the research corroborates its exploratory approach, promoting the improvement of ideas on the subject.

As research limitations, we highlight the use of a non-probabilistic sample in the study. However, the expertise of the professionals that participated in the survey should be emphasized. Finally, it is suggested as a future survey the development of a case study in companies that provides IS with the objective of applying techniques to develop the KAs least developed, as indicated by this survey, in order to verify if there is a greater success in Industrial Services Project Management through the improvement of the corresponding CSF. In addition, the use of PSS (Product-Service Systems) approach in the sector of industrial services could be explored in future research.

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