Identification and Evaluation of Critical Success Factors for Construction Projects

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Abstract

In the last decade, the Brazilian economic scenario was favorable to the construction sector, fostering its growth especially in large infrastructure projects such as the expansion and construction of airports, roads, stadiums, among others. However, many of these projects have gained notoriety for their poor management performance, leading to schedule delays, increased costs and quality gaps of the delivered works. Still, some projects have been successful in this environment suggesting the need to identify the factors that had influenced such performance. Thus, this study aims to understand the influence of the Critical Success Factors (CSFs) in the performance of construction projects in Brazil. To achieve this goal a survey which obtained data on 164 projects considered successful in one (or more) of four dimensions: efficiency, organizational learning, customer satisfaction and capacity to achieve strategic goals, providing insights about the influence of the CSF over the project performance.

Keywords: Critical Success Factors, Project Success, Construction projects

1. Introduction

The Construction Industry is traditionally one of the most relevant to the development of any country, because in addition to visible physical transformations, its activities have a direct influence on several economic sectors as well as on the quality of life of its inhabitants.

In 2015, according to de Mattos (2016), the construction sector had a direct stake in 9.1% of the Brazilian GDP. In recent years, governmental pro-grams that were implemented to foment the real estate market, along with Brazil's participation in two major international sporting events (the 2014 World Cup and the 2016 Olympics), caused an evolution of the entire construction market in order to attend to the growing demand. During this period, there was growth in the construction of houses, apartment buildings, the creation and renovation of stadiums, hotels, airports, paving and widening of roads and avenues as well as the development of basic infra-structure, etc.

Due to the relevance of the construction sector to the economy, it is imperative to ensure that these projects reach their expected performance (HWANG & LOW, 2011). Therefore, there is a need to identify all factors that might influence the likelihood that such projects will succeed.

In this respect, there is a line of study (and corresponding literature) in the field of project management that deals with the so-called "Critical Success Factors" (CSFs), a term that was first used by Rockart (1982) to designate "critical elements" that influence success in any kind of project.

In fact, according to Inayat et al. (2015), there is currently consensus among researchers that much of the success of a project is related to the presence or absence of CSFs, and that, due to their impact on project performance, these factors should be closely observed by managers.

However, despite there being a number of studies about CSFs in the available literature, is very difficult to obtain a list of those that are related to construction projects since that it is not clear which are these elements.

Moreover, although any factor could be considered critical, some have greater potential to contribute to the success of a project than others, and this categorization has also received even less attention of researchers (YU & SHEN, 2015).

The identification and categorization of these elements would serve to guide managers who work in construction, and also expand the academic under-standing concerning the determinants of success in construction projects. So, considering this scenario, main purpose of this research is to understand the in-fluence of CSFs in achieving success in construction projects.

After this introduction, this paper presents a synthetic review of the literature on FCS in construction projects, followed by a section on research methods, a sample description, presentation and discussion of the results and finally the conclusions.

2. CSF for construction projects

In the scientific literature about project management there are many studies that deal with Critical Success Factors. However, there are few studies on CSFs that are directly associated with construction projects. Thus, in order to support the research, this section lists the CSFs that have been identified in the existing literature for these types of projects. By analyzing these studies, it is possible to verify that there are relations among the CSFs that allow them to be categorized into groups, as is shown in the following tables.

Table 1. CSFs related to human factors

CSF	Authors
Project manager competence	Iyer & Jha (2006)
Project manager experience	Pheng & Chuan (2006)
Project manager leadership	Liphadzi *et al.* (2015)
Project team integration	Zou *et al.* (2013)
Project team flexibility	Zhang & Zhou (2013)
Conflict management	Chen & Chen (2007)

Table 1 shows CSFs related to the human factor. The list contains project management features and competencies, level of experience in project leadership, as well as team characteristics such as level of integration, flexibility at work and the capacity to solve potential conflicts.

Table 2. CSFs related to organizational factors

CSF	Authors
Efficient communication	Ihuah *et al*. (2014)
Empowerment	Rowlinson & Cheung (2008)
Organizational structure	Yu & Kwon (2011)
Change management	Anees *et al*. (2013)
Top support management	Aksorn & Hadikusumo (2008)
Lessons learned	Paranagamage *et al*. (2013)

Table 2 presents the second group of CSFs as they relate to the organizational factors of construction projects. Among these factors are the establishment of efficient communication between project members, the increase of team decision making power (empowerment), an organizational structure that meets project requirements, the proper management of change requests, top management support of project decisions and maintaining a record of the lessons learned during their life cycle.

The third group of CSFs is associated with the management of the project itself. The factors identified in the scientific literature are presented in Table 3.

Table 3. CSFs related to project management

CSF	Authors
Project planning	Pérez *et al.* (2010)
Monitoring and control	Azimi (2011)
Clear objectives	Adnan *et al*. (2014)
Requirements management	Jari & Bhangale (2013)
Risk identification	Kog & Loh (2012),
Risk responses	Kuo & Lu (2013)
Risk control	Qiang *et al*. (2015)
Incentive mechanisms	Kog *et al.* (2012)
Disincentive mechanisms	Meng & Gallagher (2012)

The CSFs presented in Table 3 are related to specific aspects of project management such as the planning and monitoring/control of processes, the establishment of clear and achievable objectives, the use of stakeholders' requirements as a guide, the identification of risks that the project is subject to, the creation of appropriate responses and control of these risks and the use of incentive/disincentive mechanisms in contracts with suppliers to avoid delivery delays.

Finally, Table 4 shows the last group of CSFs as they relate to the environment in which the project is inserted.

Table 4. CSF related to project environment

CSF	Authors
Project size	Alzahrani & Emsley (2013)
Corruption	Lavagnon *et al.* (2012)
Excessive bureaucracy	Duy Nguyen *et al*. (2004)
Stakeholder involvement	Yu & Kwon (2011)
Safety conditions	Hwang & Lim (2013)

CSFs as they relate to the project environment involve the size of the project (an increase in size usually means a corresponding increase in complexity), resistance to corruption, preventing the project compromise, the presence of excessive bureaucracy (which tends to cause delays), stakeholder involvement (i.e., acting as project facilitators and in the establishment of appropriate safety conditions in the workplace), reducing the risk of accidents that impact the budget, schedule and the team's work satisfaction and quality of life.

It is important to emphasize that the literature review is not exhaustive and that the CSFs presented in this section represent the author's selection based on the adherence of the analyzed studies to construction projects.

The above literature review is presented in a synthetic form and supported the implementation of empirical research. The next section presents the research methods used in this study.

3. Methods

By seeking to understand the influence of CSFs to achieving success in construction projects, this research can be classified as explicative: it seeks to determine cause and effect between the variables involved in the phenomenon studied.
The research began with a literature review (presented in section 2) and the identification of the CSFs that are associated with construction projects.
The conceptual model shown in figure 1 is based on the information gathered from the literature review:

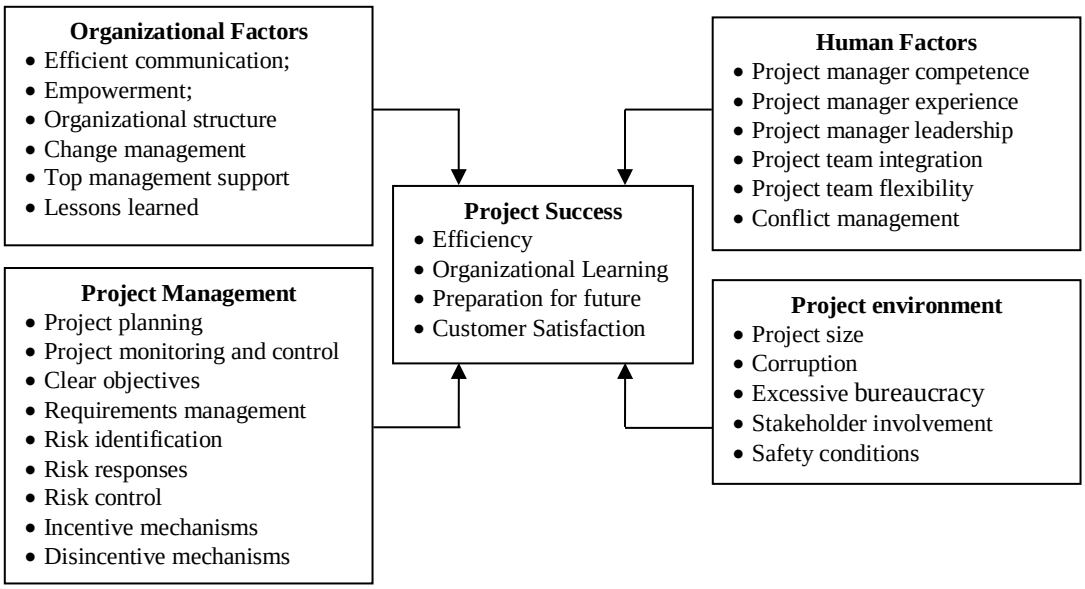

Figure 1. CSF and project success dimensions

The model shown in Figure 1 considers that the CSFs presented in Section 2 affect the likelihood of achieving success. However, according Cookie-Davies (2002), the definition of success in projects is complex and multidimensional. This success can be interpreted through the following four dependent variables: Efficiency (a project's ability to meet schedule and cost parameters),

Organizational learning (knowledge obtained during a project's lifecycle), Preparation for the future (competitive advantages gained from the project) and Customer satisfaction.

The methodological approach used in this research was a survey that was conducted with a sample of companies in the Brazilian construction sector during a one-year period. A judgment sampling was conducted by choosing respondents based on the adherence that they had with the researched theme. Data collection was carried out through a questionnaire that was structured using the conceptual model illustrated in Figure 1, containing statements about the presence of each respective CSF in projects managed by the respondents. Responses were measured using the five-point Likert scale ranging from "strongly disagree," with the numerical value 1, to "strongly agree with the numerical value 5.

An initial pre-test was conducted with 30 respondents who suggested minor changes to the questionnaire, and then Cronbach's alpha was calculated in order to ensure internal consistency of the instrument. The obtained value was 0.873.

The technique used to analyze the data was logistic regression, where the CSFs were considered as independent variables, and the success dimensions taken as response dependent variables. This technique was chosen due its capacity to identify the marginal effect of each of the independent variables over the probability of achieving success in the four dimensions considered.

According to Hair (2005), the name of this technique is associated to the logistic transformation used with the dependent variable, which allows one to directly calculate the likelihood of whether the phenomenon analyzed will occur. Johnson & Wichern (1998) point out that the model is based on the following logistic function:

(1)
$$f(z) = \frac{1}{1 + e^{-(z)}}$$

Which can be expressed as:

(2)
$$z = \ln\left(\frac{p}{1+p}\right) = \alpha + \beta_1 X_1 + \beta_1 X_1 + ... + \beta_n X_n$$

Where:
p = probability of response for the ith factor (or covariate)
α = constant
β_i = coefficient of independent variables
X_i = independent variables

However, according to Hosmer and Lemeshow (2004), this technique is appropriate when binary variables are used; therefore, all the variables obtained were recoded so that the answers 1 (strongly disagree), 2 (partially disagree) and 3 (neither agree nor disagree) were converted to zero, while responses 4 (agree) and 5 (strongly agree) were converted to a value of one.

Before starting the analysis using the logistic regression technique, multicollinearity verification was made among variables using the Spearman coefficient as a measure of correlation.

The results showed only correlations lower than 0.4, allowing (at the beginning) the inclusion of all variables in the regression model.

It is noteworthy to mention that all calculations were performed with the IBM software SPSS 21 and all the analyzes used the general model (including all CSFs) with a refinement method known as "backward stepwise," where the software removes the variables that do not contribute significantly to increasing explanatory power and generating four sub-models, one for each dimension of success (as will be presented in Section 5).

4. Sample descriptions

The questionnaire mentioned in the previous section was sent directly to the selected project managers, generating 164 valid responses. The sample description is presented in Table 5:

Table 5. Sample description

Enterprise size (number of employees)				
< 100		100 to 499		> 499
42,07%		31,70%		26,23%
Project types				
Residential		Industrial		Infrastructure
25,61%		34,14%		40,25%
Project experience of respondents (years)				
0-5 anos	6-10 anos	10-15 anos	15-20 anos	>20 years
17,02%	27,43%	29,87%	19,51%	6,09%

As can be seen in Table 5, companies with up to 100 employees form the most predominant group (42.07%), but larger firms form the rest of the sample with 100-499 employees (31.70%) and 500 employees or more (26.23%).

Regarding project type, the majority is related to infrastructure projects (40,25%), followed by industrial projects (34,14%) and residential projects (25,61%)

Finally, Table 5 shows the respondents' years of experience in project management. The majority of respondents have between 10 and 15 years of experience (29,87%), followed by those who have 6 to 10 years (27,43%) and those who have between 15 to 20 years (19,51 %). The smallest group has between 0 to 5 years (17.02%) and above 20 years (6,09%) of experience.

5. Results

The results presented in this section are organized according to the four success dimensions presented in Section 3. The first dimension that will be analyzed is efficiency. The first aspect of this dimension that will be analyzed consideration is the goodness of fit model (which should be done for each dependent variable or success dimension), and is based on the Hosmer and Lemeshow test. To be approved, the value must be greater than 0,5. The value obtained for this dimension was 0,681, indicating that there were no problems with this aspect.

Another factor that must be analyzed is the explanatory power of the model, which must be made for each success dimension. For this analysis the R^2 Nagelkerke was used and the obtained value was 0,686, which indicates that the model is capable of explaining 68,6% of success in the efficiency dimension.

Table 6 shows the variables that compose the final model for this dimension.

Table 6. "Efficiency" dimension results

Variables	B	S.E.	Sig.	Exp(b)
Project manager competence	**2,015**	**0,639**	**0,002**	**7,497**
Clear objectives	**1,493**	**0,515**	**0,004**	**4,450**
Project manager experience	**1,159**	**0,544**	**0,033**	**3,186**
Lessons learned	**0,742**	**0,371**	**0,046**	**2,099**
Project planning	**0,63**	**0,308**	**0,041**	**1,878**
Corruption	**0,603**	**0,265**	**0,023**	**1,828**
Empowerment	**0,579**	**0,281**	**0,039**	**1,785**
Stakeholder involvement	0,741	0,413	0,073	2,098
Top management support	0,583	0,345	0,091	1,791
Disincentive mechanisms	0,453	0,275	0,099	1,573
Constant	-2,286	2,098	0,276	0,102

The first seven rows of Table 6 show the CSFs considered significant at the level of 1% or 5% (values of column "Sig" lower than 0,05).

To achieve the research objective, it is necessary to focus the analysis on the column entitled "Exp(b)," also known as "Odds Ratio", which shows the variation in the probability of a project's success (in this case regarding efficiency) when the CSF is present.

Thus, the research verified that project manager competence increases the likelihood of success, obtaining 7,497 times in relation to projects where this CSF does not exist. This result may be associated with the project manager's ability to make correct decisions, apply resources correctly and apply good management practices (which tends to keep the baselines on track as specified in the planning processes).

Another significant CSF of this dimension is the definition of clear and achievable objectives, which increase the probability of success in 4,450 times. This CSF tends to better guide the project work, because there is a greater understanding among the staff about what work must to be done, thereby avoiding activities that do not contribute to the achievement of project objectives.

Table 6 also shows that a higher project manager experience level increases the likelihood of success in 3,186 times. An experienced manager can take advantage of the tacit knowledge gained in previous projects to improve work performance and minimize the effect of similar problems that have already occurred, thus improving project performance in this dimension.

Similar to previous CSF, the lessons learned elevate the likelihood of project success in 2,099 times. In this case the difference from project manager experience is that knowledge is explicit and institutional, formally registered from previous projects.

Appropriate project planning effort also increases the likelihood of achieving success, in this case 1,878 times. In fact, as all projects are unique, they have a level of uncertainty and are subject to various risks. Adequate planning is therefore essential in order to properly define the baselines (time, cost, quality, risk and others) that guide the executed work. This planning tends to consequentially increase the probability of success.

The resistance to corruption also increases the probability of successful 1,828 times as compared to projects where this CSF does not occur. This result may indicate that the payment of bribes and other similar activities deviates the project from its goals and possibly affects the organizational climate, demotivating the team and leading to a less efficient project. Thus, if the project resists corruption it is possible that it will achieve greater performance in terms of efficiency.

The last significant CSF in the dimension of efficiency is empowerment, which increases the likelihood of success in 1,785 times. This result could be associated with the agility of decisions, which occurs when more decision-making power is assigned to team members, generating faster responses to problems and increasing work efficiency.

Regarding the dimension of organizational learning, the Hosmer and Lemeshow test obtained a score of 0,592, indicating that the model has the necessary adjustment. In addition, the R^2 Nagelkerke obtained was 0,652, indicating that the model is able to explain 65,2% of the phenomenon's occurrence.

Table 7 shows the significant CSFs (at 1% and 5%) related to dimension organizational learning.

Table 7. "Organizational learning" dimension results

Variables	B	S.E.	Sig.	Exp(b)
Conflict management	1,649	0,451	**0,000**	**5,201**
Project manager experience	0,862	0,420	**0,040**	**2,368**
Change management	0,760	0,338	**0,025**	**2,137**
Project manager competence	-1,074	0,523	**0,040**	**0,342**
Risk response	-1,262	0,462	**0,006**	**0,283**
Project size	-0,559	0,291	0,054	0,572
Project monitoring and control	-0,506	0,270	0,061	0,603
Risk identification	0,641	0,390	0,101	1,898
Constant	-1,061	1,778	0,551	0,346

As shown in Table 7, the CSF with the greatest impact on successful achievement in this dimension is conflict management. When this factor is applied, it increases the likelihood of success in 5,201 times. This number can be explained by the tacit knowledge generated when conflicts occur and when there is a team effort to solve the conflict, thereby helping those who are involved to learn and evolve through the situation.

Greater project manager experience increases the probability of achieving success in 2,368 times in this dimension. This result may stem from socialization, which is the generation of knowledge that occurs when the tacit knowledge of someone more experienced is shared with others who are less experienced through observation, imitation and practice.

The change management also contributes to organizational learning, raising the likelihood of success in this dimension in 2,137 times. This result may be associated with the effort caused by the analysis of change requests made by stakeholders and the study of their possible impact on the project, thereby generating new knowledge for the organization.

The project manager's competence (knowledge, skills and technical capacity) has a negative impact on organizational learning, reducing the likelihood of success for 0,342 times. This result may mean that managers with these characteristics tend to use their own knowledge and management methods, leaving few opportunities for the use of new tools or non-traditional approaches to problems, which usually bring new knowledge.

Finally, the risk responses also reduce the likelihood of success to 0.243 times in this dimension. This result can be explained by the composition of the sample that is formed largely by smaller companies (<100 employs the) that generally have lower levels of maturity in project management. In this case, it is probably that few of the successful projects carried out in this dimension made use of risk management, which is usually done in organizations that have more mature project management.

For the dimension of customer satisfaction, the result obtained in the Hosmer and Lemeshow test was 0.619 showing a good fit of the model. Moreover, R^2 Nagelkerke was 0.716 indicating that the model can explain 71.6% of success in this dimension.

Table 8 shows the results for the dimension of customer satisfaction.

Table 8. “Customer satisfaction” dimension results

Variables	B	S.E.	Sig.	Exp(b)
Top management support	0,549	0,279	**0,049**	**1,731**
Project planning	0,540	0,263	**0,040**	**1,716**
Efficient communication	**0,437**	**0,272**	**0,039**	**1,548**
Disincentive mechanisms	-0,336	0,168	**0,046**	**0,714**
Project manager competence	-0,654	0,331	0,109	0,520
Incentive mechanisms	-0,333	0,219	0,129	0,717
Team flexibility	-0,504	0,311	0,105	0,604
Project size	0,270	0,224	0,230	1,309
Constant	0,063	1,674	0,970	1,065

According to Table 8, the factor with the greatest impact on a project's success is top management support, which increases the probability of success in 1,731 times. Top management usually has a strong concern in the results of the project and how customers will perceive it because a higher level of customer satisfaction may mean the execution of additional projects, which may explain this result.

Project planning once again appears as a significant CSF, this time related to customer satisfaction, and increases the likelihood of achieving success in 1,716 times. This result is probably related to the fact that is during the phase of project planning that work activities are defined, oriented by customer requirements. Thus, if project planning is performed properly, customers are more likely to be satisfied.

Another CSF that increases the probability of success in this dimension is efficient communication. According to Table 8, this CSF increases the likelihood of success in 1,548. Efficient communication probably explains this result. By communicating efficiently, many project problems can be easily resolved, thereby avoiding delays and quality failures that would have negative impact on customer satisfaction.

The last significant CSF in this dimension is the inclusion of disincentive mechanisms in supply contracts. Interestingly, the results showed that this CSF had a negative impact on success. This factor marginally reduced success in 0,714 times. Although it is expected that this factor act by inhibiting delivery delays, which would tend to improve project performance, is possibly enforcing suppliers to strive to deliver on time to avoid penalties, but with lower quality in their supplies, which can later be perceived by customer in the final product, lowering their satisfaction.

For the last dimension of success, called "preparing for the future," the result of the Hosmer and Lemeshow test was 0,997, showing a great fit for the use of logistic regression. In addition, the R^2 Nagelkerke obtained was 0,752, indicating that the model used is able to explain 75.2% of the dependent variable.

Table 9 shows the significant variables and their odds ratio on the dimension "preparing for the future".

Table 9. “Preparing for the future” dimension results

Variables	B	S.E.	Sig.	Exp(b)
Project manager experience	1,488	0,521	**0,004**	**4,430**
Requirements management	1,360	0,535	**0,011**	**3,894**
Organizational structure	1,225	0,603	**0,042**	**3,405**
Conflict management	0,823	0,386	**0,033**	**2,278**
Excessive bureaucracy	-0,777	0,329	**0,018**	**0,460**
Safety conditions	-0,849	0,351	0,056	0,428
Disincentive mechanisms	-0,881	0,422	0,057	0,414
Clear objectives	-0,908	0,416	0,059	0,403
Project management experience	-0,971	0,437	0,056	0,379
Risk identification	-0,781	0,433	0,072	0,458
Risk control	0,839	0,437	0,055	2,314
Constant	-5,194	2,458	0,035	0,006

The first CSF to be analyzed is the project manager’s experience level, whose marginal factors indicate an increase in achieving success in 4,430 times. This result may indicate that the experience this professional can contribute affects not only to the project objectives, but also long-

term results that benefit the organization (such as entry into new markets and obtaining competitive advantages).

The second significant CSF in this dimension is the management of project requirements, which increases the likelihood of success in 3,894 times. This CSF involves defining which requirements must be met by the project and which ones cannot be. It also involves the analysis of whether or not to include new requirements throughout the project lifecycle. Thus, this result may indicate that if this work is properly carried out, stakeholder satisfaction increases, preparing the business environment for new future projects.

An efficient organizational structure adopted by the organization also appears to be a significant variable that increases the probability of success in 3,405 times. This result indicates that having a proper structure favours communication and decision making, supporting the projects carried out in a more mature form which can be a font sustained competitive advantage against competitors.

The results also show that the positive and effective conflict management is a significant CSF, which increases the likelihood of success in 2,278 times. By solving conflicts, the project environment improves and the team evolves, thereby expanding the perception related to how the project can contribute to the organization in its market.

The last significant CSF in this dimension is excessive bureaucracy, which has odds ratio that negatively affect the achievement of success, reducing it to 0,460 times as compared to projects where this CSF is not present. This result indicates that the effort required to meet the excessive bureaucracy is harmful to the project, affecting the team's ability to orientate the results of the project in such a way as to increase the organization's competitiveness.

6. Conclusions

This study aimed to understand the influence of CSFs on attaining success in construction projects. To achieve this goal, a survey was conducted with project managers in the construction sector. This survey generated 187 valid responses.

First, literature review reflected that there are many CSFs that can be associated with this type of project, and that achieving success in these projects is complex and must be understood in a multidimensional manner.

Another important conclusion of the study is that although there is a wide range of CSFs related to construction projects, not all are significant to explaining their successful achievement.

In this regard, it was found that out of the 26 CSFs studied, only the following are significant to explaining success: 7 explain success in the efficiency dimension, 5 in the organizational learning dimension, 4 in the customer satisfaction dimension and 5 in the "preparation for the future" dimension.

By observing these "sub-models," it was found that among the 4 CSF categories studied (human factors, organizational, project management and project environment), some of them seem to have a greater connection to success: human factors appear 7 times, organizational and project management 6 times and association to the project environment with only 3 times.

Thus, the results show the first three categories have the greatest influence on the project’s success, and environmental factors have little influence.

Refining the results, it is possible to conclude that the most influential CSFs are related to human factors: high competence of the project manager increases the likelihood of success in the efficiency dimension on 7,497 times, effective conflict management increases the likelihood of success in the organizational learning dimension in 5,201 times and the experience level of the project manager, which increases the likelihood of success in the dimension "preparation to the future" in 4,430 times, indicating that in addition to appearing more times in success dimensions, this category has the greatest impact on achievement (the organizational factors category appears to have the greatest influence on success in the customer satisfaction dimension with 1,731 times).

The authors believe that the results presented in this work contribute to the existing literature from a primarily academic point of view, as these results increase the understanding about which CSFs have the most significant influence on the achievement of success in construction projects, and with what degree of influence.

In addition, the results presented in this study could be useful to organizations within the construction sector because they could support decisions made by top management, project managers and also their teams.

Is important to mention that this study has two limitations. The first limitation is related to the sampling process, which was non-probabilistic and so did not allow statistical inference. Another limiting factor is that the attempts to explain the phenomenon in Section 5 derive from the perception and experience of the authors and is based on scientific literature about project management. It therefore must be confirmed by in-depth studies in companies similar to those used in the sample used in this research (this is a suggestion for future research).

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