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# MANAGEMENT MODEL WITH CRITICAL SUCCESS FACTORS (CSFs) FOR RESEARCH PROJECTS

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[Fernando Salazar-Arrieta](#)<sup>\*</sup>, Aracely Sánchez-Serna, Mauricio Diez-Silva, Milton Rueda-Varón

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Article

# Management Model with Critical Success Factors (CSFs) for Research Projects

Aracely Sánchez-Serna <sup>1,\*</sup>, H. Mauricio Diez-Silva <sup>2</sup>, M. Januario Rueda-Varon <sup>3</sup>  
and Fernando Salazar-Arrieta <sup>4</sup>

<sup>1</sup> Pontificia Universidad Javeriana, Carrera 7 #40B-36 Piso 6, Bogotá, Colombia

<sup>2</sup> Universidad Pedagógica y Tecnológica de Colombia – UPTC, Tunja, Colombia, henry.diez@uptc.edu.co

<sup>3</sup> Universidad EAN, Bogotá, Colombia, mramon.d@universidadean.edu.co

<sup>4</sup> Escuela Naval de Cadetes Almirante Padilla, Barrio el Bosuque, Isla Manzanillo, Cartagena, Colombia, fsalazar.network.com@gmail.com.

\* Correspondence: a-sanchez@javeriana.edu.co .

**Abstract:** This article aims at presenting the results that were found in the design and implementation of a new management model of Critical Success Factors for improving the effects of research projects. The model was based on the theory of structural equations derived from factor analyses and multiple linear regression models. For achieving the purpose, the authors developed an empirical evidence analysis founded on a literature review in the knowledge area of project management. Afterwards, the process of identification of the CSFs was carried out for a group of research projects launched in Colombia as a result of the application and measurement of an instrument. They were the basis for the development of a structural relationship modeling. Also, this contributed to determine the CSFs that explain the generation of effects of research projects, and the project management execution process from which it can be carried out based on said measurement indicators.

**Keywords:** Critical Success Factors (CSFs); impacts of research projects; management model; research projects

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## 1. Introduction

This research work was motivated by the need for obtaining a better management and performance rate for the research projects that went beyond the completion of the project itself, covering the ex-post scope of the same cycle; thus, improving the impacts that are generated by the Science, Technology, and Innovation (STI) research projects. The research model that is presented aims at aligning itself to the purpose of society improvement, if one takes into account that investment in research and development (R&D) has high social profitability. Additionally, the objective is to increase the knowledge pool, and consequentially, to increase productivity and innovation [1–3]. This is how this research triggers and feeds on the decision-making that must drive society to achieve higher and better levels of development.

Through this research, a model for the support of decision-making was developed, aiming at managing Critical Success Factors (CSFs) to improve the impact of research projects in STI. The model attempts to help improve the performance of STI research projects, to go beyond the completion of the project, and to identify, evaluate, and measure its effects. Also, we intend to motivate researchers and academics to adopt best project management practices, and to provide them with tools to better manage those projects.

This research adopted a mixed study approach (qualitative and quantitative) with an exploratory, descriptive, correlational, and proactive scope. Our data included a questionnaire-type instrument, and data from research projects collected with leaders and university researchers from the higher education field in Colombia. These data, together with the findings of an extensive literature review, were used for the definition and construction of a CSFs management model to improve the impacts of research projects. The main result is a model that can be used in the management of research projects in their initiation, execution, monitoring, and closure; therefore, the

main conclusions and the validation of the model confirm the relationships that exist between CSFs and the impacts of research projects, as well as the ratification that it is possible to predict these impacts from the CSFs of the projects. Based on what has been described, the hypotheses that were generated to be verified through the research work were:

**H1.** The particular characteristics of the projects: requirements, life cycle, and expected benefits entail specific CSFs for each project.

**H2.** It is possible to analyze the characteristics of research projects in Science and Technology and determine their CSFs.

**H3.** The identification and appropriate management of the CSFs positively influence the impacts that are generated by the projects.

The preliminary results show the pillars that support the model, which takes as a starting point the conceptualization of the projects related to a specific research typology. These are usually not studied in the area of project management, but they identify the characteristics and approaches to define this type of research projects as a particular and essential typology of the area. After that, a framework for the definition of impact and CSF of research projects is made; and finally, the model that will be used is defined.

## 2. Empirical Evidence Supported in the Literature Review

This section presents a review of the relevant literature that supports the development of a model to improve the management of CSFs and the impacts on research projects. We aim to identify, from the empirical evidence supported by the literature, the requirements for the development of a model that leads to the improvement of results beyond the completion of the project.

### 2.1. Project Conceptualization and Research Project

A review of the most recognized authors and professional associations in projects will be presented, in order to identify the elements that characterize the definition of the project and that are the basis for a management model.

The definition of the project denotes its characteristics, as following:

Temporality has a beginning and an end, indicating that the project is transitory and meets the achievement of specific objectives; therefore, it requires the integration of material and financial resources for its completion [4–20].

In a project, the tasks that are established have particular highlights that are a priority for the development of the project and the achievement of objectives [4,7,8,10,16,17,20,21].

The creation of a project must essentially be unique and innovative [5,6,9–11,17–19,21,22].

It is by means of the development of a project that a beneficial change is sought. It has a results-oriented approach, which implies uncertainty [4,5,7,8,10,11,13–15,18,19,21,22].

The project is carried out by a project team that is shaped around the objectives for which they need to have competencies. Changes in team members do not cause the project to lose its identity [6,7,10,12,16,17,19–21].

Thus, the characteristics derived from the definition of projects could be said to cover the following: (1) key aspects of the management process such as the initiation, monitoring, execution, and completion of the project; (2) the need to search for resources and/or tools required to achieve the objectives; (3) the identification of an interrelated set of activities and tasks where the best practices of project management are to be integrated; (4) the definition of results and deliverables that lead to a change; and (5) a list of terminology and language to be used in the project environment as a common denominator.

On the other hand, the characteristics that frame the typology of research projects are presented below. The first difference, in both cases, refers to how the temporal effort that is determined by the scope and the objectives of the project is delimited; but from the project's theory, it focuses on a

temporary organization where the scope is defined by the client, while on the research projects, the temporality is determined by the researcher [23,24].

A project seeks to achieve a beneficial change where there is a before and an after that are crucial. In a research project, this change is aimed at generating new knowledge. It focuses on producing a contribution where there is a gap in the subject of study [25–27]. This beneficial change is in line with the results. A project generates a unique product or service that is previously defined, and it can be tangible or intangible. In terms of results with the development of a research project, it seeks to solve an identified need or an existing problem; the results are exploratory, and must be shared or published effectively [28–30].

The transience of the projects means that they are not repositories of knowledge; however, they lead to lessons learned that are used for the development of other projects. On the contrary, in a research project being a generator of new knowledge, it constitutes the basis for the development of new projects in which it continues, advances, or deepens in the same thematic line raised in the project [24].

In essence, a project is a unique job that must meet the given specifications, and there is always at least one of the following parameters that change: the objectives, the resources, or the environment. Additionally, due to their unique nature, they are exposed to uncertainties or differences in the results they produce. A research project is a creative and innovative process that turns out to be unique because of those characteristics [24,26]. The research work is characterized not only by uncertainty in terms of project duration and budget, but also by the nature of the results [28].

Likewise, they differ in their management. A research project involves particular aspects and needs that implicate going beyond the completion of the project itself to evaluate and measure its impacts. Meanwhile, in other projects, the management is associated with its temporality [30].

Regarding the methodology, projects in general, follow a process and approach in which a series of interrelated activities supported by dedicated management tools are involved, that is, typical of project management. On the contrary, a research project follows a systematic approach to its development, known as the research method [25].

Finally, a project team is created around the objective and time that is available, taking into account that the individual performing a task requires a certain degree of competence. The changes that are generated in the team members do not cause the project to lose its own identity. In fact, the team that constitutes a research project is formed around the subject, and the withdrawal of members could affect the course or continuity of the project.

The previous considerations allow us to conclude that a research project has a particular focus [31], which must be taken into account in the definition of a management model and identification of critical success factors.

## *2.2. Effect on Research Projects*

In line with the approaches that were made in the previous section related to the conceptualization of research projects based on the attributes, particularly on the results, this section presents a review of relevant literature supporting the definitions of effect, its relevance, and the challenges for its measurement. The aforementioned is useful in order to know the mechanisms that allow evaluating the impact on the framework of research projects and inquire about their processing and management.

Polcuch [32] points out that impact is a change brought upon the society as the effect of research. The measure of effectiveness is given by the degree of focus of the impact on the desired goals. On the other hand, Penfield et al. [33] differentiate two types of impact: a) the academic, understood as the intellectual contribution to a specific field of study within the academy; and b) the external socio-economic impact that goes beyond the academy.

Ortiz, Viamontes, and Reyes [34] refer to the scientific impact as the effect that is produced by the novelty and theoretical-practical contributions of new knowledge as a result of the research process that is accepted and disseminated through different official publications, recognized and cited by the national and international community. On the other hand, Hernández et al. [35] specifies

that the impact should not be conceived as an end result, but incorporates a process of individual and social growth.

Diversely, Grand et al. [36] incorporate the concept of impact according to the Research Quality Framework (RQF), an initiative of the Australian Government to formulate a framework of best practices for the evaluation of research quality and research impact, which defines it as the social, economic, environmental, and/or cultural benefit of the research to end-users at the level of the entire community, whether regional, national, and/or international.

For the purposes of this research, impact is understood as the targeting of results beyond the completion of the project, which lead to a change, effect, or benefit in society (environmental, social, and/or economic), as a result of the novelty of the research process.

The purposes for measuring impact in the framework of research projects are focused on: a) knowing and evaluating their social contribution [37,38] ; b) monitoring its performance and contribution [32,39]; c) demonstrating the value of research to stakeholders [33,35,40–42]; and d) understanding the methods and routes for the maximization of results [26,34,36,43,44].

However, the measurement of impact represents challenges [26,33,43], such as: the time span in which the impact occurs, the nature of its development, the attributions to fortuitous findings, the knowledge creep (when they arise out of time), and the collection of evidence itself.

In the international scope, there are three variables that have been identified in order to determine and measure the impacts of research projects: quality, context, and results. The quality, understood as the intrinsic value of the project, is related to the originality of the research and its results [45–47]; the context, which states that contributions to social objectives or practices differ from one field or research program to another [48]; and finally the results, which are the means to improve a certain situation and/or solve an identified need or an existing problem, seeking to generate effects that go beyond the completion of the project [47,49,50]. These three variables become key aspects that must be taken into account in the proposal of the model because they are supported and have been internationally validated in favor of improving the evaluation of results that go beyond the completion of a project.

### *2.3. Critical Success Factors in Research Projects*

The information described in the previous section, related to what the impact on research projects represents and the initiatives that have been undertaken internationally, allowed us to identify three variables that contribute to their evaluation and to improve the results of this type of projects. Now, based on the conceptualization and understanding of the Critical Success Factors (CSFs), another pillar of the model is supported, since its management depends on its identification and evaluation in favor of improving the impacts of research projects.

The CSFs are understood as conditions, circumstances, events, or inputs into the management system that lead directly or indirectly to the success of the project; or key variables that explain the success of the project [51–54].

Shenhar et al. [55], Dvir and Lechler [56], and Shenhar and Dvir [16] mark a breakpoint in the understanding of the CSFs. They state that the success measurement scale must go beyond the iron triangle in order to incorporate features such as the project efficiency, the impact on beneficiaries, the organizational success, and the future projection. Thus, Carvalho et al. [57] and Carvalho and Rabechini Junior [58] include another category of sustainability (environmental and social) while the previous five categories contemplate the economic dimension of sustainability. These variables, according to Shenhar et al. [55], should be taken into consideration during the phases of definition, planning, and execution of the project, given that they provide a set of guidelines for project leaders.

Kerzner [20] classifies the CSFs into primary and secondary. The primary ones are seen through the eyes of the beneficiary; they are based on cost, time, quality limits, and acceptance of the project. The secondary, in turn, respond to internal benefits provided by the project. He also states that in an innovative project, the CSFs go further, and the general focus is the delivery of value [59].

Among the latest studies related to the CSFs of projects, there is the one by Khan et al. [60], which is based on the most recent literature that is a set of success criteria from the leading researchers in

project success. They developed a success factors model derived from a review of the literature over the last 40 years. Their model offers a balance between hard and soft factors, and measures success using 25 variables that are organized into five dimensions, and that can be applied to different types of projects. The model contains the criteria of the three key factors from the iron triangle, plus four dimensions of additional project success criteria: project efficiency, organizational benefits, project impact, stakeholder satisfaction, and future potential.

Regarding the evolution of the identification and evaluation of the CSFs of projects, it is evident that in the '80s, '90s, and the early 2000s, they were oriented to the internal factors of the project and the benefits for the organization, such as the definition, mission, control, communication, project team, processes, tasks, tools, costs, time, quality, organizational benefits, etc. This is what Kerzner [20] defined as primary and secondary CSFs [4,61–64]. From now on, the focus of the CSFs is on external factors such as results, stakeholder satisfaction, acceptance of end-users, impacts, etc. For this new approach, according to Kerzner [59], a CSF that leads to the generation of the project value should be defined.

Within the research projects framework, Mahmood, Asghar, and Naoreen [65] state that for a project to be successful, it is important for the requirements of the project to be taken into account from their inception, as they provide the guidelines for researchers and their respective teams. They also help to execute the project efficiently; from which it follows that the CSFs must be managed throughout the project life cycle.

According to Papke-Shields et al. [66], successful CSFs lead to a series of project management dimensions, including how projects are carried out and the internal and external contexts in which they are executed. This influences both the result and the management of the project.

From the years 1970 to 1990 and even the first years of the 2000s, the success factors of the project became a popular topic in research [4,67–69]. As a result, the CSFs can be classified according to the environment where the project is located [70–72]; according to people [68]; according to processes and tools; and according to the context [73].

In line with what is stated above about the CSFs, Grand et al. [36] presented the results of a study conducted by the Higher Education Funding Council for England (HEFCE) focused on reviewing international practices in terms of research impact assessment, and of the identification of the relevant challenges, lessons, and observations from the international practice. They identified three areas of evaluation for research projects: quality, impact, and environment.

Notwithstanding the scarce literature regarding CSFs in the typology of research and development (R&D) projects, it is possible to show indirect contributions in key aspects for the success of these projects, where it was viable to identify a marked alignment when compared with the factors of international research evaluation that were evidenced in the impact section of the research projects.

Thus, the CSFs of a research project will be understood as aspects or areas of activity that should be subject to constant and careful management attention in order to improve the results and benefits of the research beyond the completion of the project. Then, it can be said that the CSFs of a research project are based on quality, results, and context.

The originality, novelty, and intrinsic aspects of the project in terms of international reference frameworks for research evaluation define quality. Quality refers to elements of the project such as requirements, mission, scope, objectives, communication with stakeholders, characteristics of the leader, methodology, tools, and project team, among others.

The results are the incentive for researchers to focus on generating effects, changes, or benefits in society beyond the end of the project. These results and impacts must be value-generating, innovative, non-redundant with previous proposals, efficient, and sustainable.

The context influences the definition, the design, and the execution of the project itself. The context allows characterizing the project, and both the internal and external aspects of the project are involved.

In summary, the knowledge and management of the CSFs increase the level of benefits granted by a research project.

#### 2.4. Model Conceptualization

Model understanding is the fourth conceptual pillar that supports the CSFs management model. The attempts of representation can be abstract (a mathematical formula, a linguistic paradigm of the conjugation of a verb), or particular (a map, a scale model of a ship, the physical representation of a structure).

A large number of model definitions or model theories can be found in the literature over the last thirty years. In one of them, Gago [74] defines a model as the form that is proposed and followed in the execution of an artistic work or otherwise, that is exemplary to be imitated. On the other hand, Vanegas [75] defines a model as an ideal representation of a system and the way in which it operates; and is the system that best lends itself to an analysis in mathematical terms. The objective is to analyze the behavior of the system or predict its future behavior. It is apparent that the models are not as complex as the system itself, so it is necessary to make assumptions and establish restrictions in order to represent its most relevant portions. Clearly, there would be no advantage of using models if they did not simplify the real situation.

The model is also understood as a pattern to follow, or a sample to know something. There is also the idea that a model must be used to test a hypothesis or a theory, or just to be able to explain a process or an abstraction. One of the most used trends is to understand the model as an explicit representation of a part of the existing reality; thus, it can be used to understand, change, manage, predict, and control that part of reality [76].

A management model, conversely, describes the process of institutionalization of practices and leads to work in organizations that embody carrying out the model successfully. Garel [77] states that project management is identified, highlighted, and generalized in itself, becoming a management model. The management model that will be carried out uses a series of statistical techniques that can be considered as an extension of multivalent techniques among which there are multiple regression or factor analyses that allow researchers to quantify and verify scientific theories of different areas of knowledge.

### 3. Methods

The research is based on the information collected by using instruments that were validated by technical experts, and where validation coefficients such as Cronbach offer values greater than 80%.

The Structural Equation Model (SEM) allows to simultaneously analyze a chain of dependency or independency relationships depending on the case and is generally useful when a dependent variable becomes an independent variable in subsequent dependency relationships as is the case of this investigation. Similarly, many of the variables affect each of the dependent variables, but with effects that are normally different. For instance, in this case, one may think that the structural equation model is an extension of various multivariate techniques such as multiple regression and factor analysis; however, it has particular characteristics that differentiate it from other multivariate techniques. For this investigation, for example, the models were developed independently since each phase required to analyze its results autonomously. One of the differences of this type of modeling is that it has the ability to estimate and evaluate the relationship between unobservable constructs, generally called latent variables. A latent variable is an assumed construct (economic impact, as an illustration) that can only be measured by observable variables. Compared to other analysis techniques where the constructs can be represented with a single measurement, and the measurement error is not modeled, the SEM allows to use multiple measurements that represent the construct and to control the specific measurement error of each variable. This difference is important since the researcher can evaluate the validity of each measured construct and can obtain unique conclusions at each stage of the process. Figure 5 helps understand the development of the model by presenting the relationship between the variables that have been analyzed and the estimated interrelationships. As previously mentioned, the factorial techniques are used seeking to reduce the number of variables that are analyzed and seeking to generate factors that add the existing relationships among them. Once these factors (latent variables) have been generated, the new factors are used to relate them to each other through multiple linear regressions; then, the Akaike

Information Criterion (AIC) allows to determine the model that offers a better fit by means of the goodness of fit test.

#### 4. Analysis and Results

The analysis and presentation of results were carried out through the discovery of findings that allowed the validation of each hypothesis, and that was the support for the model approach.

In this sense, the first hypothesis that arises refers to how the particular characteristics of the projects: requirements, life cycle, and expected benefits, entail specific CSFs for each project. From the development and application of the model, which has a theoretical basis and is supported by the literature review, it was shown that in relation to the CSFs in the typology of research projects, key aspects for the success of the projects were identified.

Based on the results of this review, the categories of analysis in the research projects are: formulation of the research project, team or team members, leadership of the main investigator, project completion time, technical resources and project financials, institutional support, results, project beneficiaries, and project differentiating factors (Figure 1). These categories are the basis for the identification of the CSFs of a research project in its requirements, life cycle, and expected benefits.



**Figure 1.** Categories of analysis in a research project. Source. Own elaboration.

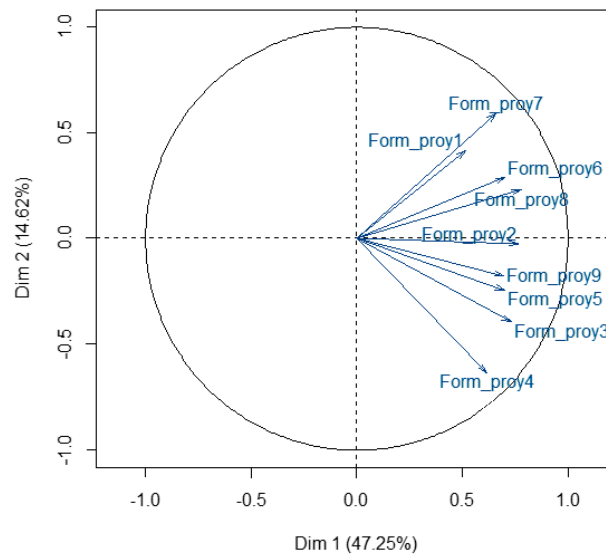
These categories of analysis were the basis for the development of an instrument on CSFs which has been measured by implementing it on a primary source of information. This questionnaire was applied to selected researchers from a sample of 86 research projects, which allowed identifying the specific CSFs for each project. These are evidenced in the estimation of each project in the definition and measurement of the factor with the factorial analysis. In this fashion, it is clear that the particular characteristics of the projects: requirements, life cycle, and expected benefits, entail specific CSFs for each project.

Moving on with the hypothesis, the next statement to study is whether it is possible to analyze the characteristics and determine the CSFs of research projects in Science and Technology. The information that was collected by means of the implementation of the instrument was used to carry out the measurement model based on the factorial analysis.

A factorial analysis led to the reduction of variables and the subsequent identification of latent variables (CSFs). This relied on the analysis of perceptual maps through which those variables with a greater contribution to explain (measure) the latent variable were defined and identified. As an example, we present the exercise performed on the Formulation variable (figure 2).

In Figure 2, the behavior of each of the observed variables with which the formulation factor was measured can be identified. Moreover, based on them, we performed a reduction of variables

looking for better results related to the explained variance, given that it reduces the variance produced by particular subjects. It is observed that all the variables go in the same direction, which indicates that they all focus on the same dimension, in this case formulation (Cronbach's Principle), allowing its validation.



**Figure 2.** Analysis of Perceptual Maps on the formulation factor. Source. Own elaboration.

The process of eliminating variables is done by analyzing those that are highly correlated (graphically very close), which means that they offer analogous measurements, such as the case of Form\_proy1 (definition of the subject of the project) and Form\_proy7 (definition of the problem). In this case, it is said that they measure the same or are closely related. The one with the greatest variability, Form\_proy7, is eliminated (it is more distant from the x-axis) since the definition of the theme is in line with the definition of the project problem. On the other hand, the analysis inferred that it is not necessary to have two variables with the same measurement object.

Similarly happens with the variables Form\_proy6 (research question) and Form\_proy8 (definition of objectives), because they measure the same. Form\_proy6 is eliminated because it has the least factor load and shows greater variability between the two variables. It can be said that in Form\_proy8 (definition of objectives), they are based on the formulation of the research question.

It is also observed that the variables Form\_proy3 (scientific and technical rigor of the methodology), Form\_proy5 (feasibility of the methodology to be developed), and Form\_proy9 (correspondence of the proposed results with the objectives of the project) are measuring the same, given that the methodological development of a project research defines the guidelines and the correspondence of the results with the objectives. Form\_proy3 and Form\_proy5 are eliminated, out of which it can be said that these two variables show the greatest variability in relation to the formulation factor.

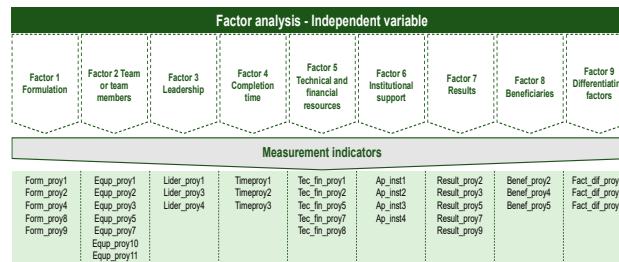
The variables Form\_proy2 (methodology definition), and Form\_proy4 (rigor in the application of the methodology) are variables that are observed and are independent. Thus, for the evaluation of the variables that remain, they are analyzed individually.

In the graphical analysis by individuals (by study projects), shown in Figure 3, we plotted an ellipsoid where the concentration and homogeneity of the information that is collected in one factor (latent variable) is shown. In that way, those that are isolated and gather particular aspects in very specific projects are the ones that go to a second factor, and are defined as one (latent variable).



particular things into very specific projects. The first factor is taken as a reference for measuring the latent variable.

The factorial analysis allowed the identification and determination of the CSFs corresponding to the latent variables that are based on the implementation of the measurement model made to the independent variable, showing in each case the measurement indicators (Figure 4). They are the basis for the management of the CSFs in the variance explained, and in the graphic analysis that was carried out by applying perceptual maps to the CSFs. These analyses and processes led to validate that it is possible to analyze the characteristics of research projects in Science and Technology and determine their CSFs.



**Figure 4.** Analysis of the Independent Variable Factor – CSFs. Source. Own elaboration.

The last study statement that was analyzed is that the identification and appropriate management of the CSFs positively affect the impacts that are generated by the projects.

The determination of the CSFs for each of the research projects, the results of the implementation of the instrument, and its appropriate management based on the measurement indicators that the factor analysis yielded, were the basis for the development of the structural relationship model, which in turn is based on the multiple linear regression model.

The objective of the multiple regression analysis was to use the independent variables whose values are known to predict the only criterion variable (dependent) previously selected [78]. A multiple linear regression model was run in order to establish the relationships between independent and dependent variables, and thus assess that both independent variables explain the dependent variables.

The correlations between the factors resulting from the independent variable were analyzed. They are showing that the correlations are low, proving to be a clear indication of non-multicollinearity (independence between independent variables).

For the implementation of the regression model, each of the factors (latent variables) resulting from the factorial analysis of the independent variable were taken and were crossed with each of the factors resulting from the dependent variable: academic impact, social impact, environmental impact, and economic impact, all of these identified in the literature review and which may arise when a research project is carried out.

The first regression model that was run was performed by crossing the nine CSFs factors resulting from the factorial analysis of the independent variable with the academic impact factor, or of the dependent variable knowledge, obtaining the following results:

Out of the results that were obtained with the model (Table 3), a first finding could be determined: in order to achieve and improve the academic impact, institutional support is a determining factor with a Beta ( $\beta_1$ ) of 0.328 and a p-value of 0.002 (significant). This outcome shows how the support that is provided by the office of the vice chancellor for research at a university to the promotion and incentive of research and innovation are key motivational aspects; and this added to the economic support for publications, the participation in knowledge socialization events, the evidence of research results, the submission of articles in WoS (ISI) and Scopus journals, and the points that are assigned for the categories of teaching promotion as product of the research activity are aspects that significantly influence and motivate the generation of academic impacts from research projects.

**Table 3.** Coefficients of the Linear Regression Model for Academic Impact. Source. Own elaboration.

Model		Coefficients <sup>a,b</sup>		Standardized coefficients Beta	t	Sig.
		Unstandardized coefficients B	Std. Error			
1	Institutional support	,381	,100	,381	3,805	0,000
2	Institutional support	,328	,101	,328	3,243	0,002
	Results	,223	,101	,223	2,208	0,030

a. Dependent variable: Impacto Académico o de conocimiento

b. Linear regression through origin

In addition, it is evident that the results factor is a boosting factor of academic impacts with a Beta ( $\beta_2$ ) of 0.223 less than in institutional support, and a p-value of 0.03 (significant), because the focus on results that entails to some commitments influences the generation of academic and knowledge impacts.

The equation derived from the model can be expressed like this:

$$Y_1 = F_6\beta_1 + F_7\beta_2 \quad (1)$$

Where:

$Y_1$  = Academic Impact

$F_6$  = Institutional support factor

$F_7$  = Results factor

$\beta_1$  = Regression model coefficient Institutional Support

$\beta_2$  = Regression model coefficient Results

For the projects that generated social impacts, the second regression model that was determined was carried out by crossing the nine CSFs factors resulting from the factorial analysis of the independent variable with the social impact factor of the dependent variable, obtaining the following results:

The second finding of the regression model (Table 4) is that the results factor, with a Beta ( $\beta_1$ ) of 0.344 and a p-value of 0.023 (significant), is a key aspect to determine and improve the social impact of research projects. This analysis shows how an approach that is oriented to generate results beyond the completion of the project and aimed at improving the quality of life, the social conditions, and the generation of benefits for a community or an organization, among others, is a differentiating aspect that derives from results and evidence found in the development or execution of the project based on the established indicators.

**Table 4.** Coefficients of the Linear Regression Model for Social Impact. Source. Own elaboration.

Model		Coefficients <sup>a,b</sup>		Standardized coefficients Beta	t	Sig.
		Unstandardized coefficients B	Std. Error			
1	Results	0,454	0,142	0,428	3,208	0,002
2	Results	0,344	0,147	0,324	2,345	0,023
	Leadership of the main researcher	0,352	0,170	0,286	2,068	0,044

a. Dependent variable: Social impact

b. Linear regression through origin

Furthermore, the leadership of the main researcher is a factor that defines social impacts with a Beta ( $\beta_2$ ) of 0.352 and a p-value of 0.044 (significant). Moreover, this is consistent not only with institutional principles, as the main researcher is privileged and summoned for special internal financing of research projects for these purposes, but with the interests and characteristics of the leader, whom from her/his thematic expertise, training, and applied research, attempts to address the problems of communities and organizations.

The equation derived from the model can be expressed like this:

$$Y_2 = F_7\beta_1 + F_3\beta_2 \quad (2)$$

Where:

$Y_2$  = Social impact

$F_7$  = Results factor

$F_3$  = Main researcher leadership factor

$\beta_1$  = Regression model coefficient Results

$\beta_2$  = Leadership regression model coefficient

For the projects that generated environmental impacts, the third regression model was implemented by crossing the nine CSFs factors resulting from the factorial analysis of the independent variable with the environmental impacts factor of the dependent variable, obtaining the following results:

A third finding detected in the model is that in order to achieve and improve the environmental impact (Table 5), the resulting factor is a key aspect with a Beta ( $\beta_1$ ) of 1,812 and a p-value of 0.002 (significant). This study showed how an approach with the purpose of generating results beyond the completion of the project, and these aimed at creating awareness on the relationship with the environment, the optimization of natural resources, and the management of waste and environmental care, faces challenges in a globalized community where the university, in the research projects that have been proposed, assumes it as a social commitment. The Beta of 1.812 is significant, which means that the results factor is preponderant, thus making the difference for this impact. This means that if you want to measure the environmental impact, the projects should be designed on results.

**Table 5.** Coefficients of the Linear Regression model for Environmental Impact. Source. Own elaboration.

Coefficients <sup>a,b</sup>						
Model		Unstandardized coefficients		Standardized coefficients	t	Sig.
		B	Std. Error	Beta		
1	Results	1,812	0,417	0,838	4,347	0,002

a. Dependent variable: Environmental impact  
b. Linear regression through origin

The equation derived from the model can be expressed like this:

$$Y_3 = F_7\beta_1 \quad (3)$$

Where:

$Y_3$  = Environmental impact

$F_7$  = Results Factor

$\beta_1$  = Regression model coefficient Results

The fourth regression model that was run was executed by crossing the nine CSFs factors resulting from the factorial analysis of the independent variable with the economic impacts factor of the dependent variable, for the projects that generated economic impacts, obtaining the following results:

According to the fourth finding and as shown in the model (Table 6), the beneficiary factor of the project, with a Beta ( $\beta_1$ ) of 0.897 and a p-value of 0.012 (significant), is key to achieve and improve the economic impact. Since they represent the ulterior purpose of scientific research projects, such as the "ought to be", which transcends the merely economic and growth aspects in order to become a principle of development from research groups, and the community and organizations that are directly benefited from the research project, they must be aligned with the research policies.

**Table 6.** Coefficients of the Linear Regression Model for Economic Impact. Source. Own elaboration.

Coefficients <sup>a,b</sup>						
Model		Unstandardized coefficients		Standardized coefficients	t	Sig.
		B	Std. Error	Beta		
1	Beneficiaries	0,897	0,320	0,551	2,802	0,012

a. Dependent variable: Economic impact  
b. Linear regression through origin

The equation derived from the model can be expressed like this:

$$Y_4 = F_8\beta_1 \quad (4)$$

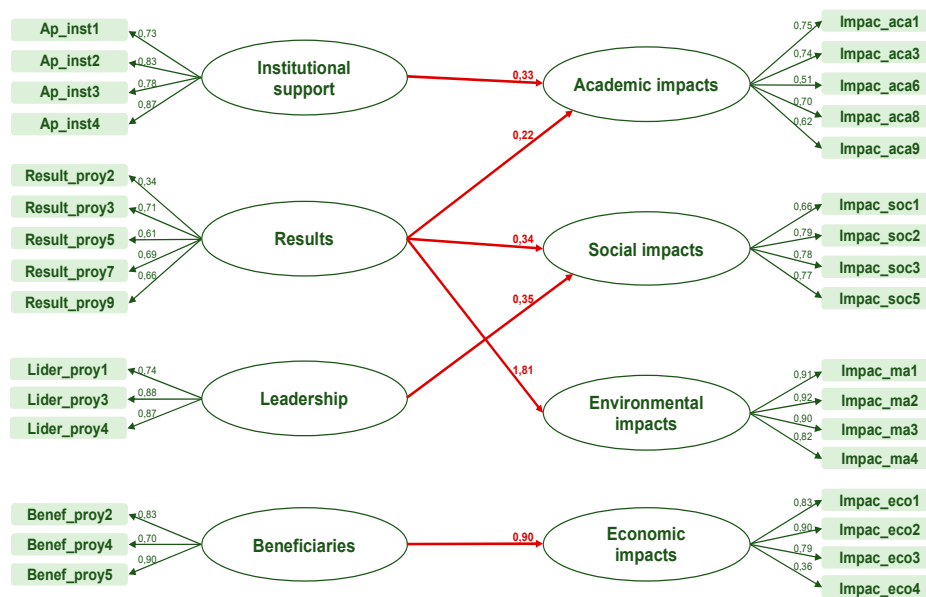
Where:

$Y_4$  = Economic impact

$F_8$  = Beneficiary factor

$\beta_1$  = Regression model coefficient Beneficiaries

As findings of the multiple linear regression model, it was possible to demonstrate the relationships between the independent variables (CSFs) and the dependent variables (impacts), and to evaluate that the independent variables explain the dependent variables (Figure 5). With a significant p-value, the last hypothesis could be tested as an adjustment measure (the identification and appropriate management of the CSFs positively affect the impacts that are generated by the projects) with the existing relationships, as follows: the institutional support and the results explain the academic impact; the results and the leadership of the main researcher predict the social impact; the focus on results is decisive for the generation of environmental impacts; and the beneficiary factor explains the economic impacts.



**Figure 5.** CSF management model to improve the impact of S&T research projects.

The conceptual representation of the model (Figure 5) is expressed as follows: the ovals represent the latent variables resulting from the factorial analysis; and the arrows with their respective factorial loads that leave from the latent variables towards the rectangles, indicate the observed variables that measure the latent variable or the measure indicators.

The latent variables institutional support, results, the leadership of the main researcher, and beneficiaries represent the CSFs, which is the independent variable of the model. These, in turn, are measured by measurement indicators like this:

- Institutional support is measured through: administrative support (Ap\_inst1); physical resources such as infrastructure, library, laboratories, etc. (Ap\_inst2); technological resources such as equipment, specialized software, etc. (Ap\_inst3); and human resources (Ap\_inst4).
- The results are measured by the results that are measurable (Result\_proy2); results generator beyond project completion (Result\_proy3); knowledge transfer through participation in events (Result\_proy5); effects and impacts that are monitored once the project is finished (Result\_proy7); and the project taken as the basis for teacher update (Result\_proy9).
- The leadership of the main researcher is measured through thematic expertise (Lider\_proy1); its ability to solve problems and conflicts (Lider\_proy3); and its technical competencies (Lider\_proy5).
- Beneficiaries are measured by the acceptance of the project by beneficiaries (Benef\_proy2); the support of the research group to which it belongs (Benef\_proy4); and the satisfaction of the interested parties (Benef\_proy5).

Furthermore, the literature review on research project impacts showed that they are the focus of results beyond the completion of the project, which lead to a change, effect, or benefit in society. The impacts can be academic or knowledge, environmental, social, and/or economic.

The conceptual representation of the model also shows the latent variables resulting from the factorial analysis to the dependent variable, that is: academic or knowledge impact, social impact, environmental impact, and economic impact. These are computed by measurement indicators like this:

- The academic or knowledge impact is measured through the knowledge that is generated in the research and that is used by the members of the research team (Impac\_aca1); the bibliography of the classes of the research team was updated when the research was finished (Impac\_aca3); the results of the research were disclosed in national events (Impac\_aca6); the research project was the basis for the development of degree projects (Impac\_aca8); and the research was the support for the development of formal training programs (Impac\_aca9).
- The social impact is measured through the development of the project that was contributed to the training of researchers (Impac\_soc1); the results of the project improved the quality of life, health, food, housing, mobility, work, etc. (Impac\_soc2); I use the results of the research in the daily work of my organization, community, company, etc. (Impac\_soc3); and the product/service that was developed in the research was beneficial for my organization, community, company, etc. (Impac\_soc4).
- The environmental impact is measured by the way that the project increased the commitment to the use of resources which led to improved environmental conditions (Impac\_ma1); the results of the project generated environmental effects, awareness of environmental care, pollution reduction, water care, etc. (Impac\_ma2); the development of the project in the management of resources diminished the environmental effect due to the waste management that was carried out (Impac\_ma3); and as a result of the research project, my ethical commitment in the use of living beings in the research changed (improved) (Impac\_ma4).
- The economic impact is measured by the income that is generated by the project and that is used for the support of the research (Impac\_eco1); the project generated income for the support of the research group (Impac\_eco2); the project increased the level of income for my organization, community, population, etc. (Impac\_eco3); and the results increased revenues from the generation of a patent (Impac\_eco4).

In the conceptual representation of the model (Figure 5), it was found that the CSFs, an independent variable of the model, explain and/or predict the impacts of the research projects, which are indicated by arrows (containing the betas resulting from the structural relationships model) that leave from the independent variable (CSFs) towards the dependent variable (impacts).

## 5. Conclusions

This article presented the results that are evidenced in the design and implementation of a new management model of Critical Success Factors (CSFs) to increase the impact of research projects as a contribution to the knowledge field of Project Management with a new typology of analysis that is not usually studied in this area.

As a result of the factorial analysis of the independent variables, nine latent variables emerged, which correspond to the CSFs and are explained in each case by a small number of variables improving the results in terms of the explained variance and the analysis of the perceptual maps. Likewise, four latent variables of the dependent variable corresponding to each of the impacts were defined. The factors yielded from the factorial analysis are elements that constitute the basis for the development of the structural relationship model based on the multiple linear regression model.

The multiple linear regression model allowed us to demonstrate the relationships between independent variables (CSFs) and dependent variables (impacts), and thus evaluate how much independent variables explain the dependent variable. Using an iterative modeling based on the significance of each of the variables, it was possible to confirm the existing relationships as follows: the institutional support and the results explain the academic impact; the results and leadership of

the main researcher predict the social impact; the focus on results is decisive for the generation of environmental impacts, and the beneficiary factor explain the economic impacts.

The feature called institutional support can be said to promote and encourage research and innovation, and it is an aspect that involves a quality factor. Likewise, the results are the incentive to focus researchers on generating effects, changes, or benefits in society beyond the end of the project. The results are differentiating aspects of a research project that are framed within the context in which it is developed. Thus, institutional support and results are integrated to be academic impact enhancers where, in addition, it could be said that other CSFs are collected.

On the one hand, the results of the CSFs as a differentiating element of a project focused on improving the quality of life, social conditions, and the generation of benefits for a community and/or organization, answer to particular projects that within a context aim at addressing the needs identified in a community. The aforementioned aligned with the interests and characteristics of the leader who, from his thematic expertise, training, and applied research, seeks to address issues from communities and organizations. Therefore, the results and leadership of the main researcher become two factors that are motivators and incentives for social impacts.

On the other hand, an approach with the purpose of generating results beyond the completion of the project, and these aimed at creating awareness of the relationship that there is with the environment, the optimization of natural resources, and the environmental care, presents challenges in a globalized community where projects with this specific focus on their results are generating environmental impacts, and where the university in the proposed research projects assumes such impacts as a social commitment.

With regards to the beneficiary factor, it can be said that it represents the subsequent purpose of scientific research projects, such as the "ought to be" which transcends the merely economic and growth aspect to become a tenet of development from the research groups; and from that stance, it drives the generation of economic impacts.

The identification of the CSFs for each of the research projects, the results of the implementation of the measurement in the instrument, and it's appropriate management based on the measurement indicators that the factor analysis yielded, which were the basis for the development of the model of structural relationships based on the multiple linear regression model, made it possible to show the CSFs that affect and explain the generation of impacts by research projects.

These CSFs as findings of the model include factors that must be understood as aspects or areas of activity within a research project and must be subject to constant and careful management in order to improve their impacts and benefits beyond the completion of the project.

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