Business Management Dynamics
Vol.4, No.1, Jul 2014, pp.29-51

Measuring Project Complexity and Uncertainty: Scale Proposal

Jefferson de Souza Pinto*[1], Olívio Novaski*[2], Rosley Anholon*[3] and Élen Nara Carpim Besteiro*[4]

Abstract

This work develops an instrument for evaluating projects – a range of numerical measurement in degrees – which includes a set of attributes of complexity and uncertainty variables in projects. Through theoretical foundations, we identified a set of variables that represent the attributes complexity and uncertainty. This set of variables was evaluated by 32 project managers who, through a questionnaire, validated two groups of 14 variables, one for each attribute, which were analyzed through multivariate statistical techniques – the Multidimensional Scaling and Cluster Analysis. The analysis results showed that 10 variables have greater adhesion to each one of the attributes, therefore they became part of the range measurement. This analysis also allowed establishing a criterion for calculating the scores to form that scale, resulting in the production of a matrix that converges to the classification of attributes into a single point in relation to the complexity and uncertainty of projects.

Key words: Project Management; Complexity in Projects; Uncertainty in Projects

Available online
www.bmdynamics.com
ISSN: 2047-7031

INTRODUCTION

There is a perceptible need to develop new studies in order to verify other variables that fall within the project management process, such as the issue of uncertainty, because the larger the company and its project complexity, the greater the uncertainties involved, requiring better management control and a more suitable connection of each project to its ongoing operations (PMI, 2013).

The current business environment is much more complex and unstable than in the past, which in turn makes the professionals in the project area strive to better understand processes and the effective management of activities related to a given project, which comprises its planning up to the control of its results. Based on this assumption, projects should be managed considering various factors, influences, resources and external and internal variables related to the context such projects are inserted in, and which somehow influence their degree of complexity and uncertainty over their life cycles.

The high level of uncertainty in projects deviates from the traditional view of project management, making them fail (Williams, 2005). The author also states that traditional project management methods are inadequate for the context of complex and uncertain projects. A view complemented by Shenhar and Dvir (2010), stating that project management based on a predictable, fixed, relatively simple and conventional model is dissociated from changes in the business environment and its needs, thus failing because it does not focus on the aspects of complexity and uncertainty.

According to Shenhar and Dvir (2010), project management requires monitoring the aspects of complexity and uncertainty, not fulfilled by traditional management, which is precisely the issue this work aims to study.

Project management increasingly displays adverse conditions for measuring and controlling the performance of such types of events. These adverse conditions are identified by predominantly qualitative attributes and are therefore more difficult to measure, even though their presence significantly influences the performance and degree of success of a given project, and therefore need to be taken into consideration in decision making processes.

* *State University of Campinas, School of Mechanical Engineering, Manufacturing and Materials Engineering Department*
[1]*E-mail: jeffsouzap@uol.com.br*
[2]*E-mail: novaski@fem.unicamp.br*
[3]*E-mail: rosley@fem.unicamp.br*
[4]*E-mail: besteiro.elen@gmail.com*

This scenario gives rise to a study which seeks to identify the variables that affect the degree of complexity and uncertainty, and which due to their qualitative nature, are difficult to measure numerically. Thus, this work presents a measuring criterion for the degree of influence of variables on the attributes of complexity and uncertainty in project management, in order to propose a numerical measuring scale for these attributes, duly validated by project managers in order to support decision-making processes.

BIBLIOGRAPHIC REVIEW

Complexity Attribute in Project Management and its variables

Nassar and Hegab (2006) argue that it is difficult to accurately quantify and standardize the complexity of a project. This difficulty lies in the interpretation of the meaning and effect of complexity in the parameters of the project, and these parameters can be the availability of resources and their variability, multiple concurrent activities and their durations, which among others are conflicting objectives.

To Kujala *et al*. (2007), projects have attributes that are seen as contingency factors in the context of projects, namely: discontinuity, frequency, uniqueness, complexity, interdependence, size, uncertainty, and total cost of the life cycle of the project product. According to Shenhar *et al*. (1997), the success of a project is based on four dimensions: (1) Efficiency of the project; (2) Customer influence/satisfaction; (3) Commercial influence on organization; and (4) Opening of new opportunities for the future.

As a consequence of the above and according to Kujala *et al*. (2007) and Shenhar *et al*. (1997), it is difficult to determine which are the components inserted into the complexity attribute in project management, thus this paper proposes to establish and assess which are the sub-attributes of complexity related to project management, and in this work these sub-attributes will be treated as variables.

From this requisite the conception of Vidal, Marle and Bocquet (2011) emerges, which from a survey that included 38 professionals, including international experts in project management, determined which are the complexity attributes in projects, a survey that was conducted in a diversified manner according to geographic location and gender. While, Little (2005) states that complexity is composed of the size of the project team and its critical aspect.

In order to evaluate the complexity in projects, Carvalho (2003) proposes a project-related complexity analysis in the Information Technology (IT) area. In the analysis proposed by the author three areas are proposed – project scope, project products and influence on processes, areas that are developed and that incorporate in their analysis items such as: number of organizations involved in the project, project type, level of changes in business processes derived from the project, among other items.

What can be noted in the analysis proposed by Little (2005), Carvalho (2003) and, Vidal, Marle and Bocquet (2011), is that the aspects demonstrated by the authors are present in the projects, however the analyses do not clearly classify how complex the projects are or establish a criterion to perform an analysis of the level of complexity, which makes the proposals subjective, as they treat many aspects of the projects only qualitatively.

Furthermore, and complementing the analysis, the work of Toledo *et al*. (2008) is relevant, which analyzed a sample of 62 companies working on projects, and from this research a number of variables that can influence the degree of complexity of the projects was raised.

In summary, the results raised in the theoretical framework are the variables that make up the complexity attribute, which are 44 variables, as shown in Table 1.

Table 1. Variables raised of the complexity attribute.

Number	Variables of the complexity attribute	Author(s)
1	*Team size;*	Little (2005)
2	*Critical mission;*	
3	*Team location;*	
4	*Team efficiency;*	
5	*Domain of knowledge gaps;*	

6	*Project facilities.*	
7	Number of systems;	Kujala *et al.*(2007)
8	Integration needs;	
9	Required Skills.	
10	Number of project stakeholders;	Vidal, Marle e Bocquet (2011)
11	Variety and interdependence of combinations of information systems;	
12	Geographical location of project stakeholders (and their mutual dissatisfaction);	
13	Variety of interests of project stakeholders;	
14	Dependence on the environment;	
15	Availability of people, materials and other resources to share;	
16	Inter-relationships between areas, departments and companies;	
17	Interconnectivity and feedback of tasks and project networks;	
18	Team cooperation and communication;	
19	Dependence between chronograms;	
20	Interdependence of information systems;	
21	Interdependence of objectives;	
22	Level of inter-relationship between stages;	
23	*Interdependence of processes - size;*	
24	*Cultural variety and setting;*	
25	*Interdependence of specifications;*	
26	*Complexity of the environment (network environment);*	
27	*Number of organizations involved in the project;*	Carvalho (2003)
28	*Information systems involved in the project;*	
29	*Number of departments that define business rules for the project;*	
30	*Project types;*	
31	*Acquisition information from the business manager;*	
32	*Number of providers for the project;*	
33	*Level of change that the project will cause in the business processes;*	
34	Result of the new product; (Successful or not)	Toledo *et al*. (2008)
35	*Degree of product innovation;*	
36	*Characteristics of the target market;*	
37	*Technology sources;*	
38	*Product Features;*	
39	*Company skills;*	
40	*Project leader skills;*	
41	*Organization of project teams - structure;*	
42	*Quality of execution of other activities;*	
43	Integration of PDP; (Product Development Process)	
44	*Implementation quality of PDP activities.*	

Source: Prepared by the authors

Uncertainty in Project Management and its variables

Perminova *et al*. (2008, p. 76) defines "a context for risks as events that have a negative influence on project outcomes or opportunities, such as events that have an advantageous influence on project performance." According to the authors, this definition emphasizes the conceptual duality of uncertainty with potential influence – positive and negative – on project outcomes. Therefore, project risks are certain or known, over which the project manager can predict potentially hazardous events and set preventive measures.

Uncertainty, as suggested by McFarlan (1981), requires adapting the style of project management, and that it can be measured based on the following dimensions: project size, project structure, and experience with technology used in the project. Thus, according to Souza (2004), there is an association of uncertainty with imperfect knowledge about endogenous and exogenous factors to the project. The author's statement points to the projects' internal and external factors as influencing their degree of uncertainty.

This corroborates Jun *et al.* (2011), which from the study conducted argue that the factors which can promote uncertainty in projects are: relative size of the project; technical complexity; customer/user experience; project team ability; project planning and control; internal integration; user participation; product performance; and process performance.
Shenhar *et al.* (2002) present factors and variables that are analyzed in the context of uncertainty, these factors are divided into five categories: origin of the idea and project milestones; planning and control; project policies and considerations; organizational factors; and documentation, reporting and management policy. It is possible that the authors' present variables that include the five process groups described by PMI (2013), from project initiation to completion, which shows that at all stages of the project there are factors that influence the degree of uncertainty, reinforcing the need to know the uncertainty in projects. From the analysis regarding uncertainty it is seen that there are many variables comprising this attribute, in summary, the variables that compose the uncertainty attribute of the results raised in the theoretical framework are 54 variables, as shown in Table 3.

Table 3. Variables in the uncertainty attribute.

Nº.	Variables of the uncertainty attribute	Author(s)
1	*Market uncertainty;*	Little (2005)
2	*Technical uncertainty;*	
3	*Project duration;*	
4	*Dependencies, scope flexibility;*	
5	Technological uncertainty – established technology; mostly established technology; advanced technology; highly advanced technology;	Shenhar e Wideman (2000)
6	Origin of idea;	Shenhar *et al.* (2002)
7	Formal procedures;	
8	Project milestones;	
9	Analytical Project Structure (APS);	
10	Planning and control techniques;	
11	Management of cycles;	
12	Management considerations;	
13	Technical Management ;	
14	Quality management;	
15	Organizational Structure;	
16	Sharing of resources;	
17	Autonomy in project management ;	
18	Project team;	
19	Customer participation;	
20	Documentation;	
21	Project Reviews;	
22	Management policies;	
23	Formal contracts.	
24	Relative project size;	Jun *et al.* (2011)
25	Technical complexity ;	
26	Customer/user experience;	
27	Project team skills;	
28	Project planning and control;	
29	Internal integration;	
30	User participation;	
31	Budget performance process;	
32	Chronogram performance process;	
33	Performance of the product.	
34	The organization can absorb project failure (though still undesirable);	Cleden
35	The benefits of project success justify the high risk of failure;	

36	Shared recognition of high levels of uncertainty among all project stakeholders;	(2009)
37	Consequences of failure are usually limited and the focus is only on the financial aspect (human lives are not at stake);	
38	High number of inexplicable questions;	
39	Mature processes exist to detect and respond in advance to the warnings of unexpected results;	
40	A risk outweighs the benefits of success;	
41	Failure has highly undesirable implications;	
42	The consequences of failure are limitless;	
43	A failure goes beyond financial losses; because human lives may be involved;	
44	*The project organization is not agile or unable to adapt to unexpected results;*	
45	In most cases uncertainty is predominant, which is quantifiable;	
46	Volume of investment.	
47	Short term results expected from the project in terms of cost, time period, and	Moraes (1999)
48	Relationship with the activities to be performed in the project;	
49	Relationship with the duration of project activities;	
50	Relationship of precedence between project activities;	
51	Relationship with project costs;	
52	Relationship with availability of funds for project execution (budget);	
53	Relationship with technology and domain of skills necessary for the project;	
54	Relationship with resources availability to implement the project.	

Source: Prepared by the authors**.**

Thus, through the analysis of the theoretical framework, 98 variables that have greater adhesion to the context of complexity or uncertainty attributes were selected because they are subject to some kind of measurement or quantification, in other words, the measurability of each one was verified, including the support of the theoretical framework.

Models for Measuring Complexity and Uncertainty in Projects

According to Latva-Koivisto (2001), the criteria to measure complexity should include the following characteristics: (a) validity; (b) reliability; (c) computability; (d) implementation ease; (e) intuitively; (f) independent of other related measures.

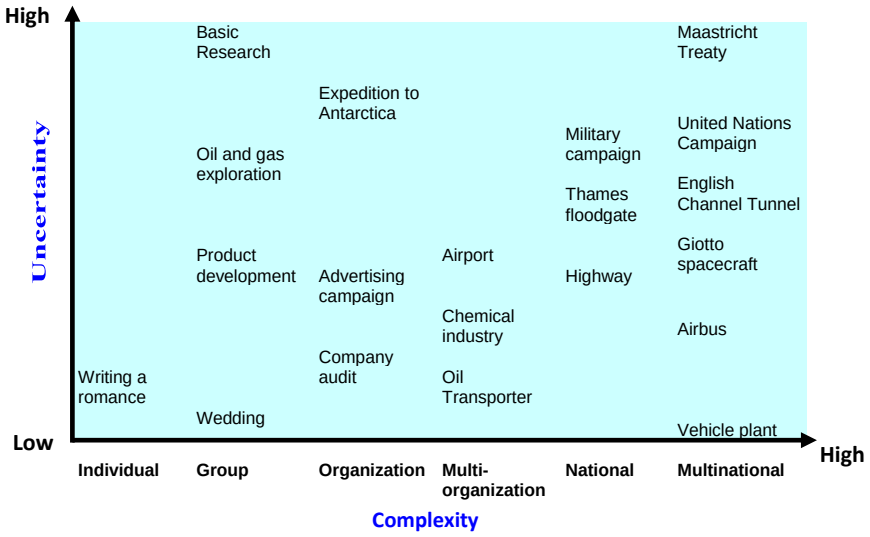
Thus, there are some matrices that seek to establish the relationship of complexity and uncertainty in projects by building measures that show their behavior, these matrices often seek to establish a relationship with more than one aspect in the project management scope, as for example, uncertainty. To establish an understanding of the matrices which seek to analyze complexity and uncertainty within the scope of the project, the design matrices of Nicholas (1990) are exhibited, adapted by Slack, Chambers and Johnston (2002), and by Maximiano (2008), because both corroborate the matrix structure proposed in this work.

Nicholas (1990), adapted by Slack, Chambers and Johnston (2002), presents a classification of projects from the analysis of two variables that make up the context of projects, complexity and uncertainty, where complexity is in the abscissa axis, and uncertainty is in the ordinate axis, and both can be classified as levels ranging from low to high, but without establishing a quantitative scale in order to better understand the classification process.

Figure 1 shows this classification in two axes in a two-dimensional plane and shows the level of complexity by analyzing the number of individuals involved in the project and/or size of the organization, determining that a project executed by only one individual is of low complexity, as for example, shown in Figure 1, writing a novel; and at the other extreme, a multinational project is of high complexity, as for example, the manufacture of vehicles. However, it should be emphasized that this

classification is done in a qualitative and subjective manner, since it does not take into account all the variables, or also mention characteristics that comprise a project, which makes this classification model fragile by considering that a project consists of a network of variables, as already mentioned earlier, which interrelate hence making them increasingly complex, and also, it should be mentioned, that if there is more than one project being developed simultaneously by the organization, this could affect its complexity.

Figure 1. Project Typology.



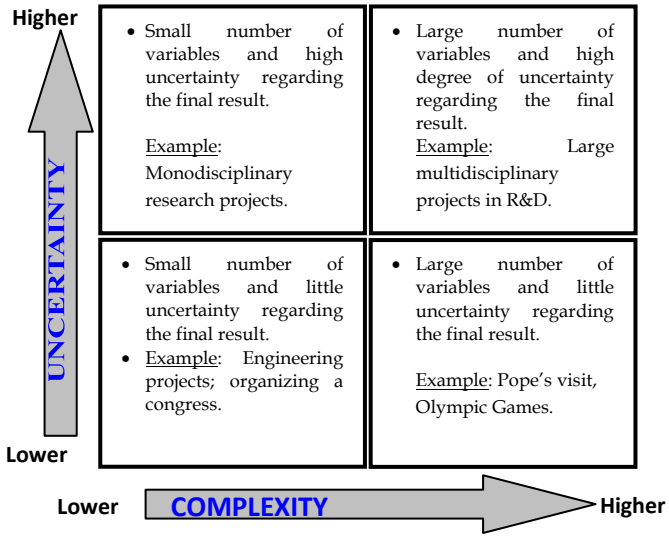
Source: Nicholas (1990) adapted by Slack, Chambers and Johnston (2002, p. 513).

However, as regards the level of uncertainty classification, the authors also did not establish a quantitative scale, only a qualitative analysis that demonstrates how uncertain projects can be, and the analysis of Figure 1 shows that the more complex the project, taking into account the level of individuals engaged in the project, the more uncertain it becomes.

According to Maximiano (2008, p. 07), the complexity is measured by the number of variables that contain a given project, hence a complex project is one that has a large number of variables to be managed, such as: (a) multidisciplinary or diversity of professional profiles necessary to carry out a project; (b) physical distance between people or project resources; (c) number of persons, organizations or facilities involved; (d) diversity and volume of information to be processed; (e) duration; (f) conditions to be observed (such as risk and safety).

Also according to Maximiano (2008), uncertainty in projects means not knowing the result or the path to achieve it, or both. Figure 2 shows the correlation between the complexity and uncertainty variables, which shows that increasing the number of variables there is a higher degree of complexity, and which also occurs with uncertainty in the outcome of the project. It should be noted that in the author's classification, no quantitative scale is attributed to determine the level of complexity and uncertainty in projects, there is only a classification from lower levels to higher levels, making the classification virtually a two-dimensional plane divided into four quadrants, as seen in Figure 2, thus making the classification subjective, as attributing a score is not possible for classifying the levels of complexity and uncertainty.

Figure 2. Relationship matrix of project complexity and uncertainty.



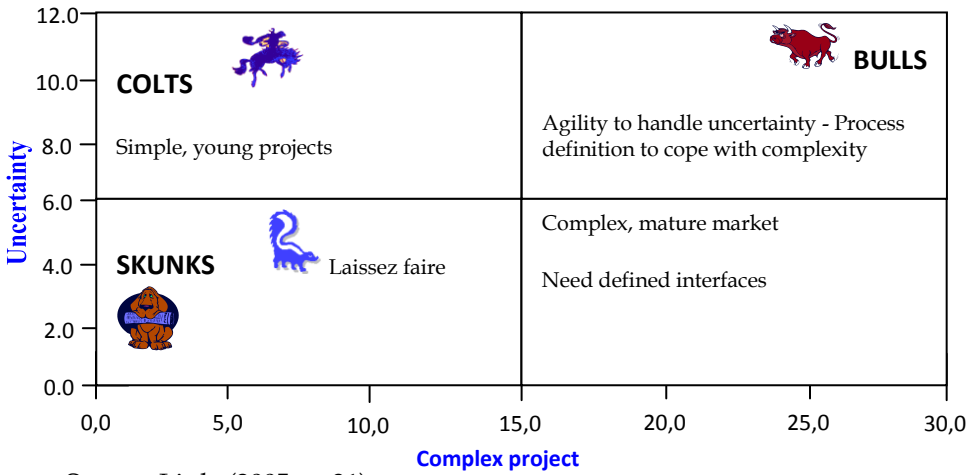
Source: Maximiano (2008, p. 08).

In an empirical context, according to other classification matrices proposed by other authors, among them Slack *et al*. (2008), Shenhar and Wideman (2000), Carvalho (2003), Barcaui (2006), Kerzner (2011), they have different classifications related to complexity and uncertainty, but as these showed no substantial similarity with the matrix proposed in this paper, they will not be exhibited.

However, all matrices show the complexity relationship in projects, demonstrating that complexity is a highly relevant and influential factor in project performance, requiring that organizations establish greater control in the mapping of complexity.

Finally, the classification matrix proposed by Little (2005) is presented, which proposes a model with a scoring matrix for both dimensions – complexity and uncertainty, divided into four quadrants and termed as Houston Matrix, shown in Figure 3.

Figure 3. Houston Matrix of complexity and uncertainty relationship.



Source: Little (2005, p. 31).

As shown above, the proposed matrix uses animal names to create the classification and represent projects in each of the quadrants. Little (2005) designates the following categorization: (1) Dogs – simple

projects with low uncertainty: these are typically mature product projects developed by small teams, they are simple projects with low uncertainty. This quadrant also has a prototype figure or skunk projects, or simply skunks, these are Research and Development (R&D) projects often classified in this category, these projects bring a *laissez-faire* approach; (2) Foals – simple projects with high uncertainty: these are new product projects, they generally have market and technical uncertainty; (3) Cows – complex projects with low uncertainty: these are more mature product projects and parts of products, they have large project teams, and are also the money "cows" of the organization; and (4) Bulls – complex projects with high uncertainty: these are projects that generate problems at all fronts. The "bulls" projects detain greater visibility in the organization, and consequently end up generating products that require high investments, which show high levels of complexity and uncertainty.

METHOD

The research developed herein has an application purpose, since it intends to cooperate with the managing process of organizations, specifically relating to project management and the implicit control problem of the complexity and uncertainty variables. The research typology is exploratory, since it focuses on increasing the understanding of the aforementioned variables of the complexity and uncertainty attributes in projects, based on the existing studies on this subject. From the research strategy standpoint, a study was initially developed through a literature review to present the existing theoretical referential framework. This referential framework raised the key concepts guiding this research with regards to the identification and quantification of variables that affect the complexity and uncertainty attributes in project management, and introduced them from the perspective of various authors, experts in the subject.

Next, a set of variables that can be measured and subjected to the project managers' review was selected. The procedure used in the work acted as a filter which, from a significant number of variables of the complexity and uncertainty attributes – already identified by the theoretical studies available – enabled creating a set of 10 variables subject to measurement, for each attribute.

In order to evaluate the 98 variables identified in the theoretical framework, by the managers' perception regarding the degree of adhesion to the complexity and uncertainty attributes, from the variables mentioned for each of the attributes in the projects – complexity and uncertainty – a survey-type exploratory research using a questionnaire with three sets of questions was outlined: one for analyzing the profile of the respondent and the organization that developed the project that subsidizes the answers; one with a group of 14 variables of the complexity attribute; and finally one with 14 variables of the uncertainty attribute. These 14 variables of both attributes were developed after an extensive study about the concepts of these attributes, using a measuring criterion of the variables based on the literature contributions on project management, where the variable should be subject to measurement or quantification, through its typology or by inserting some sort of classification.

From these assumptions the variables of the attributes studied were selected – complexity and uncertainty, as shown in Table 4, and later their classification levels were developed (Table 5).

Table 4. Variables of the complexity attribute and uncertainty that makes up the questionnaire.

Variables of the complexity attribute	
1	Size of the project team
2	Relative size of the project
3	Type of innovation
4	Size of organization
5	Location of project team members
6	Number of organizations involved in the project
7	Type of project
8	Number of departments of the organization involved in the project

9	Level of influence of changes caused by the project
10	Number of project stakeholders
11	Geographical location of project stakeholders
12	Structure type of project
13	Deadline pressure
14	Dependence level on other projects within the organization
	Variables of the uncertainty attribute
1	Projects' target market(s)
2	Project duration
3	Level of technology involved
4	Project milestones are met
5	Project manager's knowledge about the type of project being managed
6	Project completion on schedule
7	Project completion within budget
8	Costs budget
9	Changes in project scope
10	Level of dependence on third parties to carry out the project (from contracts set)
11	Project planning and control activities
12	Volume of investment for project execution
13	Project documentation
14	Project Risks

Source: Prepared by the authors.

Table 5. Analysis levels of the questionnaire.

Analysis levels	Options
Response choices for **Influence Level to project**	**1 –** no influence of the variable; **2 –** low influence of the variable; **3 –** little influence of the variable; **4–** average influence of the variable; **5 –** high influence of the variable.
Response choices for **Significance Level to project**	**1 –** no significance of the variable; **2 –** little significance of the variable; **3 –** average significance of the variable; **4 –** significant variable; **5 –** highly significant variable.

Source: Prepared by the authors.

For the data, 66 questionnaires were forwarded to organizations of different sizes and industries, of which 32 questionnaires were answered and validated, confirming the external validity. For the attributes of this survey, the respondent was asked to evaluate the level of influence and level of significance of each variable based on the last project he/she participated in.

The respondent was asked to assign a score from 1-5 to each of the levels mentioned, where '1' represented the "weakest" level and '5' the "strongest" level (The structure used for constructing this scale is based on the Likert scale). The response options for this scale are split and presented in Table 5. In the scale the analysis includes the influence of the variable on the attribute analyzed and the significance of the variable analyzed for the project that this analysis is based on.

The scales presented measure the judgments for similarity or preference, providing a metric scale with intervals in the form of a numbered and named anchor line, that is, an ordinal scale. And here, according to Hair, Jr. *et al*. (2005, p. 185), the numbers in this interval scale, as treated in the area of management

research, contain all the properties of nominal and ordinal scales, thus allowing the objects (respondents) to be compared in terms of their differences in the scale.

The research analyses of the variables of complexity and uncertainty attributes were performed with two statistical multivariate analyses – Multidimensional Scaling (MDS) and Cluster Analysis.

The Multidimensional Scaling (MDS), also called perceptual mapping, is an interdependence multivariate method for analyzing data, which is composed of a number of methods which help identify the most important dimensions from the assessments made by respondents in a multidimensional space. Thus, the graphical analysis represents the relationships discovered by the data representing similarity or preference (HAIR, Jr. *et al.*, 2009). It should be underscored that the dimensions and their scales, such as the outputs of the SPSS 15 software (dimension 1 and 2) are subjective and characteristic of the method, not referring to the variables analyzed in this work.

While the Cluster Analysis analyses a set of interdependent relationships, making no distinction between dependent and independent variables in order to analyze the interdependence relations between the whole set of variables. Thus, the main goal of the method is the classification of objects into relatively homogeneous groups based on the set of variables under consideration (Malhotra, 2012).

These methods supported the screening of the more relevant variables that have more adhesion to the behavior of the attributes analyzed. And the outcome of the application of the methods enabled to perform a screening of the number of significant variables, which were reduced from 14 to 10 in each of the attributes.

The variables of the attributes of the projects were entered and analyzed by the SPSS 15 software to process the analysis, where the 14 variables are coded as follows: (a) VC1 to VC14 (complexity influence variables); and, (b) VC1I to VC14I (significance complexity variables); (c) VI1 to VI14 (uncertainty variable); and, (d) VI1I to VI14I (uncertainty significance variables). The analyses are performed with all variables of the complexity and uncertainty attributes, individually or combined. To understand the analysis through the multivariate analysis techniques selected, a combined set of analyses of the attributes is presented, the others are not presented in this work.

Data Collection

Interestingly, the 32 completed questionnaires represent approximately 48.50% of the sample, a high percentage taking into account that research studies that use electronic means or postal mail to forward data collection instrument generally have a low return. This significant return is also due to the fact that access to respondents was convenient, since the questionnaires were sent to project managers who were available to answer the questionnaire. The project managers in the sample had some professional contact with the research group, to which the author of this work belongs to. The project managers of the pre-test answered the final version of the questionnaire and are inserted in the sample.

It should be clarified that this work is not influenced by using probabilistic samples, hence the sampling technique used was not probabilistic by judgment. Since this technique of intentional or trial sampling, according to Selltiz *et al.* (1974), is used when the researcher, through good judgment and proper strategy, chooses the cases he believes are necessary for the sample to achieve the research needs, usually those defined as typical of the population. Trial sampling is a form of convenience sampling in which the researcher's judgment is used to select the sample elements (Hair, Jr. *et al.*, 2009, p. 247). As already explained, of the judging criteria, convenience was also a selection factor of the work sample.

Furthermore, the survey questionnaires were forwarded to the respondents' e-mail, which according to Gray (2012) is an efficient data collection manner.

From the overall description of the study sample, there was external validation of the research because the results can be generalized across organizations that have projects to be managed.

Characterization – Company Profile

With regard to the organizations' performance sector, 40.63% belongs to the industrial sector's processing of goods, while 46.88% are from other sectors, of which the main ones are the following: research and development; consultancies; pharmaceutical; automotive; manufacturing, trade and services; oil; energy; and information technology. The other sectors represent 46.88%.

Most of the organizations comprising the sample (62.50%) have more than 1000 employees, characterizing them as large organizations, whereas organizations with up to 1000 employees represent 37.50% of the sample, that is, small to medium size, as shown in Figure (3.7). Of the organizations in the sample, 75% have sales or gross operating revenues of over 60 million Reais, based on the previous year, which reinforces their characterization as large-sized companies.

Characterization – Respondent Profile

In order to characterize the respondent's profile, the project managers responsible for filling out the questionnaire sent to them, to determine the projects' level of complexity and uncertainty, are mostly (78.13%) men. Women represent only 21.88%.

The respondents in the sample, 43.75%, hold the position of project managers, engineers and/or supervisors, or are members of the project team in the organizations' hierarchy. 28.13% hold the position of functional manager, which shows the function/role of project managers still being held by functional managers, as a result of the functional structure that most companies have, rather than a projectized organization structure. Only 6.25% of respondents hold the position of director in the organizational hierarchy.

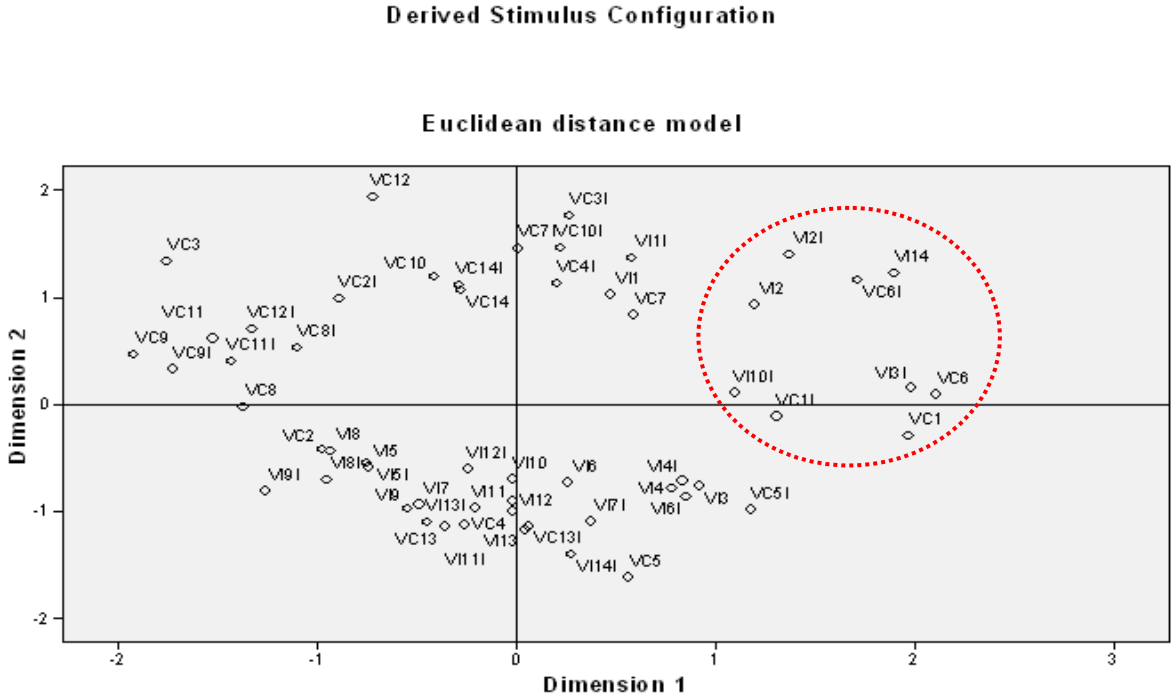
RESULTS, DISCUSSION AND ANALYSIS

Multivariate analyses of the Complexity and Uncertainty Attributes: combined

The analysis of the attributes complexity and uncertainty is set jointly from both the selected multivariate techniques, Multidimensional Scaling (MDS) and Cluster Analysis, combining the attributes and their levels of influence and significance in order to verify the adhesion relationship of all the variables of the analyzed attributes and their similarity.

Setting a joint analysis of both statistical methods, Figure 1 shows the perceptual map of MDS that the variables of the attribute complexity: (1) – "size of project team" and (6) – "number organizations involved in the project", have lower adhesion to the attribute. This confirms other acknowledged analyses, which showed the lowest adhesion to the variable (6) in the set of variables of project complexity, and adds the variable (1) with lesser adhesion.

Figure 1. Perceptual map of similarity (variables) - Euclidean distances - complexity attribute together with uncertainty: unification - influence and significance. Source: Research data.



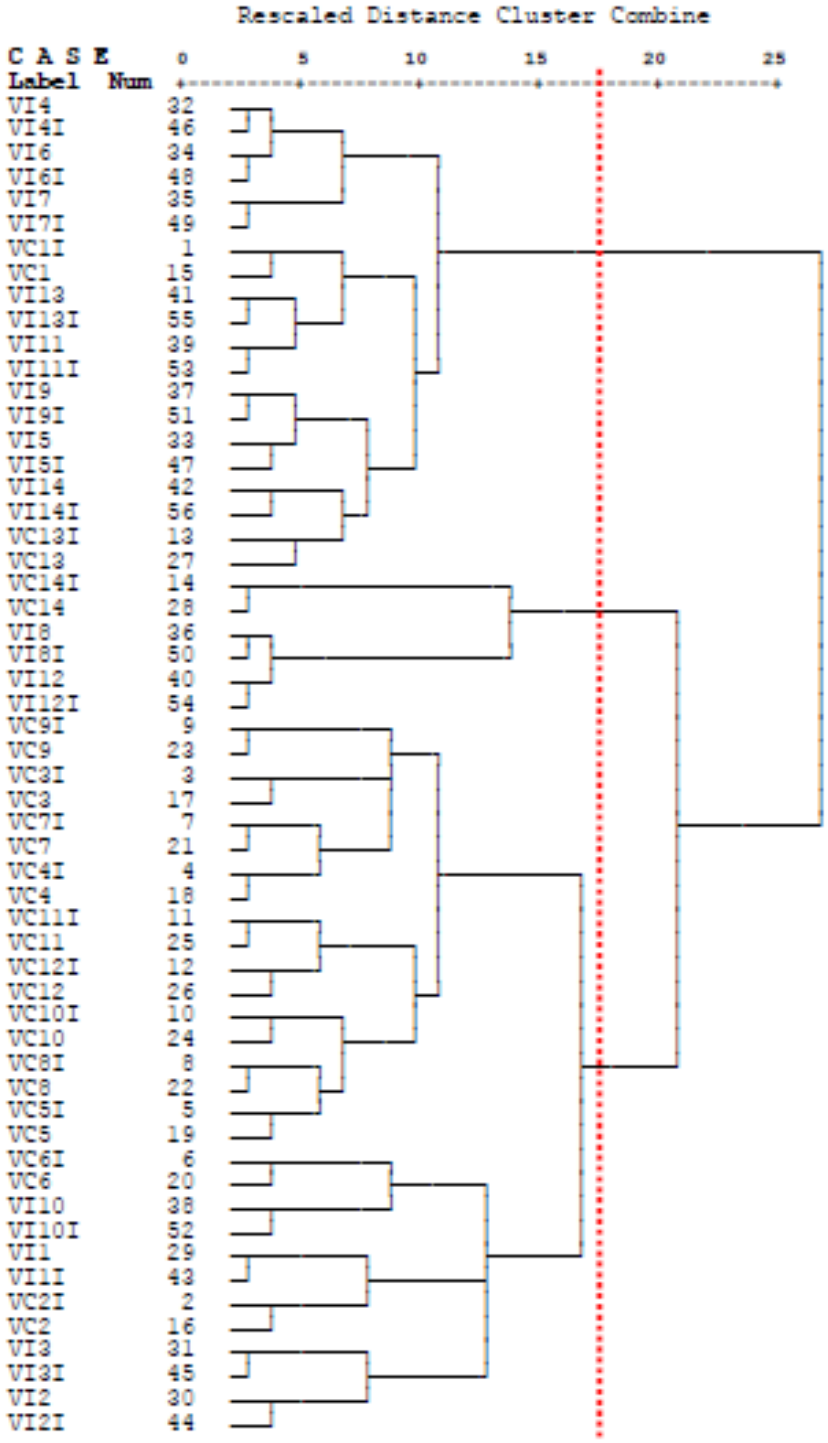
This figure shows that the variables that are closer to each other have greater similarity, because here the Euclidean distances between them are smaller, with greater similarity between themselves and greater adhesion to the behavior of the attribute analyzed.

With the MDS approach for the analysis of the uncertainty attribute, as highlighted in Figure 1, it is seen that the variables: (2) – "project duration", (3) – "level of technology involved", (10) – "level of reliance on third parties to carry out the project (according to the contracts established)", and (14) – "project risk", have lower adhesion to the attribute cited with respect to the other variables included, which partially supports the analyses carried out, dissociated from each of the approaches: influence joined with significance; and, influence and significance, separate from each attribute.

Thus, as in MDS, in the Cluster Analysis the variables of two different attributes are unified – complexity and uncertainty – forming a higher number of clusters than in the other analyses, 55 clusters with greater dispersion in Euclidean distances. The last two clusters formed, separated from the others by the line highlighted in Figure 2, include the variables that have lower adhesion to the general behavior of the two attributes. It should be explained that the unified cluster analysis of the attributes complexity and uncertainty assembles all the variables that compose it, including the analyses of levels of influence and significance jointly or alone, as shown in Figure 2.

Specifically addressing the project complexity attribute in the unified cluster analysis, Figure 2 shows the lower adhesion of the variables (1) – "size of the project team" and (14) – "level of reliance on the organization's projects", since they exhibit lesser adhesion for the set of other variables of the attribute, namely complexity. In particular, variable (14) is confirmed in more than one analysis of the attribute. The variables (8) – "cost budget" and (12) – "investment volume to execute the project", in the unified cluster analysis for the uncertainty attribute, show that the variables mentioned have lower similarity, adhesion, to the attribute in question.

Figure 2. Dendrogram (variables) using Ward's Method in the Hierarchical Cluster Analysis - complexity together with uncertainty: unification - influence and significance.



Source: Research data.

This confirms other analyses conducted to develop this work, and though this analysis unifies two different attributes – complexity and uncertainty – this unification can interfere in the relationship and

formation of the clusters, because not all variables are directly related to the scope of uncertainty, though they are all related to the project.

Conclusions of the Analysis of the Multivariate Analysis Methods

The analyses in Table 6 show that the methods of multivariate analysis – Multidimensional Scaling (MDS) and Cluster Analysis – were supplementary in the analyses, providing a greater range in the selection of the variables that will compose the final analysis instrument of the project attributes – complexity and uncertainty. Therefore, these analyses show the variables that have more adhesion or "capacity" to explain the behavior of attributes.

Table 6. Variables with lower MDS and Cluster Analysis adherence – complexity and uncertainty.

Attribute	Analysis Level *	Multivariate Analysis Method	
		MDS	Cluster Analysis
		variables	Variables
Complexity	Influence + significance	**6** and **14**	**6** and **14**
Complexity	influence	**6** and **14**	**6** and **14**
Complexity	significance	**6** and **14**	2, **11** and **14**
Complexity	complexity + uncertainty → influence + significance	**1** and **6**	**1** and **14**
Uncertainty	influence + significance	**1**, **8** and **10**	2 and **3**
Uncertainty	influence	**1**, **8** and **10**	2, **3** and 14
Uncertainty	significance	**1**, 2 and **10**	2 and **3**
Complexity	Uncertainty + complexity → influence + significance	2, **3**, **10** and 14	**8** and 12

* "+" means jointly. Source: Prepared by the authors.

Table 6, based on both methods, indicates that the variables with greater confirmation or repeatability, selected to be excluded from the initial data collection instrument, are shown in Table 7.

Table 7 Variables of the attributes complexity and uncertainty to be excluded after analysis.

Attribute	Variables excluded
Complexity	Variable (1): "size of project team"; Variable (6): "number of organizations involved in the project"; Variable (11): "Geographic location of the project stakeholders"; Variable (14): "level of dependence on other projects within the organization".
Uncertainty	Variable (1): "intended target market(s)"; Variable (3): "level of technology involved"; Variable (8): "cost budget"; Variable (10): "level of dependence on third parties to carry out the project (according to the contract established)".

Source: Prepared by the authors.

It is seen that in relation to project management there is consistency to what is presented in the analyses, because the projects will not be influenced or will not have their level of complexity changed, in relation to the variables of this attribute, according to Table 7. It should be explained that the variables: (2) – "project duration", (12) – "volume of investment to execute the project", and (14) – "project risks", though indicated by the multivariate analysis methods as variables with lower adhesion to the uncertainty attribute, from the theoretical framework analysis, support keeping them as they exhibited adhesion to the attribute, suggesting their significance to explain their behavior. Within the context of project management in the literature, it can be seen that it corresponds to the smaller "power" in explaining the

variables that were selected to be excluded from the context that determines the degree of uncertainty in projects.
The complementary analyses of the variables of complexity and uncertainty attributes were performed through statistical measures – position, dispersion and Cronbach's Alpha Coefficient – using the SPSS 15 software. An initial consideration is that the complexity and uncertainty variables in projects indicate internal consistency (reliability), because the Cronbach's Alpha coefficients, a statistical measure to assess internal consistency, presented indices above 0.90 for all variables. This confirms what was found in the analysis through the multivariate methods. Therefore, from the questionnaire described, the variables which best describe the behavior of the attributes complexity and uncertainty in projects is determined.

PRESENTATION OF THE PROPOSED SCALE
For the construction of the proposed model, a survey is determined from the questionnaire with the variables that best describe the behavior of the attributes complexity and uncertainty in projects. Table 8 shows the previously selected variables, which can be measured are inserted in the complexity attribute of the project.

Table 8. Variables of the complexity attribute of the proposed scale.

Variable	
1	Relative size of the project
2	Type of innovation (technological or organizational)
3	Organization size
4	Location of the project team members
5	Type of project
6	Number of departments in the organization involved in the project
7	Level of influence of the changes caused by the project
8	Number of project stakeholders
9	Type of project structure
10	Deadline pressure

Source: Research data.

Table 9 shows the variables that represent the project uncertainty attribute, which were previously selected and that can be measured.

Table 9. Variables of the uncertainty attribute of the proposed scale.

Variable	
1	Project duration
2	Milestones achieved
3	Knowledge of project management regarding the type of project to be managed
4	Completion of project on schedule
5	Completion of project within budget
6	Changes in project scope
7	Planning and project control activities in place
8	Volume of investment to execute project
9	Project documentation in place
10	Project Risks

Source: Research data.

Proposed Scale Structure

From the survey and after conducting the analyses by EMD and Cluster Analysis, after screening the variables presented in Tables 8 and 9 the results characterize the projects in terms of complexity and uncertainty. As a result a score can be produced for the projects, according to their level of complexity and uncertainty, creating a classification in a two-dimensional space.

From these variables that underwent the screening process, the weighted scores for the level of influence and significance of the project variables are presented. According to the analysis, the variables have no dispersion (or almost zero). At the expense of this, the "weights" that are assigned to the level of influence follow those used in the questionnaire, and their levels are set in a range from '1' to '5' points, where '1' point means that the variable has no influence on the attribute, and '5' points means a variable with high influence on the attribute, as shown in Table 10.

Table 10. Scores of the level of influence of the variables proposed.

INFLUENCE	1	2	3	4	5
"Weights" of attributes	1.0	2.0	3.0	4.0	5.0

Source: Prepared by the authors.

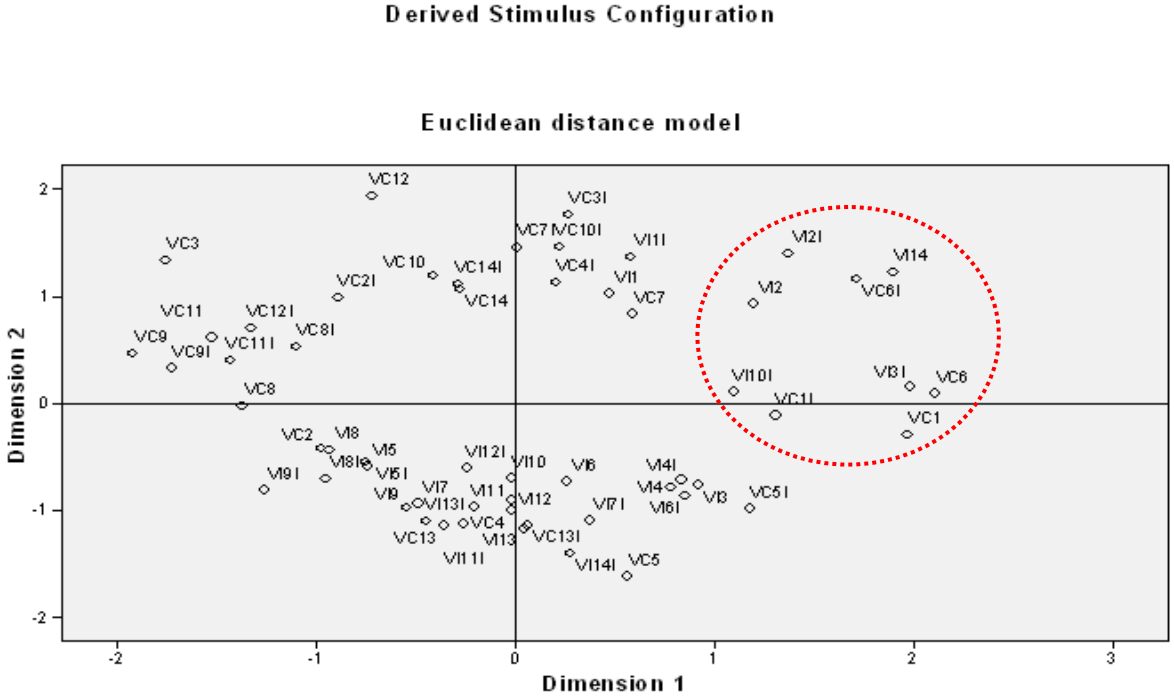
Table 11 shows the variable's level of significance for the project, which follows the same logic as the level of influence, and here dispersion is also approximately zero, thus the significance levels are set in the range of 1 to 5 points, where '1' means that the variable has no significance to the project, and '5' when the variable is very important to the project.

Table 11. Score for the level of significance of the variables in the proposal.

SIGNIFICANCE	1	2	3	4	5
"Weights" of the attributes	1.0	2.0	3.0	4.0	5.0

Source: Prepared by the authors.

Figure 1. Perceptual map of similarity (variables) - Euclidean distances - complexity attribute together with uncertainty: unification - influence and significance. Source: Research data.



Therefore, the author proposes determining the equations to calculate the score of the attributes – complexity and uncertainty, which are, respectively, Equations 1 and 2,

$$\text{complexity} = \sum_{i=1}^{10} \text{impact} \times \text{importance} \quad \textbf{(1)}$$

$$\text{uncertainty} = \sum_{i=1}^{10} \text{impact} \times \text{importance} \quad \textbf{(2)}$$

Where:

a) "influence" is the point (score) assigned to the level of influence of the variable in the attribute, for both complexity and uncertainty;
b) "significance" is the point (score) assigned to the level of significance of the variable in the attribute, for both complexity and uncertainty.

With regards to the scores determined, Table 12 shows how the calculations are done for the minimum and maximum scores of the attributes – complexity and uncertainty, which here represent its lowest and highest level.

Table 12. Minimum and maximum scores of the complexity and uncertainty attributes determined by their respective "weights" in the proposal.

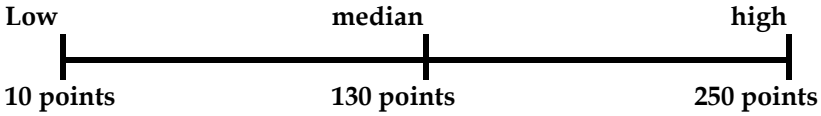
Variable	Minimum score of influence	Minimum score of significance	Calculation of score	Total score	Maximum score of influence	Maximum score of significance	Calculation of score	Total score
1	1 point	1 point	1 x 1	1 point	5 points	5 points	5 x 5	25 points
2	1 point	1 point	1 x 1	1 point	5 points	5 points	5 x 5	25 points
3	1 point	1 point	1 x 1	1 point	5 points	5 points	5 x 5	25 points
4	1 point	1 point	1 x 1	1 point	5 points	5 points	5 x 5	25 points
5	1 point	1 point	1 x 1	1 point	5 points	5 points	5 x 5	25 points
6	1 point	1 point	1 x 1	1 point	5 points	5 points	5 x 5	25 points
7	1 point	1 point	1 x 1	1 point	5 points	5 points	5 x 5	25 points
8	1 point	1 point	1 x 1	1 point	5 points	5 points	5 x 5	25 points
9	1 point	1 point	1 x 1	1 point	5 points	5 points	5 x 5	25 points
10	1 point	1 point	1 x 1	1 point	5 points	5 points	5 x 5	25 points
Total	-	-	-	10 points	-	-	-	250 points

Source: Prepared by the authors.

The totals shown in Table 12 are the initial and final points of the classification for the scale of attributes – complexity and uncertainty, respectively, 10 points and 250 points.

In order to determine an intermediate point, both scales use the average points as the extremes of each attribute. The average is the value in the middle of the distribution, that is, a value that is below (and above) the half of the distribution values, which is an adequate measure of the central tendency for the data (HAIR, Jr., 2005, p. 270). Using the average for the central point of the score is justified because of the low dispersion of the values, hence following a stable behavior of the values assigned by the respondents, and this justification is also used for their own scores. From this consideration, the average score points (intermediate) of the scale of attributes are '130' points. Thus, from these scores of the attributes, the ranges for the measurement scale of the complexity and uncertainty of projects is set, as seen in Figure 3.

Figure 3. Proposal of classification scale of complexity and uncertainty of projects developed. Source: Prepared by the authors.

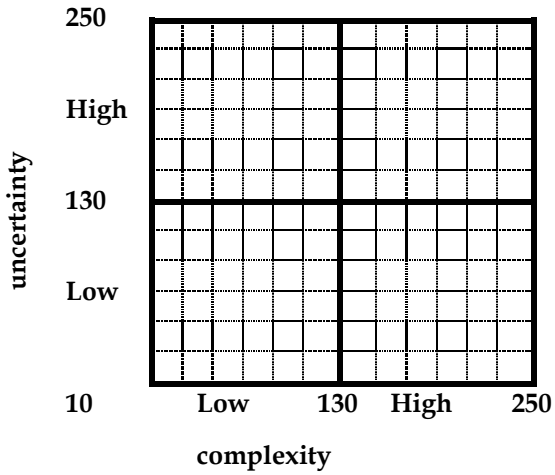


It should be noted that these scores are only the references of extremes and averages, constructed from the respondents' perceptions of the model, "n" integer values in that range, as different scores can be assigned to the levels of influence and significance, with several combinations, which will result in different scores, for both the complexity and uncertainty level.

Classification Matrix of Complexity and Uncertainty

From the scale shown in Figure 3, a correlation matrix on a Cartesian plane is developed with the two-dimensional space, as shown in Figure 4, to classify the level of complexity in the axis of abscissa "x" and in the ordinate "y", uncertainty. The classification illustrated in the two-dimensional space helps to understand how complex and uncertain the projects are, and when classifying the project with these attributes the scores of the level of complexity are correlated with uncertainty in order to have a single point to represent the project in the Cartesian plane.

Figure 4. Classification Matrix of project complexity and uncertainty proposed. Source: Prepared by the authors



In the two-dimensional plane of Figure 4, the classification of the attributes analyzed is divided into a matrix, which is divided into four quadrants, and these segments are by means of the minimum and maximum scores and the average of the scores, according to that previously exposed in Figure 3. Due to this, a classification was developed, and it should be noted that in the literature researched, there are no numerical classifications such as those proposed by this work.

This classification, shown in Figure 4, originated from the new data collection instrument compiled as a result of the variables that have greater adhesion to the attributes – complexity and uncertainty, which are analyzed in the projects. Thus, the classification levels were developed and inserted in the construction of the instrument, which relate the variable to the attribute and the form to measure the development.

From the already described selection of variables and the compilation of scores of the attributes, Table 13 shows the variables that contain the description of the behavior of the complexity attribute.

Table 13. Variables of the complexity attribute for project analysis.

Variable of influence on COMPLEXITY		Influence Level					Level of Significanc				
VARIABLE 1 - Relative size of the project		**1**	**2**	**3**	**4**	**5**	**1**	**2**	**3**	**4**	**5**
Consider the following project durations to classify them according to their relative size: **Small:** below 600 hours. **Median:** between 600 to 1200 hours. **High:** over 1200 hours.	Small										
	Average										
	Big										
VARIABLE 2 - Type of innovation(technological or organizational)		**1**	**2**	**3**	**4**	**5**	**1**	**2**	**3**	**4**	**5**
Consider the following to classify the type of innovation of the project: **Radical:** innovation that produces a great economic or market influence, as it creates a radical change in the existing paradigms. **Incremental:** innovation through continuous technical enhancements. **Apply:** something already in the market but new to the	Radical										
	Incremental										
	Apply										
VARIABLE 3 - Size of organization		**1**	**2**	**3**	**4**	**5**	**1**	**2**	**3**	**4**	**5**
From the SEBRAE (2011) classification, consider the following to classify the company size of the project, the segmentation below from the number of employees and the performance sector (industrial or service): **Micro and small (industrial sector):** up to 99 employees. **Medium enterprise (industrial sector):** 100 to 499 employees. **Large company (industrial sector):** more than 499 employees. --- **Micro and small (service sector):** up to 49 employees. **Medium enterprise (service sector):** 50to 99 employees. **Large company (service sector):** more than 99 employees	Micro and small										
	Medium										
	Large										
VARIABLE 4 - Location of project team members		**1**	**2**	**3**	**4**	**5**	**1**	**2**	**3**	**4**	**5**
Consider the following to classify the location and proximity of the team members in relation to the location to execute the project.	Location										
	National										
	Internation										
VARIABLE 5 - Project Type		**1**	**2**	**3**	**4**	**5**	**1**	**2**	**3**	**4**	**5**
Consider the "final product" of the project to determine the type of project.	Product										
	Process										
	Service										
VARIABLE 6 - Number of departments of the organization involved in the project		**1**	**2**	**3**	**4**	**5**	**1**	**2**	**3**	**4**	**5**
For the classification consider the number of departments that are related to the project: **Low:** up to 3 departments. **Medium:** between 4 and 9 departments. **High:** over 10 departments	Low										
	Average										
	High										
VARIABLE 7 – Level of influence of changes caused by the project		**1**	**2**	**3**	**4**	**5**	**1**	**2**	**3**	**4**	**5**
Consider the following to classify the level of influence of changes caused by the project:	Low										

Low: when the influence of the project occurs only in the unit that executes it. **Average:** when the influence occurs in some units of the organization **High:** when the influence occurs in the entire organization	Average											
	High											
VARIABLE 8 - Number of project stakeholders		**1**	**2**	**3**	**4**	**5**	**1**	**2**	**3**	**4**	**5**
Consider the following to classify the main stakeholders in the project: project manager, sponsor, company contracted, contracting company, end users of the product, persons or companies that will develop the product, and person responsible for the product. **Small:** project with up to 10 stakeholders. **Medium:** more than 10 and less than 30 stakeholders. **Large:** more than 30 stakeholders.	Small											
	Medium											
	Large											
VARIABLE 9 - Type of project structure		**1**	**2**	**3**	**4**	**5**	**1**	**2**	**3**	**4**	**5**
Consider the person responsible for the type of project in the company to classify the structure of the company.	Functional											
	Matrix											
	Projectized											
VARIABLE 10 – Deadline Pressure		**1**	**2**	**3**	**4**	**5**	**1**	**2**	**3**	**4**	**5**
Consider the following to classify the project characterized by having deadline pressure by the client, senior management or legal completion deadlines: **Low:** up to 5% reduction in the completion time of the project. **Average:** reduction between 5% and 20% in the completion time of the project **High:** More than 20% reduction in the completion time of the project	Low											
	Average											
	High											

Source: Prepared by the authors.

Table 14 shows the uncertainty variables that are in the final model of this work.

Table 14. Variables of the uncertainty attribute for project analysis.

Variable of Influence on UNCERTAINTY		**Level of Influence**					**Level of significance**				
VARIABLE 1 - Project duration		**1**	**2**	**3**	**4**	**5**	**1**	**2**	**3**	**4**	**5**
Consider the following to classify project duration: **Short term:** less than 6 months. **Medium term,** lasting 6 to 18 months. **Long term:** more than 18 months.	Short										
	Medium										
	Long										
VARIABLE 2 – Project milestones are met											
Consider the following to classify the fulfillment of its milestones in relation to the planned project scope.	Yes										
	No										
	Partially										
VARIABLE 3 - Knowledge of project management regarding the type of project managed		**1**	**2**	**3**	**4**	**5**	**1**	**2**	**3**	**4**	**5**
Consider the project manager's experience time to quantify his knowledge: **Low:** 0 to 3 years of experience.	Low										
	Average										

Medium: 4 to 5 years of experience.	High										
VARIABLE 4 - On schedule project completion		**1**	**2**	**3**	**4**	**5**	**1**	**2**	**3**	**4**	**5**
Classify the comparison of the schedule seen in the conclusion of the project with that set in the planning phase of the project.	Yes										
	No										
	Partially										
VARIABLE 5 - Completion of project within budget		**1**	**2**	**3**	**4**	**5**	**1**	**2**	**3**	**4**	**5**
Compare what was actually spent to complete the project in relation to what was budgeted in the planning phase of the project.	Yes										
	No										
	Partially										
VARIABLE 6 - Changes in the project scope		**1**	**2**	**3**	**4**	**5**	**1**	**2**	**3**	**4**	**5**
Consider for classification if the project has a formal process for managing changes in the project scope.	Yes										
	No										
	Partially										
VARIABLE 7 - Existence of project planning and control activities		**1**	**2**	**3**	**4**	**5**	**1**	**2**	**3**	**4**	**5**
Consider if the project has planning and control activities for monitoring its progress up to completion.	Yes										
	No										
	Partially										
VARIABLE 8 - Volume of investment for project execution		**1**	**2**	**3**	**4**	**5**	**1**	**2**	**3**	**4**	**5**
Consider for classification the amount of capital available for executing the project: **Low:** investment value up to $ 49.99 thousand in the reference currency. **Medium:** investment value between 50 thousand and $ 499.99 thousand in the reference currency. **High:** investment value of more than $ 500 thousand in the	Low										
	Average										
	High										
VARIABLE 9 - Existence of project documentation		**1**	**2**	**3**	**4**	**5**	**1**	**2**	**3**	**4**	**5**
Consider for classification if the project has pre-established document control of the stages completed.	Yes										
	No										
	Partially										
VARIABLE 10 - Project Risks		**1**	**2**	**3**	**4**	**5**	**1**	**2**	**3**	**4**	**5**
Consider for classification if there is a formal process of analysis and control of project risks.	Yes										
	No										
	Partially										

Source: Prepared by the authors.

Given the analyses it is important to state that organizations working with methods that address project management can use the Scale Measurement proposed because it has no restrictions on its applicability, it is necessary, however, that the person responsible for the project, consequently the respondent of the instrument that will collect the data to classify the project, is aware of the information that the model uses to classify the project's complexity and uncertainty.

CONCLUSIONS

The conclusions of the work are the outcome of the analysis and discussion of the results and of the proposed scale. From the problem investigated, the goal was reached to introduce a criterion for measuring the degree of influence of variables on the attributes of complexity and uncertainty in project management and propose a numerical scale measurement of these attributes, in order to support the decision-making processes.

It is important to understand the idea of complexity and uncertainty in the context related to the projects, and thus this work enabled to examine how the attributes can influence the projects, which are embedded in dynamic contexts. Thus, organizations need to take steps in order to reduce the influence of these attributes on the projects, which will increase their performances.

Though projects contain numerous variables in their contexts, through multivariate analysis methods – Multidimensional Scaling and Cluster Analysis – this work identified the most relevant ones and those that have greater adhesion to the attributes complexity and uncertainty.

The Measurement Scale developed to classify the attributes complexity and uncertainty in projects can be used by organizations of varying sectors and sizes, only requiring as a prerequisite that the person responsible for the project, usually the project manager, has solid familiarity of the information considered in the scale to attain a score that classifies the project in the proposed matrix.

The proposed Measurement Scale to classify the attributes complexity and uncertainty in projects can be easily used for any project. Thus, the user, the project manager, has to respond the questionnaire of the scale, calculate the score of each of the attributes, and plot in the two-dimensional plane each of the scores, which has the role of project location coordinates in the proposed matrix.

It is observed that the Measurement Scale proposed here is simple to use, and by enabling managers to classify the degree of complexity and uncertainty of a given project, enables setting actions that may preventively mitigate these two attributes given the controllable and uncontrollable variables that are within the projects. Interestingly, the Measurement Scale can be used for product projects and also for organizational processes.

The multivariate statistical methods – Multidimensional Scaling (MDS) and Cluster Analysis – used in this work for choosing the variables that have greater adhesion to the attributes analyzed in the projects, were found to be adequate. Initially, the Cluster Analysis in the research planning would be used as a result confirmation method, and as the analyses progressed, it was decided to also use it as a confirmatory method, together with the Multidimensional Scaling (MDS), which initially was the primary selection method for the variables. The external validity, the internal validity, the validity of the constructs, the validity of the conclusions and internal consistency were reached in this work.

The dynamic environments in which organizations develop projects have more possibilities to have more complex and uncertain projects, and due to this new environment, organizations need new tools to assist in their decision-making process, hence looking for ways to support those decisions more objectively rather than the qualitative techniques that permeate most of the project managers' decisions, in other words, searching for more objective methods and with greater possibility to quantify the attributes inherent to the projects.

Therefore, in this scenario the proposed Measurement Scale fits with the Project classification matrix in degrees of complexity and uncertainty, which increases the traditional project management approaches, a new paradigm for quantifying these attributes and their respective variables, thus providing an instrument to support the decision making process of the project.

Importantly, this proposed Scale Measurement enables analyzing the attributes of complexity and uncertainty that traditional project management methods (those based on the principles guided by the PMI in the PMBOK® Guide) do not, thereby contributing to management projects. Thus, managers can rely on a tool to assist them in the decision-making process and the actions in the environment of the projects, which are increasingly more dynamic, complex and uncertain.

REFERENCES

Carvalho, F., 2003. Prioritization of the project portfolio using strategic planning, In: VI Seminars in Management – SEMEAD, São Paulo, Annals. São Paulo, School of Economics, Business and Accounting, University of São Paulo, São Paulo. (in portuguese)

Cleden, D., 2009. Managing project uncertainty: advances in project management. United Kingdom, Gower Publisnhig, Ltd..

Gray, D.E., 2012. Doing Research in the Real World, 2nd ed., Porto Alegre, Penso.

Hair, Jr, J.F., Babin, B.J., Money, A.H., Samouel, P., 2005, Essentials of business research methods, Porto Alegre, Bookman.

Jun, L., Qiuzhen, W., Qingguo, M., 2011. The effects of project uncertainty and risk management on IS development project performance: a vendor perspective. International Journal of Project Management, 29, 7, 923-933, October.

Kerzner, H., 2011. Project management: a systems approach to planning, scheduling and controlling,10th ed., São Paulo, Blucher.

Kujala, K., Artto, K., Parhanksngas, A., 2007. Towards theory of project business. 19th, Nordic Academy of Management Conference, Bergen, Noruega, August.

Little, T., 2005. Context-adaptive agility: managing complexity and uncertainty, Software IEEE, 22, 3, 28-35, May/June.

Malhotra, N., 2012. Marketing research: an applied orientation, 6th ed., Porto Alegre, Bookman.

McFarlan, F.W., 1981. Portfolio approach to information systems, Harvard Business Review, 59, 5, 142-150, Sept.-Oct..

Moraes, R.O., 1999. Planning, programming and control software projects, Dissertation (Masters in Production Engineering), Mechanical Engineering Graduate Program, Paulista University, São Paulo - SP. (in portuguese)

Moraes, R.O., Laurindo, F.J.B., Pereira, P.S., 2008. Uncertainty portfolio of projects, Industrial Management Review, 04, 01, 39-56.

Nassar, K.M., Hegab, M.Y., 2006. Developing a complexity measure for project schedules, Journal of Construction Engineering and Management, 132, 6, ASCE, 554-561, June 1.

Perminova, O., Gustafsson, M., Wikström, K., 2008. Defining uncertainty in projects: a new perspective, International Journal of Project Management, 26, 1, 73-79, January.

PMI. Project Management Institute (ed.), 2013. A guide to the project management body of knowledge – PMBok, 5th., Newtown Square, Pennsylvania, PMI Publishing Division.

Selltiz, C., Wrightsman, L.S., Cook, S.W., 1987. Methods and techniques of research in the social relations, São Paulo, EPU. (in portuguese)

Shenhar, A.J.; Levy, O., Dvir, D., 1997. Mapping the dimensions of project success, Project Management Journal, 28, 2, 5-13, June.

Shenhar, A.J., Tishler, A., Dvir, D., Lipovetsky, S., Lecher, T., 2002. Refining the search for project sucess factors: a multivariate, typological approach, R & D Management, 32, 2, 111-127, March.

Shenhar, A.J., Dvir, D., 2010. Reinventing project management: the diamond approach to successful growth and innovations, São Paulo, M.Books do Brasil.

Sinha, S., Thomson, A.I., Kumar, B., 2001. A complexity index for the design process, International Conference on Engineering Design, ICED'01, 1, Glasgow, Professional Engineering Publishing, Bury St. Edmunds, 157-163.

Toledo, J.C., Silva, S.L., Mendes, G.H.S., Jugend, D., 2008. Critical success factors in project management of product development in technology-based companies small and midsized, Management and Production, São Carlos, 15, 1, 117-134, jan./abr.. (in portuguese)

Vidal, L.-A., Marle, F., Bocquet, J.-C., 2011. Measuring project complexity using the analytic hierarchy process, International Journal of Project Management, 29, 6, 718-727, August.

Williams, T.M., 2005. Assessing and moving on from the dominant project management discourse in the light of project overruns, IEEE Transactions on Engineering Management, 52, 4, 497-508, November.