

Application of Quantitative Methods in The Generation of Innovation and Creativity

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Abstract

SMEs need to develop approaches to innovation, with defined directions for developing processes based on innovation structures, and integrated with the innovation management approach. Few authors have discussed the measurement and development of scales applied in the area of administration, which provide the preliminary steps for validating measurement scales. What procedures are required to carry out the validation of scales and which constructs measure innovation and creativity? The method adopted in this theoretical essay was that of content analysis. The general objective of this work was to carry out a theoretical-conceptual study of the quantitative method in the measurement of innovation and creativity; and, as specific objectives, 1) to characterize the theoretical-conceptual evolution of a valid quantitative method for measuring innovation and creativity; 2) to develop concepts of ways to validate the quantitative methods used in the academic work on innovation and creativity; and to present constructs that would indicate the presence of innovation and creativity for the generation of modeling. To tackle the problem, the following question is proposed: how can innovation and creativity be validly measured? To answer this question, we first carried out a theoretical-conceptual review of the existing literature. We then used the review to conceptualize innovation and creativity, search for the main instruments to measure innovation and creativity, and set out the steps needed to validate a measurement scale for them. This work is directed to researchers in the area of measurement and the development of scales.

Key words: Innovation. Creativity. Measurement. Constructs. Validity. Reliability.

1. INTRODUCTION

Innovation and creativity are recognized as indispensable resources for organizations. They enable them to gain competitive advantage and increase organizational performance. In this context, we present the concepts of innovation and creativity so as to outline a new approach. This work has the general objective of making a theoretical-conceptual study of the quantitative method as it might be used in the measurement of innovation and creativity. The specific objectives is doing so are (1) to characterize the theoretical-conceptual evolution of a valid quantitative method for measuring innovation and creativity; (2) to develop concepts for validating the quantitative methods in academic works on innovation and creativity; and (3) to present constructs which would indicate the presence of innovation and creativity and thus generate modeling. The importance of the study is justified by the scarcity of studies on measurement and the development of scales for use in administration, the small number of analyses of reliability and the validity of existing scales to measure innovation and creativity. The problem itself is summed up in the following

question: how can innovation and creativity be validly measured? This work is systematized under topics and subtopics and, after this introduction, it covers a theoretical-conceptual review, its own methodology, the results in accordance with the objectives, and a conclusion which answers the research question.

2. THEORETICAL-CONCEPTUAL REVIEW

This session identifies the conceptual parameters that define the concepts of innovation and creativity. It describes the process of measurement and the validation of scales for assessing innovation and creativity; in addition, the concepts of statistical error, reliability, translational validity, construct validity and confirmatory and exploratory factor analysis are introduced. Finally, it adds the conceptual elements inherent in constructs which help us to measure them.

2.1 Concepts of innovation and creativity

Schumpeter (1961) in his study of innovation and creativity in organizations describes the process of creative destruction that is increasingly gaining new researchers. He demonstrates that innovative entrepreneurs move the economy over the long term, so that well-known companies in the market find themselves destroyed by the impetus of innovation. The innovative entrepreneur, in the Schumpeterian conception, is an ambitious person who takes risks, not letting himself be motivated by monetary considerations alone; he seeks to create new horizons strategically within the reach of all, thus transforming the economy through the concepts of development.

Schumpeter (1983) inaugurated studies on this subject, distinguishing the term 'invention', which is the instant of generating an innovative idea, from 'innovation' which is characterized as the phase of the idea that implements it in some form in the market. The Economic Development theory by the same author indicates that innovation can be understood as the point of intersection between the means of production, the organizational tasks and the marketing actions. Some examples of innovation might be the creation of a new product, a new method of production and/or marketing, a new market, new source of raw materials; or even, in an argument treated since Schumpeter (1961), the creation of a new monopoly.

Hamel (2006) characterizes managerial innovation in his research as any marked departure from traditional management principles, processes, and practices, and describes the common organizational forms that significantly change the execution of work. This author points out that managerial innovation modifies managers' modus operandi. The work of management includes such actions as setting goals and designing plans, motivating and aligning effort, coordinating and controlling activities, accumulating and allocating resources, acquiring and applying knowledge, building and nurturing relationships, identifying and developing talents, and understanding and balancing the demands of external groups. These are examples of factors that can be tested on the platform of organizational innovation. Hamel posits that one way of changing the behavior of managers in their work is to reinvent the processes that direct their actions. Management processes, such as strategic planning, capital budgeting, project management, hiring and promotion, employee evaluation, executive development, internal communications, and knowledge management, are the gears that transform management principles into everyday practices where innovation could be applied.

A study by Pinheiro, Schreiber and Haubert (2016) points to the concept of creativity, as a fluid mix of varied meanings, with a broad theme that varies according to the vision of every individual involved in the innovation process. Some studies take creativity as a disruptive system, capable of eroding boundaries and assumptions, since it is based on divergent thinking. It is the propulsion for new ideas built on previously existing knowledge, a dynamic that results in innovation.

According to a survey by Bragança, Zaccaria, Giuliani and Pitomba (2016), creativity, using an accumulation of knowledge from the individuals concerned, is an intuitive means of problem solving. It is involuntary and common and the knowledge that it draws upon is unstructured. Extending this concept, Gomes, Rodrigues and Veloso (2016) describe the concept of creativity as intercultural dissimilarity.

2.2 Concepts on validation of measurement scales

Costa (2011) notes the scarcity of existing literature on the measurement and development of scales applied in the administration area, which incorporate the necessary steps for validating measurement scales. The present theoretical essay suggests using the steps described by Costa (2011) to verify the validity of the scales that might be used to measure innovation and creativity. Costa recommends deepening the crucial questions when analyzing the reliability of scales. Among possible errors: the first is to choose random sampling, which is linked to the concept of sample distribution in surveys. Hence it depends on the level of deviation defined or calculated, and its significance lies in the distribution of probabilities that govern the distribution of statistics. The second error is not to choose any kind of sample at all; both can be understood as sample design errors or errors associated with the measurement process, as Costa demonstrates.

Pursuing Costa's argument (2011), we may define possible design errors in measurement. In the initial sample these errors can be divided into three kinds; the first is sample selection error, which is related to the incorrect application of sampling procedures, and can occur intentionally or through mere lack of ability to collect the data; the second is structure error that is linked to faults in the available information, and to outdated or corrupted lists; and, finally, the population specification error, which is linked to a lack of consistent information about the population from which the research sample derived.

Following the study by Costa (2011), we define below the errors associated with the measurement process. According to him, these can be divided into five subtypes: first, the processing errors that are related to failures in the transfer of data from the research instrument to the computer and the analytical tools. The next group of errors is associated with the data collection and gauging agent, which, by accident or design, cause measurement problems or even influence the construct that is being attempted. The third error refers to the response, which may be influenced by the respondent's preconceptions; if so, his options for answering the questions at the time of collecting the sample become vitiated. Such an effect can also result from the respondent's inability to pay attention to what s/he is being asked, resulting in failures and oversights in general; according to Costa, errors of this kind stem from the interviewee's intention to vitiate or complicate the judgment of the scale. The next error refers to substitute information, which is usually linked to the discrepancy between what is measured and what is actually sought and soon needed. Finally, there is the error of instrument distortion associated with failures in the applied research instrument. It usually occurs when the questionnaire is inadequate and fails to comply with the objectives that are

supposed to be measured, in line with the one discussed by Costa (2011). His paper is the basis for the design of the diagram below (Figure 1) and the following Specification Table 1.

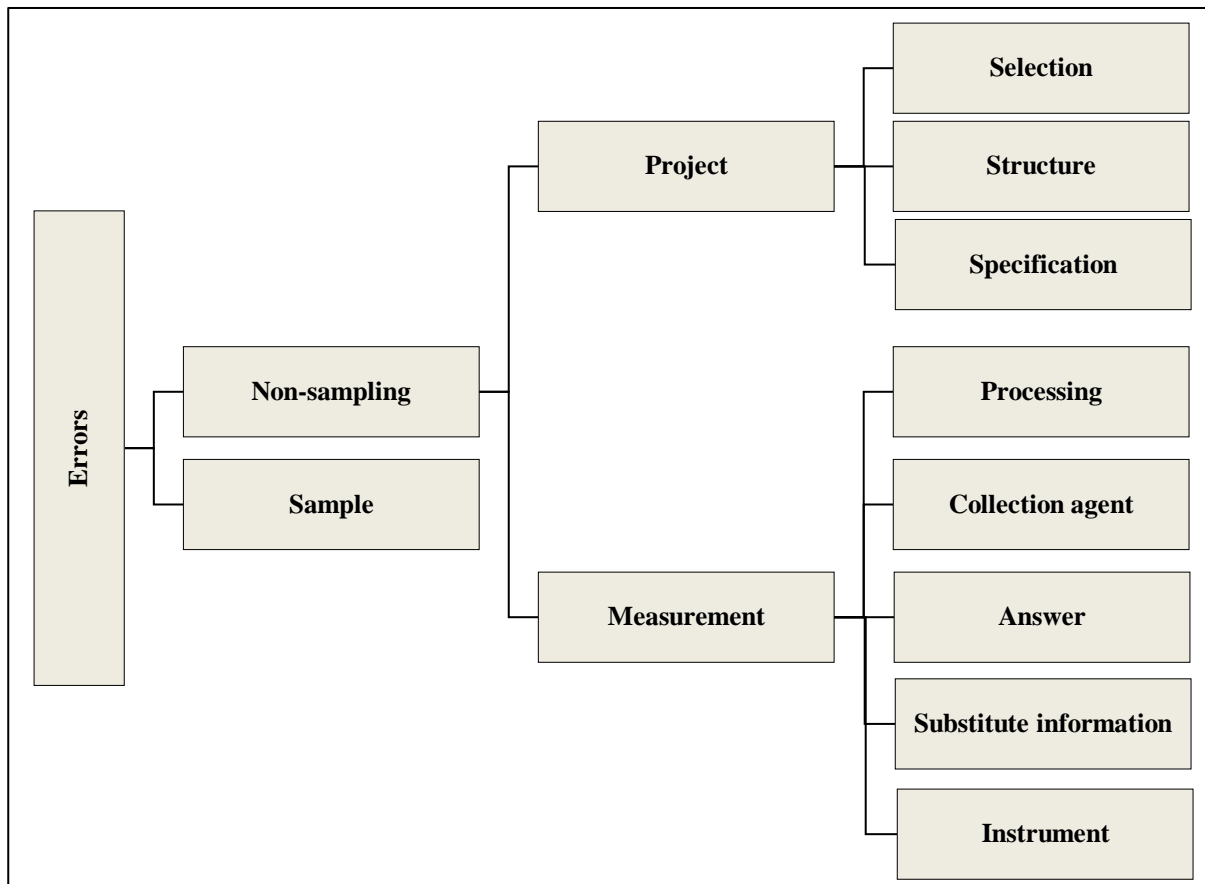


Figure 1: Errors in Measurement.

Source: Adapted from Costa (2011).

Elements	Conceptual descriptive in Costa (2011)
Errors	Defined by failures in sample collection or data analysis.
Non-sampling	Sample design errors or measurement process.
Sample	Random sampling, which is connected to sampling distribution.
Project	Detailed description for the performing of an action.
Measurement	Act of measuring something.
Selection	Choosing an act or effect.
Structure	Computers and analytical tools.
Specification	Description of a construct.
Processing	Primary Data Processing.
Collection Agent	Researcher who applies the measuring instrument.
Answer	Primary data from the respondents.
Substitute Information	Discrepancy between the information obtained and the necessary information.
Instrument	Instrument of measurement in applied research.

Specification Table 1: Defining the terms in Costa’s conceptual diagram (2011).

Source: Prepared by the authors.

Costa (2011) indicates that, to check the reliability of the scale and verify the correlation between the items of the construct, the most frequently adopted method among researchers is to use the Cronbach alpha coefficient with the help of the software program IBM-SPSS. How consistent the scale is in its results testifies to its reliability, which consists of analyzing the absence of random errors present in it. Cronbach's alpha was first described in an article by Cronbach (1951), and is considered the most appropriate way of measuring scales of multiple items of the reflective type.

According to Costa (2011), the validity of a scale can be defined by the degree to which a measuring instrument actually measures what it is proposing to measure. With this definition in mind, it was considered that in order to justify the validity of the scale that was indispensable as an instrument of measurement; it was necessary to analyze the validity of the measurement proposal; the fact that a measure has a high level of confidence does not mean that it is a valid measure, but a valid measure is necessarily a reliable one. In this theoretical essay, the two basic types of validity are shown in Table 1 below.

Validity type	Operationalization	Subtypes
Translation validity	Qualitative	Content validity
		Face validity
Construct validity	Quantitative	Convergent validity
		Discriminant validity
		Nominal validity
		Known group validity

Table 1: Types of validity.

Source: Adapted from Costa (2011).

The first type of validity verified is the validity of translation, involved in the process of qualitatively assessing the content and form of presentation of the items of the scale, which is divisible into two subtypes. The first subtype is content validity, linked to the degree to which the selected items are relevant and representative of the content, or of the domain of the construct under analysis. Then it is necessary to analyze if the items belong to a significant, non-redundant and non-vicious sample of the various facets of the analyzed construct.

Costa (2011) asserts that we should understand face validity, the second subtype of translation validity, as the degree to which respondents and experts consider the items appropriate to the construct and to the purposes of the measurement. With this definition, it is clear that face validity deals with complementary aspects, shifting the focus to the utterance and to practicalities, in order to demonstrate that content validity will be linked to the construct domain.

Finally, we have the type of validity called construct validity which, according to Costa (2011), refers to the degree to which a measure confirms hypotheses of similarity with other measures of the same construct, and confirms its difference from measures of other constructs. The validity of a construct is its power to verify the behavior of the measure in relation to a theoretical expectation associated with the definition of the construct, thus showing the difference in the validity of the criterion, because it focuses on the conceptual dimension of the construct. Although considered a more difficult validation, such analysis,

thanks to the current provision of verification methods, has greater consistency and a greater sense of rigor. Next, we turn to the subtypes of construct validity that were used in this work. The first one, called convergent validity, has three possible definitions, according to Costa (2011): the first states that convergent validity is associated with the degree to which the indicators designated to measure the same construct are related and convergent. The second is that the existence of convergent validity is possible when two different measures of the same construct confirm the expectation of being closely related if the correlation is high between two measures without the supposition that the scales are formative or reflective. The third one is defined by the convergence between different methods used to measure the same construct, taking into account the fact that they are not different measures, but different methods, and it is also assumed that the scales are formative or reflective.

The second subtype of construct validity is divergent or discriminant validity, which refers to the degree to which two measures designed to measure distinct constructs are actually different; that is, such validity certifies that measurements of different constructs do not behave as if they were measuring the same construct. For Costa (2011), the best way to evaluate this type of validity is to take measurements of the constructs with different scales and to analyze the degree of correlation; if this degree is low or nil, we count it as evidence of discriminant validity.

To Costa's mind (2011), confirmatory factorial analysis (AFC) consists of a procedure of reducing the variables, from the aggregation of a certain set of items. Conceptually, both exploratory and confirmatory factorial analysis consist of procedures with similar aims. There is, however, a central difference: in the first case, we have not defined any factorial structure a priori, but left the collection of variable sets free, while in the second case we predetermine the factorial structure and test the hypotheses relating sets of items to the factors.

2.3 Concepts about constructs indicative of the presence of innovation and creativity

Defining the constructs precisely is a fundamental part of the validation of a scale as an instrument for measuring innovation and creativity. Research is needed to find an instrument which can measure the constructs 'innovation' and 'creativity'. To use a scale correctly, certain concepts need to be understood: first the concept of a construct, which for Costa (2011) denotes the characteristics of an object of interest that presents variations which allow quantifications or classification, and which are well delimited in relation to other characteristics of the same object. The term "construct" is used to refer to a measurable characteristic. In order to measure a construct, one needs a tool that will be called a measurement scale. In this theoretical test, the scale presents a latent construct – a type of construct that cannot be directly measured, but which presents measurable manifestations.

3. METHODOLOGY

This section seeks to characterize the methodological procedures that were used during the development of the present research. In this theoretical essay, we adopt qualitative and exploratory approaches, elaborated through the Content Analysis Method, and, therefore, apply a bibliographical survey procedure from secondary data to identify how to measure innovation and creativity in a valid way.

For Creswell (2014), qualitative research consists of a set of interpretive material practices that make the focus of research visible. They transform the focus of research into a series of representations, including field notes, interviews, conversations, photographs and records. Thus, they involve an interpretive and naturalistic approach to the world and indicate that qualitative researchers study things within their natural context, trying to understand or interpret phenomena in terms of the meanings that people attribute to them. We chose a qualitative and exploratory form of research, because, according to Creswell (2010), this type of approach is necessary when the topic is new, or has never before been treated in this particular sample or group of people, or because the existing theories do not apply to the particular sample or group being studied.

In this theoretical essay we opted for the Content Analysis Method, which is a technique of communication analysis. For Bardin (2016), the term ‘content analysis’ indicates a set of techniques of analysis of the communications required to obtain, through systematic procedures and descriptive objectives of the content, indicators that allow data to be inferred regarding the conditions in which these messages were produced. Therefore, according to Bardin (2016) this method aims to capture the essential characteristics, meanings, convergences and divergences of the contents of interviews, and one must, therefore, observe some rigor in its application so that it leaps over the uncertainties and reaches the respondents.

The content analysis method followed the necessary steps, based on the bibliographical documents on the topic of this report that were selected. The elements of the methodology are presented in Figure 2, together with the steps of the content analysis process, and in the Specification Table, Table 2, the elements in the diagram are listed and defined.

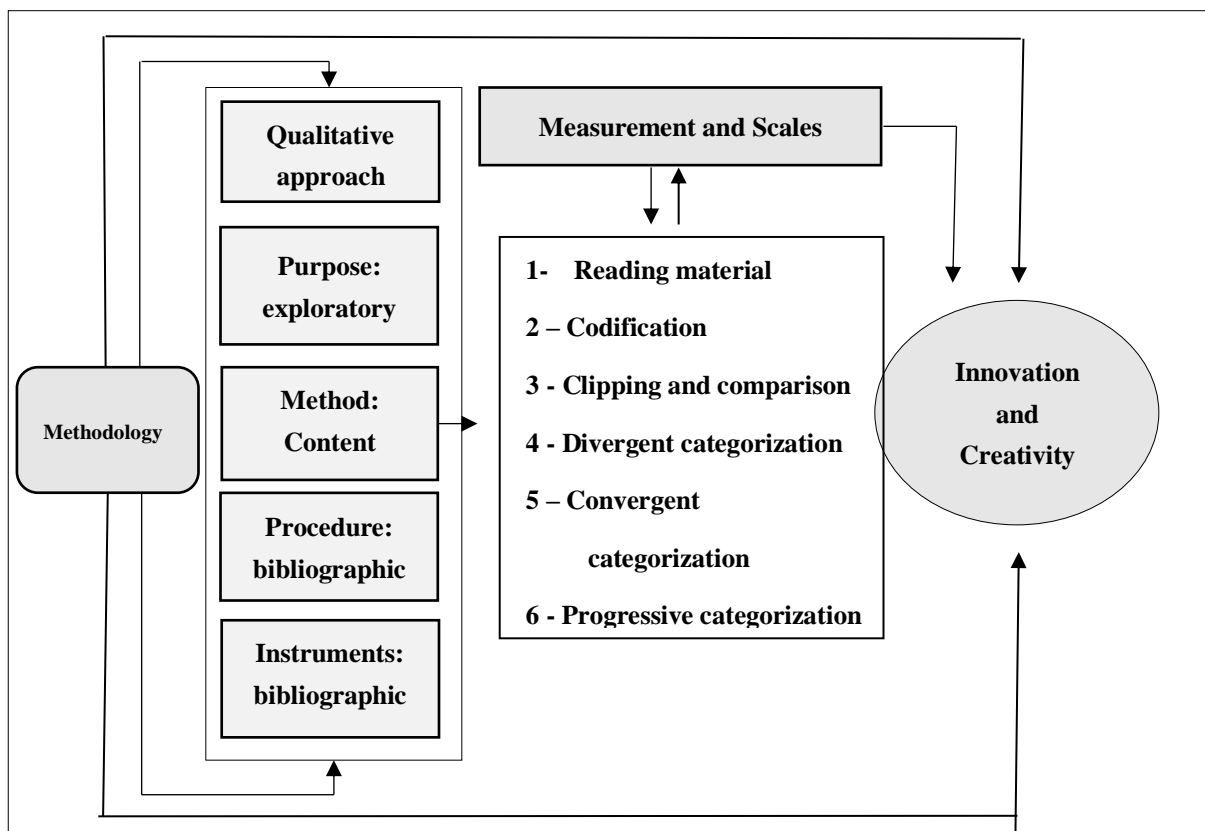


Figure 2: Diagram of the methodology used in this research.

Source: Prepared by the authors based on Bardin (2016).

Elements	Conceptual description in Bardin (2016).
Methodology	It studies and evaluates the methods for conducting scientific research.
Qualitative approach	It interprets the phenomena in terms of the contexts to which they belong.
Purpose: exploratory	It provides greater familiarity with the problem being treated.
Content analysis	Set of messaging techniques of content decomposition
Procedure: bibliographic	It is a form of bibliographic research that is constructed through studies already published.
Bibliographical sources	Compiled in a bibliographical survey of secondary data.
Measurement	Act of measuring something
Scales	Measuring instrument.
Material reading	General reading of documents collected.
Codification	Coding for the elaboration of categories.
Trim and compare	Cutting out items from the analyzed documents (words, sentences, paragraphs).
Divergent categorization	Formation of categories that are thematically different.
Convergent Categorization	Adjustment of registration units into convergent categories.
Progressive categorization	Gradual grouping of categories: initial, intermediate and final.
Results	Inference and interpretation, supported by conceptual parameters.
Innovation	Significant distancing from traditional management practices.
Creativity	Intuitive means of problem solving.

Specific Table 2: Specifications in the proposed methodology.

Source: Adapted from Bardin (2016).

4. THEORETICAL-CONCEPTUAL STUDY OF THE QUANTITATIVE METHOD IN THE MEASUREMENT OF INNOVATION AND CREATIVITY

In this chapter we find the results of the study in accordance with the proposed objectives. First, the theoretical-conceptual evolution of a quantitative method valid for the measurement of innovation and creativity is characterized, with essential notes on the subject. Then, the concepts of validation of the quantitative methods in an academic production on innovation and creativity are developed, discussing the types of validations and the essential factors for developing a valid measurement scale. Finally, the constructs indicative of the presence of innovation and creativity are presented in order to generate modeling.

4.1 Characterization of the theoretical-conceptual evolution of a valid quantitative method for measuring innovation and creativity

Following the works of Schumpeter (1961), relevant studies on innovation began to appear, in a phase characterized as the implementation of the idea in the market; the theory emerged that innovation can be understood as the point of intersection between the means of production, organizational tasks, and marketing actions. In the field of studies on innovation and creativity in organizations, Schumpeter describes the process of creative destruction that is increasingly gaining new adherents. Coral et al. (2008) state that a company which seeks innovations needs to build a pro-innovation culture, while at the same time eliminating parts of the existing culture that are considered barriers to innovation – a phenomenon which Schumpeter calls creative destruction.

In fact, the country emphasised the inclusion of many issues related to Organizational Innovation, due to the growing number of publications verified in the 1960s and 1970s. It is far to say that researchers came to understand innovation not only as a technological phenomenon, but as a strategy of competitiveness in organizations, as seen in the study by Araújo et al. (2018).

These writers analyzed innovation in Vieira (2018), from the social point of view, using the criteria of scale, scope and resonance. It was observed that innovative social actions have a direct impact on the lives of the inhabitants of the region where they are implemented. In the study, the main barriers to the development of social innovation were dependence on government and local subsidies, the habits and customs of the local population, and the low levels of activity of those who might propose innovative ideas. The association focused on in the case study, however, has been able to count on the creativity, inspiration, engagement and support of its key leaders. The alignment and engagement of other employees and associates were also crucial to the effectiveness of the proposals. The conclusion of the research made it clear that, despite being a collective work space, an enterprise's success depends on individuals who can exert a strong influence on the dynamics, especially from leadership positions; the social innovations identified do not originate from collective creation, but from the actions of some individuals who respond in a different way to the same stimuli and situations as the whole workforce experiences.

For Coral et al. (2008), an innovation-seeking manager needs to build a pro-innovation culture within the company, while at the same time eliminating parts of the existing culture that represent barriers to innovation. In this way, the benefits of innovation are not retained in companies, but also extend to the business environment, through the multiple synergy of success. It may be affirmed that, in countries and regions which excel in innovation, concern for the competitive advantage predominates, with direct reflections on the level of employment and income, besides the greater global interaction among more developed nations. Such conditions allow conceptual evolution, in Coral's view (2008), breaking the unstructured construction down to a methodological cognitive form, as shown in Figure 3 below, and in the following Specification Table. It is worth noting that, in the context of applied research, the elements treated in this compartment allow measurement, in order to satisfy all the tendencies and possibilities that come into view when addressing issues related to innovation and creativity.

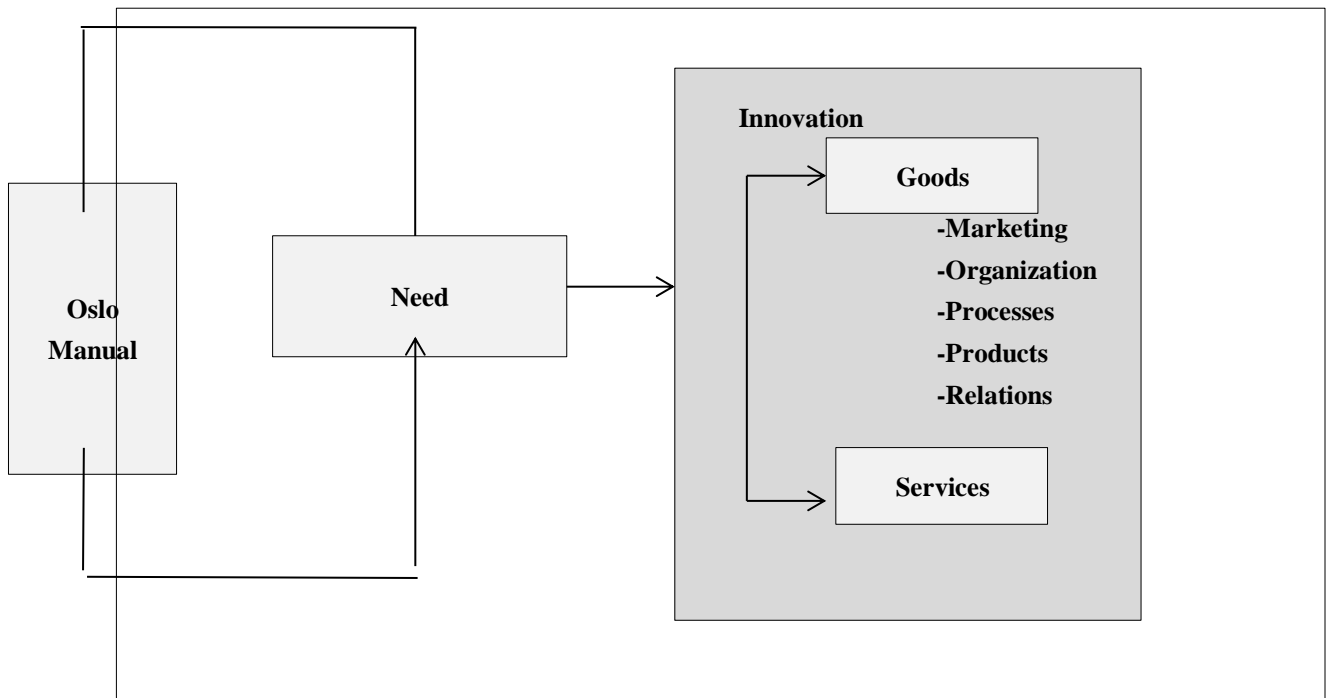


Figure 3: Conceptual evolution in Coral (2008).

Source: Prepared by the authors based on Coral (2008).

Elementos	Descritiva conceitual
Oslo Manual	In Coral (2008), the Oslo Manual is a work which aims to guide and standardize concepts, methodologies, the construction of R & D research statistics and indications of industrialized countries.
Need	A human need is felt in those states in which some privation is perceived. Needs, in Kotler’s conception, becomes desires when they are directed to specific objects capable of satisfying them (1993).
Goods	Everything that is useful to people, often a scarce resource, whether tangible or intangible and whether or not they satisfy a need, according to Fiúza (2008).
Services	A service, according to Kotler (1998), is any activity or benefit that one party may offer to another which is essentially intangible and does not result in the ownership of anything.
Marketing	According to Kotler and Keller (2006), marketing involves the identification and satisfaction of human and social needs. For these authors, it is a simplistic way of meeting needs profitably.
Organization	In Daft’s definition (2006), organizations are social entities that are directed by goals, are designed as systems of activities deliberately structured and coordinated and linked to the external environment.
Process	A process, in Oliveira's analysis (2007), is a structured and intuitive set of functions of planning, organization, direction and evaluation of sequential activities, which present a logical inter-relationship .

Products	A product is a set of attributes, tangible or intangible, constituted through the production process, according to Kotler (1998).
Relations	In the analysis of Lamb (1961). human relations are sets of interactions that prevail in establishing and maintain contacts between people.

Specification Table 3: Descriptive of the conceptual diagram.

Source: Prepared by the authors.

Wojahn et al. (2017) in their quantitative research identified the impact of knowledge management (KM) strategies and processes on creativity and organizational performance in information and communication technology (ICT) companies; they found that knowledge is a strategic organizational resource. The authors performed a multiple linear regression to test hypotheses about what might make managers reassess some of their attitudes and create mechanisms within organizations to use knowledge as a whole and not link creativity with the exclusive use of certain kinds of knowledge. The optimizing of more than one form of knowledge within an organization can lead to a competitive advantage in the market, since new ideas can arise and be feasible within the organization if creativity is transformed into innovation and thence into performance. The study evidenced the construct of organizational creativity. Finally, it was suggested that the innovation construct should be added to the model, in order to verify exactly how creativity impacts innovation.

4.2 Development of concepts on the validation of quantitative methods in academic production on innovation and creativity

For the development of concepts on the validation of quantitative methods in academic production on innovation and creativity, the following procedures are described below: Reliability Analysis, Construct Validity, Content Validity, Face Validity, Convergent Validity, Divergent Validity and Factorial Confirmatory Analysis.

Reliability is obtained by Cronbach's Alpha, which measures the percentage of total variation in the scale (summed) that is dictated by a variation of the set of covariance pairs between the variables, using the mathematical formula presented below. This formula is used to measure the correlation between responses to a questionnaire by analyzing the profile of the answers given, considering the number of questions and the variances by questions and the total:

$$\alpha = \frac{k}{k - 1} \left[1 - \frac{\sum_{i=1}^k S_i^2}{S^2_{soma}} \right]$$

where

- a) k is the number of items (variables);
- b) $S_i^2 = \frac{\sum_{j=1}^n (x_{ij} - \bar{x})^2}{n}$ is the variance of the scores of n persons responding to the i -th item ($i = 1, \dots, k$).
- c) S^2_{soma} is the variance of the total scores of all respondents.

According to Costa (2011), alpha is the proportion of the total variation of a scale that is attributable to a common source, presumably the true score of the latent variable underlying the set of items. Thus, the alpha coefficient is calculated from the variance of the individual responses and from the summated variance of the components of the questionnaire. In order to calculate its values correctly, statistical software that will facilitate the calculation must be used. The alpha values can vary from 0 to 1; the closer to 1, the greater the evidence of internal consistency, and the greater the indication of reliability of the set of items in the scale, (Costa 2011), as shown in Table 2 below.

Value	Interpretation
Up to 0,599	Reliability not acceptable
Between 0.600 and 0.699	Regular Reliability
Between 0.700 and 0.799	Good reliability
Between 0,800 and 0,899	Great reliability
Above 0.900	Excellent Reliability

Table 2: Reference values of alpha according to Costa (2011).

Source: Adapted from Costa (2011).

Although widely accepted in the academic and scientific milieu, Cronbach's Alpha is still in some doubt, owing to criticisms that cannot be dismissed. Among them is the fact that we can generate high alpha coefficients only by placing redundant variables; that is, the more similar the items are, the greater the alpha coefficient, which is contrary to the theoretical assumption that we should use different items only in order to demonstrate different facets of the construct under analysis. Another recurring criticism is that checking the coefficient value is directly influenced by the number of items in the scale, so that the more items the scale has, the higher the alpha value. The last criticism stems from the scholarly discussion of formative constructs, because, in Costa's view (2011), in the process of measuring the formative constructs, there is no need for items to correlate with each other, so the alpha cannot be expected to be elevated to the specific type of construct that leaves room for misinterpretation. To verify the validity of the content described, Costa indicates the need to systematically verify the following aspects:

- a) The definition of the construct: procedure based on the specialized literature, which should still generate a clear indication of its scope;
- b) The dimensionality used in the measurement: it is necessary to emphasize the possibility of evaluating a construct in a one-dimensional or multidimensional perspective;
- c) The purpose of the measurement: we must pay attention to the variations of purpose and the implications for analytical activities. It is relevant to evaluate whether: (i) the measurement is something very general or very specific; (ii) the measurement is of extreme or normal behavior; (iii) the construct is typical or atypical. It is also useful to analyze whether the purpose of measurement is for scientific research or for managerial diagnosis;
- d) The association between these cuts and the proposed items: here, effectively, the analysis of validity is performed.

In order to operationalize the validity check, based on the assumption that the scale items are linked to a particular construct, we must verify that:

- a) The items reflect the facets of a construct and not the aspects associated with other constructs;
- b) The items cover all facets of the analyzed construct or a representative and a representative sample of the domain of the construct;
- c) The items correspond to the proposed condition of measurement in terms of formative or reflective constructs – in this case the items must be reflected by the construct;
- d) There is a balanced proportion between the facets of the scope and the number of items, in order to avoid measuring a certain facet with one number of items, while another facet of the same relevance is measured with another number, one much larger or much smaller.

Without losing sight of the points presented, it should be considered that on an already consolidated scale, there may be distortions due to the variation that a construct may suffer in the long run, or due to changes of an ethical, moral and cultural nature within a given society, so the association between the items and the content of a scale should periodically be checked. To check if the face validity described by the author is multiplied, some recommendations may be adopted, such as:

- a) The adequacy between the statements and the selected form of measurement should be analyzed;
- b) Future respondents and not only specialists should be used to evaluate the items;
- c) The appearance of redundant items should be avoided;
- d) quality evaluation criteria should be established – such as grammar correction, the order of words in sentences, clarity of expression and statement, extensions of statements, randomness of the disposition, and so on;
- e) In the case of complete instruments, it is further recommended that face validity be used not only for scale items, but for all parts of the instrument.

Although these procedures may seem common, they are typically neglected by researchers sooner or later; however, it must be borne in mind that face validity is an indispensable stage and as relevant as other forms of validity. Finally, we describe the initial procedures for content and face validity that compose translational validity. We proceed next to the recommended procedures for analyzing a scale that measures innovation and creativity and its feasibility, as follows: we should

- a) clearly define the domain and facets of the construct;
- b) analyze initial factors of influence, such as the dimensionality, temporal condition, and purpose of the measurement;
- c) evaluate the proportion between the number of items and the dimensions and facets of the construct, verifying that all facets of the construct are well covered;
- d) define content appropriateness criteria, such as adherence to the definition; number of items by size or facet; characteristics of formative or reflective measurement and so on.
- e) define face adequacy criteria, such as language, expressiveness, extent of provision of items in the questionnaire, type of verification scale, etc.
- f) use the population itself and also specialists to analyze the scale items;

g) present the procedures and results of the content evaluation in the scale reports.

As indicated by Costa (2011), a necessary form of the verification of convergent validity is the application of correlated pairs between indicators, or by factorial analysis. This procedure is widely used due to the development of software as an operational tool. In order to analyze the scales of multiple items, one must first verify whether the factor loads are consistently linked to the factor associated with the scale and check the adherence of the item to the factor. To verify the adherence, one must observe the exits of the process of factor extraction in the procedures of Factorial Confirmatory Analysis (FCA), initially analyzing the factorial loads of the multiple items in order to verify whether the statistics are associated with the hypothesis test of the nullity of the score. There are two possible analyses: factorial loads should be greater than 0.4 (preferably 0.6); and the significance test for nullity of the score should be significant at $p < 0.05$ or at $p < 0.01$. If these verification outcomes comply, we can state that evidence of validity convergent to the set of items has been obtained.

To verify the divergent validity, Costa (2011) recommends measuring a group of items, based on the measure of variance extracted from a given construct, in addition to the variance shared with the others; if the extracted variance is greater than the variance shared between two constructs, it may be affirmed that the two have effectively different measures, an aspect that demonstrates discriminant validity, as follows:

- a) For each construct individually the extracted variance is extracted by factorial analysis;
- b) Then, for the set of constructs the Pearson correlation is extracted;
- c) The correlations are squared, thus obtaining the shared variance;
- d) A table is constructed in which the main diagonal contains the extracted variances and the respective shared variances are in the other cells;
- e) These are compared: if the variance extracted is greater than the shared variance, there will be evidence of discriminant or divergent validity.

The procedure for testing Factorial Confirmatory Analysis (FCA) described by Costa (2011) consists of making the estimates and then calculating the test statistic (in this case, the chi-square statistic), along with the number of degrees of freedom and statistical significance. The "verification" procedure is simple: the significance is verified and if a significance at $p < 0.05$ is reached, we refute the null hypothesis; that is, we understand that there is no similarity between the correlation matrices, which implies that the items cannot adequately measure the construct. Otherwise, if a significance is reached at $p > 0.05$, the null hypothesis cannot be refuted, and the items will be understood to adequately measure the construct (or dimension), as Costa states (2011). This test therefore presupposes the idea that we have a statistical hypothesis to be tested and that we have a standardized verification procedure. This is the case with the hypothesis test theory developed along statistical lines. The mathematical formula of the factorial analysis is shown below.

$$\begin{aligned}
 Z_1 &= l_{11}F_1 + l_{12}F_2 + \dots + l_{1m}F_m + \epsilon_1 \\
 Z_2 &= l_{21}F_1 + l_{22}F_2 + \dots + l_{2m}F_m + \epsilon_2 \\
 &\vdots \\
 Z_p &= l_{p1}F_1 + l_{p2}F_2 + \dots + l_{pm}F_m + \epsilon_p
 \end{aligned}$$

where

- a) $Z_i = \frac{X_i - \mu_i}{\sigma_i}$ is the standardized variable;
- b) X_i is the original variable with mean μ_i and standard deviation σ_i ; ϵ_i is the i-th random error for $i = 1, 2, \dots, p$;
- c) $F_j, j = 1, 2, \dots, m$ is the j-th common factor;
- d) l_{ij} is the coefficient of the i-th standard variable Z_i in the j-th factor F_j and represents the degree of linear relationship between Z_i e F_j . l_{ij} é called *loading*.

When the factorial scores (or loads) of a set of variables are calculated, it is possible to find the correlation measures between the observed variables and the factors. It is known that, for any of the items, the product of their factor loads is equal to the estimated correlation between the variables. But the correlation between the variables is easily calculated, since they are observable variables. The question immediately arises: how close is the estimate of the correlation (calculated by the factorial procedure) to the actual correlation observed between the variables? According to Costa (2011), the hypothesis test of the confirmatory factorial analysis aims to evaluate how far the observed correlations are from the estimated correlations. Thus, confirmatory factorial analysis tests whether the estimated correlation matrix is statistically different from the correlation matrix observed. As Costa sees it (2011), the null hypothesis of this test is that the two matrices are not distinct, and the alternative hypothesis is that there are significant differences,. For this, the adopted procedure should be that of confirmatory factorial analysis with the development of a structural equation. Through the AMOS software, the path diagram of each construct can be drawn, according to the expectation of adherence of the items to each construct, taken from the confirmatory factorial analysis performed in the SPSS. To interpret the results, we observe in the *Estimates* tab whether the values of the factorial scores estimated from the items are adequate to the measurement of the construct.

For the structural equation model, it is proposed in Costa (2011) that the values of null scores should be automatically excluded from the scale. Low values, however, should be carefully evaluated, considering the subsequent procedures. The critical-CR values should be taken into account, together with their respective significance in the regression weights table. These values indicate if the scores of the scale items are statistically different from zero and, therefore, when we have high and significant values at $p < 0.05$, they indicate that the factor loads are not zero. In the Standardized Regression weights table, we can observe the values of the factorial scores observed. They indicate the degree of relationship of the item to the construct. In the Modelfit tab, the adjustment measures of the model must be analyzed. The Discrepancy table (CMIN) shows the need to observe the qui-square value ($\chi^2 - \text{CMIN}$), the number of degrees of freedom (DF), the significance (p), and the ratio between the quadratus and the number of degrees of freedom (CMIN / DF) of the standard model. The central measure is the significance: if $p > 0.005$, it indicates the suitability of the model. The e ratio and CMIN / DF should also be checked. If the value is less than 5, good adjustment is indicated (this test corresponds to the Goodness-of-fit test of SPSS). In the RMSEA table, the value of the approximate mean square error root for the standard model should be analyzed and its size, based on values less than 0.08, indicates good adjustment, according to Costa (2011).

In the RMR table, we can observe the adjustment adequacy index (GFI) of the standard model and we analyze its size, assuming that values above 0.9 are indicative of good adjustment. In the Baseline Comparisons table, the comparative adjustment index (GFI) of the standard model should be observed, as Costa (2011) advises, and its size analyzed. Values above 0.9 should be accepted as indicative of good fit and unidimensionality (in the case of measuring constructs or dimensions). In the Modification Indexes tab, we observe the indications of improvements that the model can reach if we establish the covariances between the errors of measurement of the variables. To do so, we are recommended to check the Covariances table and analyze the decision to follow the procedure, or to exclude any of the variables. The recommendation is that if a variable presents improvements and the covariance line with more than one variable is established, it must be excluded from the model.

4.3 Presentation of constructs to indicate the presence of innovation and creativity for the generation of modeling

The existing literature indicates some constructs that are used to measure innovation and creativity. In this regard, search in Araújo et al. (2018) points out the profile of academic production in the approach of organizational innovation. Having published in scientific journals indexed in the Web of Science; the technical bibliometric format in Exploratory Factor Analysis (EFA) proposed by these authors points to innovative behavior of an instrumental nature. This is useful for measuring innovative behavior, typifying the innovation, treating the antecedents of creativity and innovation, while exposing an instrument that might be used in research on the ambit of creativity and innovation, which reverberates in a promising way as a antecedent of organizational innovation.

Eight constructs indicative of the presence of innovation and creativity have been described by Araújo et al (2018) and Wojahn et al. (2017), namely: innovative behavior and technical innovation, technology, instruments used in the measurement of innovative behavior, types of innovation, antecedents of creativity and innovation, instruments used in innovation research, antecedents of organizational innovation and organizational creativity.

A study by Igartua et al. (2018) focuses on the need for small and medium-sized enterprises to develop approaches to innovation, with defined directions for developing processes based on innovation structures, and integrated with an innovation management approach. From the perspective of innovation in small and medium-sized enterprises, exploring such maturity models in their operational nature is claimed to be the first step to firm innovation management. Researchers, while promoting such an approach as a learning element, can make strategically correct assertions in support of the integration of method and organizational structure in a culture where institutions predominate.

5. CONCLUSION

The general objective of this theoretical essay was to carry out a theoretical-conceptual study of the quantitative method in the measurement of innovation and creativity. Theoretical and conceptual elements in the evolution of a valid quantitative method for the measurement of innovation and creativity were considered, from which it could be inferred that there is a shortage of valid instruments to measure these

constructs. The problem was encapsulated in the question of how innovation and creativity can be validly measured. To measure them, it was suggested that a scale be developed with items that could measure the constructs described: innovative behavior and technical innovation, technology, instruments used in the measurement of innovative behavior, types of innovation, antecedents of creativity and innovation, instruments used in innovation research, antecedents of organizational innovation and organizational creativity; and the necessary steps should be taken to validate a measurement instrument, such as control in relation to errors (Figure 1 and Specification Table 1); translation and construct validity analysis (Table 1); convergent and discriminant validity analysis; Cronbach's Alpha coefficient analysis (Table 2); and finally, the modeling of structural equations. A valid scale was expected as a result, which could measure innovation and creativity in response to the research problem. What was described reveals the need for new theoretical-empirical studies that will carry out the necessary steps described and analyze the reliability and validity of the measurement scales. This study may serve those interested in research in the area of innovation as a support in methodological construction; it may also serve as an element to encourage reflection on what quantitative research can apply to innovation.

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