Measuring and evaluating innovation management in small and medium enterprises: proposition of a multicriteria model for selecting indicators and metrics

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Abstract. The objective of this work is to propose a model for measuring and evaluating the innovation management maturity in small and medium enterprises (SMEs), based on specific indicators and metrics (at the firm-level) established with the support of multicriteria decision-making methods, which are combined to monitoring and evaluation tools and to quality management concepts and frameworks. Based on the results of the bibliographical review and documentary analysis on the central themes of this research, a model was developed to measure and evaluate the innovation management in SMEs, seeking to fill gaps identified in the specialized literature. The conceptual model and the logical framework for the definition of indicators and metrics include four dimensions: (i) organization and management; (ii) people management towards innovation; (iii) process management for innovation; and (iv) results and impacts of innovation management. The applicability of the model could be demonstrated through an empirical study focusing on an SME that participated in the Innovation Management Support Program for SMEs at PUC-Rio. The main contributions of the research are a model for monitoring and evaluation of the innovation management by SMEs, which considers the specificities of these firms and their socio-productive contexts and a set of composite indicators associated with the four dimensions of innovation management contemplated in the proposed model.

1. Introduction

The importance of measurement is especially factual for innovation management in SMEs because these firms have little resources and cultural barriers to measure relevant issues related to innovation management and also their innovation performance. Earlier studies have shown that the models addressed to the measurement and evaluation of innovative capacity and innovation performance of firms are predominantly focused on large companies and do not take into account specificities and obstacles of smaller enterprises [1; 2].

In particular, in the context of SMEs, some studies focusing on the measurement of innovative capacity (CI) employ multicriteria methods to support decisions and propose composite indicators to measure innovation management maturity [1;3;4;5;6]. However, these works do not combine multicriteria methods with largely diffused tools for monitoring and evaluating programs (such as the logical framework and the quantitative matrix for classifying and selecting indicators) and also with
quality management concepts and frameworks (namely the 'Plan-Do-Check-Learn Cycle' and the Impact Performance Analysis - IPA). Therefore, there is a full field of research opened for the development and validation of models for measuring and evaluating the innovation management maturity of SMEs, based on the combination of multicriteria decision-making methods with the mentioned tools and frameworks. This integration should provide answers to open questions concerning the subjectivity, complexity, and uncertainty inherent in decision-making processes related to innovation in general, and in particular to innovation management in SMEs.

In this context, this paper addresses the following research question: "How to measure and evaluate innovation management in SMEs, based on specific indicators and metrics (at the firm-level) and supported by multicriteria decision-making methods integrated with largely diffused monitoring and evaluation tools and quality management concepts and frameworks?"

This article is structured in five sections. Following the introduction, Section 2 briefly reviews the approaches for measuring and evaluating innovation management, with particular attention to SMEs. Section 3 presents the adopted methodology. In Section 4, we introduce the conceptual model for defining and hierarchizing innovation management indicators and metrics classified in four dimensions: (i) organization and management; (ii) people management towards innovation; (iii) process management for innovation; and (iv) results and impacts of innovation management. Finally, in Section 5 we synthesize the concluding remarks.

2. Theoretical background
The literature review and documentary analysis covering the period of 1997-2017 encompass the following themes: (i) innovation management measurement, with particular attention to SMEs; (ii) monitoring and evaluation; and (iii) application of multicriteria decision-making (MCDM) methods in the research context.

2.1. Innovation management measurement
Previous research in the field of innovation capacity measurement has shown that most of the proposed approaches for measuring and evaluating the innovative capability of firms are based on multicriteria decision-making (MCDM) methods. Particularly for small and medium enterprises – the focus of our research – Adams, Bessant, and Phelps [1] carried out a critical review of different propositions to measure innovative capacity in these firms. They pointed out that the most common methodological approach for measuring SMEs’ innovation management maturity is a multicriteria approach. MCDM methods have been widely applied, as reported in these studies [1;3;4;5;6]. However, since a single method is not sufficient to answer the research question, there exists a need to apply an integrated approach to solving this problem.

2.2. Monitoring and evaluation
A systematic literature search focused on monitoring and evaluation was performed on peer-reviewed articles indexed in Scopus; Web of Science; and Science Direct databases, covering the period between January 1997 and December 2017. The search strategy focused on the most highly cited publications about the referred theme. From this review, four particularly useful tools for the modeling phase of our research are highlighted: (i) the logical framework [7]; (ii) the quantitative matrix for classifying and selecting indicators [8]; (iii) the concept of 'Plan-Do-Check-Learn Cycle' [9]; and (iv) Impact Performance Analysis – IPA [10].

2.3. Application of MCDM methods in the research context
Considering the specificities and obstacles of smaller enterprises to measure relevant issues related to innovation management and also the results from our review on MCDM methods, the following methods were combined aiming at selecting and hierarchizing indicators addressed to innovation management measurement in SMEs. They are: (i) Analytical Hierarchy Process (AHP); and (ii) Technique for Order Performance by Similarity to Ideal Solution (TOPSIS).
The AHP method was created by Saaty [11], and the basic idea of this method is leaning on a pairwise comparison based on the eigenvector. The main disadvantages of this method are: weight of each criterion has a significant effect on the final alternative score, as weighting criteria in this method are judgmental and based on decision maker preference so accuracy in this method can be widely varied in subjective problems. The second selected method refers to the Technique for Order Preference by Similarity to Ideal Solution or TOPSIS, introduced by Hwang and Yoon [12]. It is based on the concept that the chosen alternative should have the shortest distance from the positive ideal solution (PIS) and the farthest from the negative ideal solution (NIS).

3. Methodology
The research methodology comprised: (i) a systematic search performed on articles that were published between January 1997 and December 2017 about the central research themes and content analysis to select the most relevant works; (ii) development of a model for measuring and evaluating the innovation management maturity in those firms, based on specific indicators and metrics (at the firm level) and supported by two multicriteria decision support methods - AHP and TOPSIS, combined with the logical framework tool; the quantitative matrix for classifying and selecting indicators; the concept of 'PDCL Cycle' and the Impact Performance Analysis – IPA; (iii) proposition of indicators and metrics to measure and evaluate the innovation management of SMEs, associated to the four dimensions contemplated in the proposed model; and (iv) development of an illustrative application aiming to demonstrate the applicability of this model, focusing on a Brazilian SME that develops and provides innovative technical solutions applied to the areas of Geotechnics and Environment. Due to space limitations, we will not be able to show the results of the empirical study. Nevertheless, the whole model and the empirical study are already published in an MSc. Dissertation, on which this article was based [13].

4. A multicriteria model for selecting and hierarchizing innovation management indicators in SMEs
This section introduces the multicriteria model proposed for measuring and evaluating the innovation management maturity of SMEs in eight steps, as follows:

• Step 1: Diagnosis of innovation management maturity of a given SMS, with the support of a questionnaire with 50 questions, which were selected from the literature and adapted for the SMEs’ context. These questions are grouped around 13 key elements of innovation management, that are in turn classified into four dimensions: (i) organization and management; (ii) people management towards innovation; (iii) process management for innovation; and (iv) results and impacts of innovation management. The SME should be asked to rate its maturity level concerning each of the 42 'innovation management good practices' and eight ‘innovation results and impacts’ on a scale of 1 to 5. The inferior score being "1" (very low) and the superior score being "5" (very high). The expected results are four radial graphics (one for each innovation management dimension) and three Importance-Performance Analysis (IPA) matrices corresponding to the dimensions ‘organization and management’; ‘people management towards innovation’; and ‘process management for innovation’;

• Step 2: Development of the SME Innovation Management Plan (IMP), based on the IPA matrices it is possible to identify strengths, spaces for improvement and need for urgent actions in relation to critical issues. The SME should prioritize the short, medium and long-term actions that should be the subject of its IMP;

• Step 3: Construction of the IMP’s logical framework, according to [7];

• Step 4: Identification of the key stakeholders. In this step, the focused SME should use the tools and criteria proposed by Freeman et al. [14];

• Step 5: Definition and classification of ‘candidate’ indicators to measure and evaluate the results of the IMP. Based on the IMP’s logical framework defined in step 3, the focused SME should use a quantitative matrix for classifying and selecting indicators, according to [8];

• Step 6: Definition of the criteria for selecting and hierarchizing the indicators and metrics. In this step, a set of criteria should be established based on the literature review or even in the experience
of the SME managers and consultants. Examples of criteria include ‘relevance’; ‘measurability’; ‘traceability over time’; ‘reliability’; and ‘availability when needed’, according to [8].

- Step 7: Construction of the quantitative matrix for selecting and hierarchizing indicators with the support of a hybrid multicriteria method - AHP-TOPSIS, according to [11;12]. The results are four lists of ranked indicators – the lists correspond to the innovation management dimensions;

- Step 8: Proposition of indicators and metrics to monitor and evaluate the results of the SME Innovation Management Plan (IMP). Finally, the SME managers will be able to select which indicators will be part of its system for monitoring and evaluating innovation management efforts by consulting the four lists generated in the previous step.

5. Final remarks
The conceptual model proposed in this work may contribute to the current decision-making processes regarding the innovation management in SMEs, giving its differentials to decision-making on complex and multidisciplinary issues. We believe that its benefits can be perceived and experienced by both SMEs interested in strengthening their innovative capacity and achieving higher levels of innovation performance, and the Brazilian Support Service Micro and Small Companies (Sebrae), interested in disseminating good practices of innovation management among the Brazilian SMEs.

The results of this research may also contribute to solving the empirical problems faced by public managers responsible for the formulation, revision, and implementation of Science and Technology policies, by making available a model specially designed for SMEs.

References
[1] Adams R, Bessant J and Phelps R 2006 Innovation management measurement: a review Int. J. Manag Rev 8 1 21-47
[2] Doroodian M, Rahman M N A, Kamarulzaman Y and Muhamad N 2014 Designing and validating a model for measuring innovation capacity construct Adv Decis Sci 2014 1-11
[3] Saunila M 2016 Performance measurement approach for innovation capability in SMEs J Prod Perform Manage 65 2 162-176
[4] Boly V, Morel L, Assielou N G and Camargo M 2014 Evaluating innovative processes in French firms: methodological proposition for firm innovation capacity evaluation Res Policy 43, 608-622
[5] Forsman H 2011 Innovation capacity and innovation development in small enterprises. A comparison between the manufacturing and service sectors Res Policy 40 5 739-750
[6] Sepúlveda J, Gonzalez J, Alfarro M and Camargo M 2010 A metrics-based diagnosis tool for enhancing innovation capabilities in SMEs Int J Comput Commun 5 5 919-928
[7] W. K. Kellogg Foundation 2004 Logic model development guide: using logic models to bring together planning, evaluation, and action. W. K. Kellogg Foundation, Michigan
[8] Brasil. Ministério do Planejamento, Orçamento e Gestão 2010 Indicadores de programas: guia metodológico. Brasília: Ministério do Planejamento, Orçamento e Gestão
[9] Fundação Nacional da Qualidade. FNQ 2016 Modelo de excelência da gestão MEG 21 ed. São Paulo: FNQ
[10] Martilla J A and James J C 1977 Importance-performance analysis J Mark 41 1 77-79
[11] Saaty T L 2000 Decision making for leaders. Pittsburg: RWS Publications
[12] Hwang C L and Yoon K 1981 Multiple attributes decision making methods and applications. Berlin: Springer
[13] Macedo Filho, H F C 2018 Monitoring and evaluation of innovation management in micro, small and medium enterprises: proposition of indicators and metrics. Rio de Janeiro, 127 p. MSc. Dissertation – Postgraduate Programme in Metrology. Pontifical Catholic University of Rio de Janeiro
[14] Freeman R E, Harrison J, Hicks A, Parmar B and De Colle S 2010 Stakeholder theory: the state of the art. New York: Cambridge University Press