Downloaded by UNIVERSITY OF NEW ENGLAND (AUS) At 03:19 05 March 2018 (PT)

emeraldinsight

Management Decision

Assessing the innovation capability of small- and medium-sized enterprises using a non-parametric and integrative approach

Bernardo M.S. Castela, Fernando A.F. Ferreira, João J.M. Ferreira, Carla S.E. Marques,

Article information:

To cite this document:
Bernardo M.S. Castela, Fernando A.F. Ferreira, João J.M. Ferreira, Carla S.E. Marques, (2018) "Assessing the innovation capability of small- and medium-sized enterprises using a non-parametric and integrative approach", Management Decision, https://doi.org/10.1108/MD-02-2017-0156
Permanent link to this document:
https://doi.org/10.1108/MD-02-2017-0156

Downloaded on: 05 March 2018, At: 03:19 (PT)
References: this document contains references to 54 other documents.
To copy this document: permissions@emeraldinsight.com
The fulltext of this document has been downloaded 22 times since 2018*
Access to this document was granted through an Emerald subscription provided by emerald-srm:320271 []

For Authors

If you would like to write for this, or any other Emerald publication, then please use our Emerald for Authors service information about how to choose which publication to write for and submission guidelines are available for all. Please visit www.emeraldinsight.com/authors for more information.

About Emerald www.emeraldinsight.com

Emerald is a global publisher linking research and practice to the benefit of society. The company manages a portfolio of more than 290 journals and over 2,350 books and book series volumes, as well as providing an extensive range of online products and additional customer resources and services.

Emerald is both COUNTER 4 and TRANSFER compliant. The organization is a partner of the Committee on Publication Ethics (COPE) and also works with Portico and the LOCKSS initiative for digital archive preservation.

*Related content and download information correct at time of download.

The current issue and full text archive of this journal is available on Emerald Insight at:
www.emeraldinsight.com/0025-1747.htm

Assessing the innovation capability of small- and medium-sized enterprises using a non-parametric and integrative approach

Received 23 February 2017
Revised 18 April 2017
Accepted 23 May 2017

Bernardo M.S. Castela
ISCTE Business School, University Institute of Lisbon, Lisbon, Portugal
Fernando A.F. Ferreira
ISCTE Business School, University Institute of Lisbon, Lisbon, Portugal and Fogelman College of Business and Economics, University of Memphis, Memphis, Tennessee, USA
João J.M. Ferreira
NECE Research Unit, University of Beira Interior, Covilhã, Portugal, and
Carla S.E. Marques
Department of Economics Sociology and Management, CETRAD Research Unit, University of Trás-os-Montes e Alto Douro, Vila Real, Portugal

Downloaded by UNIVERSITY OF NEW ENGLAND (AUS) At 03:19 05 March 2018 (PT)

Abstract

Purpose – The aftermath of the recent financial crisis has shown that the ability to innovate is a vital management skill and that the methodologies used to evaluate innovation capability within small- and medium-sized enterprises (SMEs) should be as holistic and integrative as possible. The purpose of this paper is to address this issue through the combined use of cognitive mapping and the analytic hierarchy process (AHP).

Design/methodology/approach – Cognitive mapping and multiple criteria decision analysis have proved over the years to be effective in handling a wide range of complex decision problems. Following a socio-technical approach, a non-parametric method of evaluating SME innovation capability – based on the results of group meetings with a panel of information technology entrepreneurs and SME chief executive officers – was created, tested and validated.

Findings – The methodological processes adopted in this study provide promising results for decision makers seeking to identify the most innovative SMEs. Furthermore, the sensitivity analyses carried out also supported the findings.

Research limitations/implications – This study confirms the usefulness of integrating cognitive mapping and the AHP to facilitate evaluations of SME innovation capability. However, due to the process-oriented nature of the research, extrapolations without proper adjustments are not recommended.

Practical implications – The panel members who participated in this study consider the proposal extremely versatile and see great potential for further applications in the measurement of SME innovation capability.

Originality/value – The combined use of cognitive mapping and the AHP offers a holistic and well-informed perspective on the issue in question. The authors know of no prior work reporting this approach in the same research context.

Records of the expert panel meetings, including pictures, software output and non-confidential information of the study, can be obtained from the corresponding author upon request. The authors gratefully acknowledge the superb contribution and infinite willingness of the panel members: António Castela, Filipe Gaspar, João Tiago Aguiar, Vasco Lemos and Vítor Gonçalves. Facility support from the ISCTE Business School, University Institute of Lisbon, Portugal is also acknowledged.

Management Decision
© Emerald Publishing Limited
0025-1747
DOI 10.1108/MD-02-2017-0156

Keywords Analytic hierarchy process (AHP), Small- and medium-sized enterprises (SME), Cognitive mapping, Holistic view, Innovation capability evaluation, Multiple criteria decision analysis (MCDA)
Paper type Research paper

1. Introduction

Small- and medium-sized enterprises (SMEs) have long been recognized as a driving force of economic development (Drucker, 1985; Oliveira *et al.*, 2017). Europe, for instance, has over 21 million SMEs employing 88.8 million people and generating a total of 3.666 billion euros in added value within the European economy (cf. European Commission, 2015). Given the current economic scenario, SMEs are expected to be prepared to respond to the changes imposed by the market, through either their ability to differentiate themselves from competitors or their capability to be innovative and, thereby, survive. Indeed, as Bullinger *et al.* (2007, p. 17) point out, "SMEs need to innovate in order to survive and create competitive advantages."

The need for SMEs to innovate has resulted from – and/or led to – changes at different levels. First, globalization has exposed SMEs to greater competitiveness, generating a larger number of new competitors. Second, SMEs can no longer focus only on niche markets. Third, technological advances have resulted in rapid progress in information, knowledge and innovation, making SMEs more competitive and more capable of eliminating obsolete products. Last, consumer demand is now focused on higher quality products and services (for further discussion, see Bullinger *et al.*, 2007; Saunila, 2016; Oliveira *et al.*, 2017). Given these developments, two interrelated questions need to be answered:

RQ1. How can SME innovation capability be measured?

RQ2. What qualitative and quantitative metrics can be used?

In light of the changing economic environment, the methodologies used to evaluate innovation capability within SMEs should be as integrative and close to reality as possible. Therefore, the present study sought to address this issue through the combined use of cognitive mapping and multiple criteria decision analysis (MCDA). According to Zopounidis *et al.* (2015, p. 339), "a wide range of techniques and approaches can be useful […]. Among such disciplines […] MCDA has appealing distinctive features that are well suited for decision making." More specifically, we focused on developing a non-parametric method of evaluating SME innovation capability based on a constructivist stance and the results of group meetings with a panel of information technology (IT) entrepreneurs and SME chief executive officers (CEOs). This method used cognitive mapping to identify the evaluation criteria and the analytic hierarchy process (AHP) to calculate the respective trade-offs.

Cognitive mapping can bring together multiple decision makers and deal with conflicts of interest and uncertainty, which allows complex problems to be structured more clearly (Ackermann and Eden, 2001; Eden, 2004). In addition, this method helps reduce the number of omitted criteria and identifies the cause-and-effect relationships between variables (Eden and Ackermann, 2004; Damart, 2010; Canas *et al.*, 2015). The AHP was created by Saaty (1980), and it is now probably the most widely known MCDA method. Both approaches have been extensively applied to real-life decision problems, helping generate greater clarity with regard to problem definition and resolution (see Zavadskas *et al.*, 2014). However, we know of no prior work reporting these two methods' integrated use to evaluate SME innovation capability.

The next section presents an overview of the literature on SME innovation capability evaluation, after which the methodological background of the techniques applied is provided.

Downloaded by UNIVERSITY OF NEW ENGLAND (AUS) At 03:19 05 March 2018 (PT)

Section 4 presents the results, highlighting the managerial implications of the proposed framework. The last section highlights the study's contributions and limitations, as well as discussing the grounds for further research.

2. Related literature

Lawson and Samson (2001) define innovation capability as a theoretical concept referring to the actions that could be taken to improve the performance of SMEs. The development and analysis of performance indicators that facilitate evaluations of SMEs' innovation capability have become increasingly important over the past few years, motivating the search for new approaches and more sophisticated assessment mechanisms (Saunila, 2016). Table I shows some of the studies conducted so far, highlighting their respective contributions and limitations.

Notwithstanding the progress made in this field, Pawlak (1982) and Hong *et al.* (2015) underline the challenges inherent to measuring innovation capability, since this feature cannot be characterized only by either objective indicators that are quantitatively

Author	Method	Contribution	Limitations
Pawlak (1982)	Rough set theory (RST)	Allows for the development of RST-based methods for evaluating innovative technology capability	The use of this method restricts the application of unilateral tests
He (1989)	Principal component analysis (PCA); fuzzy cognitive clustering	Provides new insights into the field of fuzzy cognition, which allows for the development of new methods of multivariate statistical analysis in innovation capability evaluations	The method presents some ambiguity in the explanation of the main components and variables
Bullinger *et al.* (2007)	Three-stage Fraunhofer approach	Enables SMEs to control and improve innovation capability continuously, independent of external experts	The study used a poor source of information The research left out variables, such as governments' influence, that may be relevant in the model The method produces difficulties in weighting the evaluation criteria
Zhao and Zeng (2011)	AHP	Provides an AHP-based index system to evaluate innovation capability	The system includes difficulties in defining the evaluation criteria The method lacks transparency with regard to the use of the variables in the network of correlations
Zhang (2011)	Evaluation of entropy deviation	Proposes the idea of entropy deviation to avoid the deficiencies of combinatorial evaluation in innovation capability assessment	The results of the evaluation are strongly influenced by the way information is collected
Hong *et al.* (2015)	Fuzzy Borda	Proposes one of the first approaches to relate fuzzy Borda methods to innovation capability evaluation Combines quantitative and qualitative variables	The validation process of the performance indicators needs improvement
Yang *et al.* (2015)	Uncertain linguistic variables	Develops a method of innovation capability evaluation based on uncertain linguistic variables	The method still needs to be improved at the level of the combination of numerical and linguistic variables
Yin *et al.* (2016)	Multivariate statistical combination; forecasting method	Allows for the minimization of errors both in the sum of square errors and mean square error	It may not be possible to generalize the results to other industries The criteria weighting is exclusively based on mathematical calculations

Table I.
Innovation capability assessment methods

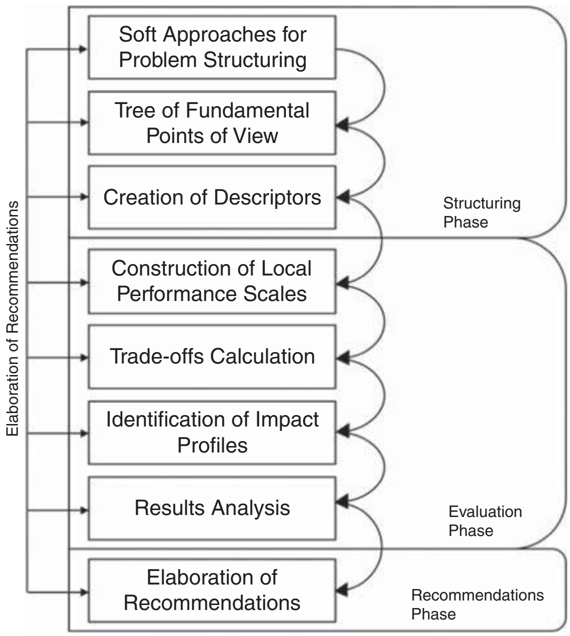
Downloaded by UNIVERSITY OF NEW ENGLAND (AUS) At 03:19 05 March 2018 (PT)

measurable or subjective indicators (i.e. decision makers' perceptions). In practice, some of the studies included in Table I (e.g. Bullinger *et al.*, 2007; Zhang, 2011) reveal that potentially important variables for innovation capability evaluation are omitted or excluded, affecting the explanatory power of the evaluation systems created. Another challenge identified in previous research is assigning weights to the identified variables and calculating trade-offs between them – issues that also seem to have been overlooked in some of the contributions presented in Table I (e.g. Bullinger *et al.*, 2007). Given these limitations, the current study integrates cognitive mapping and the AHP, aiming, thereby, to overcome some of the shortcomings of previous studies (for further discussion, see Santos *et al.*, 2008; Howick and Ackermann, 2011; Zhao and Zeng, 2011).

Although no perfect methodology yet exists and the choice of method depends on the decision context (cf. Weber and Borcherding, 1993; Ferreira *et al.*, 2012), cognitive mapping can provide the basis for a comprehensive definition of the variables to be included in an evaluation framework. In addition, MCDA techniques can help determine the weights allocated to each of these variables. According to Mingers and Rosenhead (2004) and Howick and Ackermann (2011), combining different approaches and methodologies to address real-world decision problems can produce significant benefits because these decision situations are inevitably multidimensional. Thus, different methodologies are often more effective at different stages of the decision-making process. Furthermore, as Oliveira *et al.* (2017) argue, the application of different techniques allows previous research contributions to be considered and new developments to be generated. The next section presents the methodological procedures followed in this study with regard to the combined used of cognitive mapping and the AHP.

3. Methodological background

The methodological procedures followed in this study are presented in Figure 1.



Source: Ensslin *et al*. (2000, adap.)

Figure 1. Structure of methodological processes

Downloaded by UNIVERSITY OF NEW ENGLAND (AUS) At 03:19 05 March 2018 (PT)

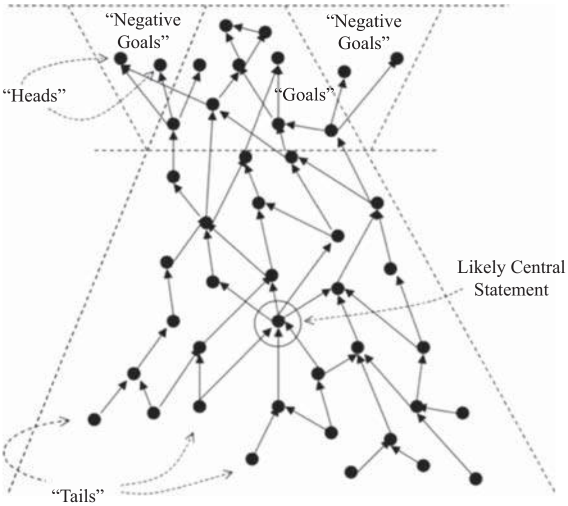
Because the present study's approach falls within the scope of MCDA (for a discussion of theoretical details, see Belton and Stewart, 2002), the methodological procedures followed were split into three phases. The first was the structuring phase, during which the factors underlying the decision problem were specified. In this case, the aim was to identify the factors that influence SME innovation capability by applying cognitive mapping techniques. The second was the evaluation phase, in which the AHP was used to obtain value functions and calculate trade-offs between criteria. The last was the recommendations phase, in which recommendations for future research were formulated based on the results obtained.

3.1 Cognitive mapping

This study assumes a constructivist epistemological stance. Porcaro (2010) states that constructivism is grounded on the baseline conviction that knowledge must be built by the learner, rather than shaped by the ideas of the person conveying the information.

One of the most well-known techniques that can be used to capture and clarify people's ideas and perceptions, and thus promote collaborative problem solving, is cognitive mapping (Ferretti, 2016). According to Ferreira, Jalali and Ferreira (2016, p. 4955), cognitive maps "are recognized in the decision-making arena as well-established and interactive visual tools, which allow for the structuring and clarification of complex decision situations." In functional terms, the process of cognitive mapping results in a "network of nodes and arrows, where the direction of the arrow implies believed causality" (Eden, 2004, p. 673). In Figure 2, the dots represent concepts and the arrows stand for the cause-and-effect relationships between them.

Eden (2004, p. 618) notes that cognitive mapping, as a methodological tool, needs to encompass the following procedures: "eliciting the different views and belief sets as individual cognitive maps, drawing together this expert opinion in the form of a composite map and, using the composite map in a work-shop setting to explore the policy arena and the possible policy options." This sequence of mapping procedures allows decision makers, first, to deal with both qualitative and quantitative factors, reducing the number of omitted criteria in the framework, increasing transparency and providing a fuller understanding of the decision problem at hand (Ferreira, Marques, Bento, Ferreira and Jalali, 2015).



Source: Eden (2004, p. 676)

Figure 2. Functional logic of a cognitive map

Downloaded by UNIVERSITY OF NEW ENGLAND (AUS) At 03:19 05 March 2018 (PT)

Second, decision makers can structure complex decision problems. Last, decision makers can provide support for the development and implementation of strategic directions. Notably, cognitive maps also allow subjectivity to be incorporated into the decision-making process, as well as identifying cause-and-effect relationships between concepts. Although not exempt from limitations (see Eden, 2004; Ferreira and Jalali, 2015), this structuring tool can, therefore, be of great use in assessing SME innovation capability.

3.2 Principles of the AHP

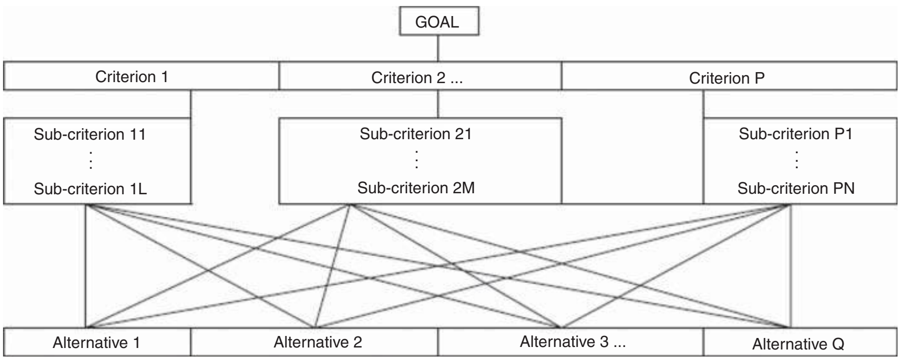
The AHP was developed in the 1970s by Thomas L. Saaty, and it is grounded on "a theory of relative measurement based on paired comparisons used to derive normalized absolute scales of numbers whose elements are then used as priorities" (Saaty, 2007, p. 860). According to Belton and Stewart (2002), this method belongs to the MCDA family, and the AHP is characterized by its simplicity, ease of use and ability to analyze elements of quantitative and qualitative nature, whether tangible or intangible.

Researchers have widely reported in the literature on MCDA that, when using the AHP, problems are decomposed into a hierarchical structure (cf. Belton and Stewart, 2002; Bhushan and Rai, 2004; Saaty and Vargas, 2012; Martins *et al.*, 2015). This is done in such way that the relationships between objectives, criteria (CTR), sub-criteria and alternatives can be established based on the information provided by the decision makers involved (see Figure 3). In this regard, Saaty and Vargas (2006, p. 2) note that, "to model a problem, one needs a hierarchic or a network structure to represent that problem, as well as pairwise comparisons to establish relations within the structure." These analyses are based on a measurement scale known as "Saaty's fundamental scale," which varies between 1 and 9. Table II shows the definitions of the scale, where "1" reflects a variable's lack of importance in relation to others and "9" reflects extreme importance.

The answers provided by the decision makers involved regarding the pairwise comparisons are then synthesized into square matrices, as shown in the following matrix form. In these matrices, the number in row i and column j provides the relative importance of criterion C_i over criterion C_j:

$$A = \begin{bmatrix} 1 & a_{12} & \dots & a_{1j} \\ a_{21} & 1 & \dots & a_{2j} \\ \vdots & \vdots & \ddots & \vdots \\ a_{i1} & a_{i2} & \dots & a_{ij} \end{bmatrix}. \tag{1}$$

:



Source: Bhushan and Rai (2004, p. 16)

Figure 3.
Conceptual structure of AHP

Downloaded by UNIVERSITY OF NEW ENGLAND (AUS) At 03:19 05 March 2018 (PT)

Intensity	Definition	Explanation
1	Equal importance	Two activities contribute equally to the objective
2	Weak or slight	
3	Moderate importance	Experience and judgment slightly favor one activity over another
4	Moderate plus	
5	Strong importance	Experience and judgment strongly favor one activity over another
6	Strong plus	
7	Very strong or demonstrated importance	An activity is favored very strongly over another; its dominance is demonstrated in practice
8	Very, very strong	
9	Extreme importance	The evidence favoring one activity over another adds up to the highest possible level of confirmation
1.1-1.9	When activities are very closely related, a decimal point is added to 1 to reflect their differences adequately	A better alternative way to assign the smaller decimals is to compare two closely related activities with other strongly contrasting ones, slightly favoring the larger differences over the smaller ones when using 1-9 values
Reciprocals of above non-zero numbers	If activity *i* has one of the above non-zero numbers assigned to it when compared to activity *j*, then *j* has the reciprocal value when compared with *i*	This represents a logical assumption
Measurement based on ratio scales		Sometimes, it is desirable to use these numbers in physical applications. Alternatively, the researcher often estimates the ratios of these magnitudes by using his or her judgment

Source: Saaty (2008, p. 11)

Table II. Saaty's fundamental scale of absolute numbers

The next step consists in estimating the weights w for each criterion in the different hierarchical levels and in relation to the alternatives considered. This is done by solving the eigenvector in the following equation:

$$W_i = \left(\prod_{i=1}^{n} a_{ij}\right)^{1/n}. \quad (2)$$

Next, the results obtained must be standardized, as shown in the following equation, in which T is the normalized eigenvector:

$$T = \left|W_1/\sum W_i \ldots W_n/\sum W_i\right|. \quad (3)$$

The normalized eigenvector identifies a hierarchy of priorities in order to obtain the relevant criteria. However, to assess whether the data are logically related, the solution should be tested for consistency. Saaty (2008) proposes the following sequence of steps to test the consistency of the solution obtained:

- Estimate the eigenvalue ($\lambda_{\max}$) in accordance with the following equation, in which w is obtained by summing the columns of the matrix of comparisons:

$$\lambda_{\max} = T.w; \quad (4)$$

Downloaded by UNIVERSITY OF NEW ENGLAND (AUS) At 03:19 05 March 2018 (PT)

Downloaded by UNIVERSITY OF NEW ENGLAND (AUS) At 03:19 05 March 2018 (PT)

- Compute the consistency index (*CI*) using the following equation, in which n stands for the order of the matrix:

$$CI = \frac{\lambda_{\max} - n}{n-1}; \tag{5}$$

- Calculate the consistency ratio (*CR*) using the following equation, in which *RI* is a random consistency index (see Saaty, 1994) and depends on the order of the respective matrix:

$$CR = CI/RI. \tag{6}$$

Details on the mathematical foundations of the AHP are widely found in the literature on MCDA (e.g. Saaty, 1980, 1994; Bhushan and Rai, 2004; Xu and Zhang, 2009; Martins *et al.*, 2015; Ferreira and Santos, 2016). However, the literature only considers *CR* acceptable if its value is below 0.10. Otherwise, the matrix of comparisons has to be revised. The process ends with an overall evaluation of each alternative and its respective ranking, allowing the contribution of each criterion to be expressed through the AHP hierarchical structure.

4. Implementation

The combined application of cognitive mapping and the AHP in the present study closely followed the sequence of procedures previously presented in Figure 1. On the premise that "the consultant [facilitator] will relate personally to a small number (say, three to ten persons)" (Eden and Ackermann, 2001, p. 22), our expert panel was composed of five participants from different industries. The participants also represent different sources of expertise regarding the evaluation of SME innovation capability (i.e. IT entrepreneurs and SME CEOs). While the number of participants was not large, it fell within the recommended guidelines for this type of study, and other studies applying cognitive mapping and/or the AHP have also addressed decision problems with expert panels of five individuals (e.g. Ferreira *et al.*, 2014; Jalali *et al.*, 2016). In addition, the present study is process-oriented, in which "there is less emphasis on outputs *per se* and more focus on process" (Bell and Morse, 2013, p. 962). With the proper adjustments, the procedures followed can be replicated in other contexts and/or with other participants. Two facilitators were also present in the group meetings (i.e. two of the authors of this paper), as these researchers were responsible for steering the negotiation process and registering the results. Three group meetings, with an average duration of four hours each, were held. The first and second pertained to the aforementioned structuring phase of this study.

4.1 Structuring phase

The first group meeting began with an initial methodological briefing to avoid misunderstandings between the decision makers and facilitators, followed by the presentation of a "trigger question" (i.e. "Based on your values and professional experience, what are the factors and/or characteristics of an SME that most influence its innovation capability?"). Although the trigger question was quite broad, it worked well as the starting point for the discussion, allowing the decision makers to share their perceptions and personal experiences.

We then applied the "post-it technique" (Ackermann and Eden, 2001), which involves writing on post-its the determinants that are relevant to evaluating SME innovation capability, according to panel members. In practice, each note is supposed to contain only a single criterion and, whenever the cause-and-effect relationship is negative, a minus sign (–) is added to the sticker. Ferreira, Jalali, Ferreira, Stankevičienė and Marques (2015, p. 478)

Downloaded by UNIVERSITY OF NEW ENGLAND (AUS) At 03:19 05 March 2018 (PT)

suggest the following procedure: "the post-its are then organized by clusters, known as areas of concern, and there is additional debate about the significance of each concept. The clusters are then carefully analyzed, one by one, and their post-its repositioned following a means-end-based structure." Based on the outcomes of this exercise, the Decision Explorer software (www.banxia.com) allowed for the construction of a collective cognitive map, which was then presented to the group for further discussion and validation. Figure 4 shows the final version of the map.

Because Figure 4 shows the agreed upon understanding of a particular panel of decision makers, it could not be regarded as a final result but, instead, as a learning tool for problem clarification. The direct involvement of the panel members and the amount of information discussed, as well as the iterative nature of the process, allowed ideas and thoughts on the evaluation of SME innovation capability to be shared and cause-and-effect relationships between variables to be explored (for further discussion on the advantages of cognitive mapping, see Ackermann and Eden, 2001; Eden, 2004; Ferreira, 2016; Ferreira, Spahr and Sunderman, 2016). Given the participants' contributions, and following the methodological guidelines proposed by Keeney (1992), five major lines of thought were identified. From these, a value tree was constructed and collectively validated by the group (see Figure 5).

Based on the group's interpretation of the value tree (or tree of CTRs), CTR01 – infrastructures – concerns the tangible and intangible infrastructures of SMEs (e.g. equipment, machinery and IT systems). CTR02 – external factors – underlines the influence of market factors (e.g. suppliers, competitors and environmental and political agents). CTR03 – organizational aspects – highlights the internal organizational and entrepreneurial characteristics of SMEs, such as the ability to create customer needs, influence the market and transfer knowledge. CTR04 – employees – addresses issues related to human resources (e.g. teamwork, working conditions and salaries). Finally, CTR05 – manager/CEO – addresses issues related to the skills and abilities of leaders, such as type of leadership, entrepreneurial skills and ability to motivate others.

In the second group meeting, the panel members were asked to construct carefully a descriptor (i.e. a set of ordered impact levels) for each CTR, using an adapted version of Fiedler's (1965) scale. In order to facilitate cognitive comparisons, "good" and "neutral" reference levels were also defined in each descriptor. Figure 6 shows an example of a descriptor and its levels of partial performance.

As shown in Figure 6, L1 represents the best possible partial performance level, while L6 stands for a very poor partial performance level. These levels of impact resulted from the sum of values assigned to each sub-criterion. This technical procedure was repeated for the four remaining CTRs. Once all descriptors had been constructed, we were able to proceed to the evaluation phase.

4.2 Evaluation phase

The evaluation phase was carried out in the third and final group meeting, during which the AHP was applied. The first part of the session started with the panel members ordering the CTRs based on their overall level of importance. This was done using a matrix, filled in by assigning "1" whenever a criterion was generally preferable to another; and "0" otherwise. During this exercise, preferential independence tests were conducted to guarantee mutual preferential independence among the CTRs, which is considered a pre-requisite for the calculation of trade-offs (cf. Belton and Stewart, 2002). The ranking obtained is provided in Table III.

Based on Saaty's fundamental scale (see Table II), the next step of the process constructed a matrix of pairwise comparisons in order to calculate the weights or replacement rates between CTRs (i.e. the trade-offs of the model). As shown in Table IV, semantic confirmations were performed to guarantee the consistency of the value

Downloaded by UNIVERSITY OF NEW ENGLAND (AUS) At 03:19 05 March 2018 (PT)

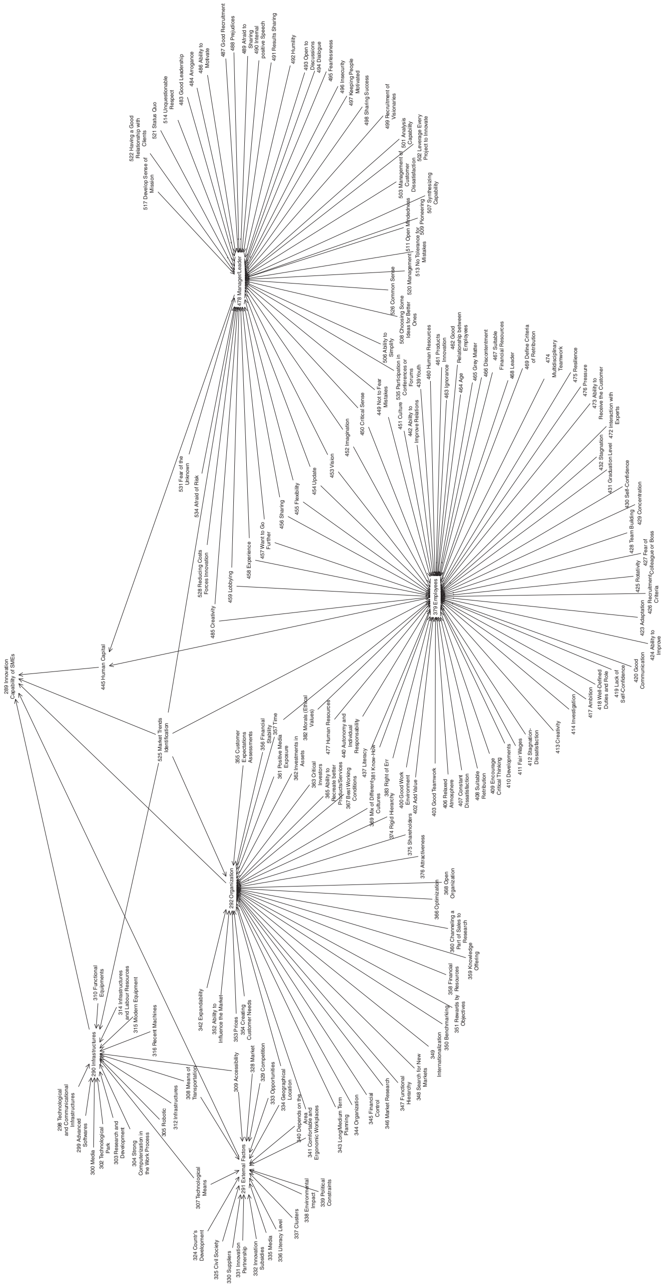


Figure 4.
Collective cognitive map

judgments, namely, the differences in importance between CTRs should increase from left to right and decrease from the top to the bottom of the matrix.

Figure 7 displays the trade-offs obtained using the Super Decisions software (www.superdecisions.com/). These were presented to the panel members for further discussion and validation. The index of inconsistency is 0.03773 (i.e. below 0.10).

As can be seen in Figure 7, the results include a consensual assignment of the lowest weight (i.e. 3.484 percent) to CTR02 and the greatest weight (i.e. 35.993 percent) to CTR04, highlighting how innovation processes need to be expanded through human resources. Having validated the trade-offs, the next step was to define a local scale for each descriptor,

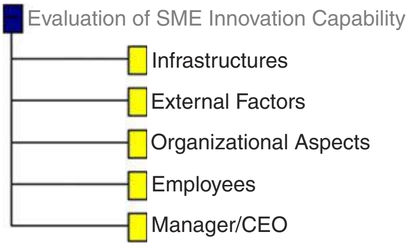


Figure 5. Value tree

Descriptor CTR04			Levels	Description
Extremely Unfriendly Working Environment	1 2 3 4 5 6 7 8	Excellent Working Environment	L1	Index COL ∈ (50-56)
Lack of Communication	1 2 3 4 5 6 7 8	High Quality Communication	Good	Index COL ∈ (41-49)
Non-Payment of Wages	1 2 3 4 5 6 7 8	Suitable and Fair Wages	L3	Index COL ∈ (31-40)
Lack of Multidisciplinary Teams	1 2 3 4 5 6 7 8	Highly Multidisciplinary Teams	Neutral	Index COL ∈ (21-30)
Total Absence of Ethical and Moral Values	1 2 3 4 5 6 7 8	High Presence of Ethical and Moral Values in the Center of Work Teams	L5	Index COL ∈ (14-20)
Incapacity to Create and Develop New Ideas	1 2 3 4 5 6 7 8	High Levels of Creativity	L6	Index COL ∈ (7-13)
Total Incapacity of Accepting Errors	1 2 3 4 5 6 7 8	Wide Receivability of an Error as an Opportunity to Improve		

Figure 6. Descriptor and levels of local performance for CTR04

	CTR01	CTR02	CTR03	CTR04	CTR05	TOTAL	RANKING
CTR01	–	1	0	0	0	1	4
CTR02	0	–	0	0	0	0	5
CTR03	1	1	–	0	1	3	2
CTR04	1	1	1	–	1	4	1
CTR05	1	1	0	0	–	2	3

Table III. Matrix of overall preferences

	CTR04	CTR03	CTR05	CTR01	CTR02	
CTR04	–	1	2	6	8	Positive
CTR03	–	–	1	5	7	Positive
CTR05	–	–	–	4	6	Positive
CTR01	–	–	–	–	4	Positive
CTR02	–	–	–	–	–	Positive

Table IV. Semantic validations and value judgments consistency

Downloaded by UNIVERSITY OF NEW ENGLAND (AUS) At 03:19 05 March 2018 (PT)

Downloaded by UNIVERSITY OF NEW ENGLAND (AUS) At 03:19 05 March 2018 (PT)

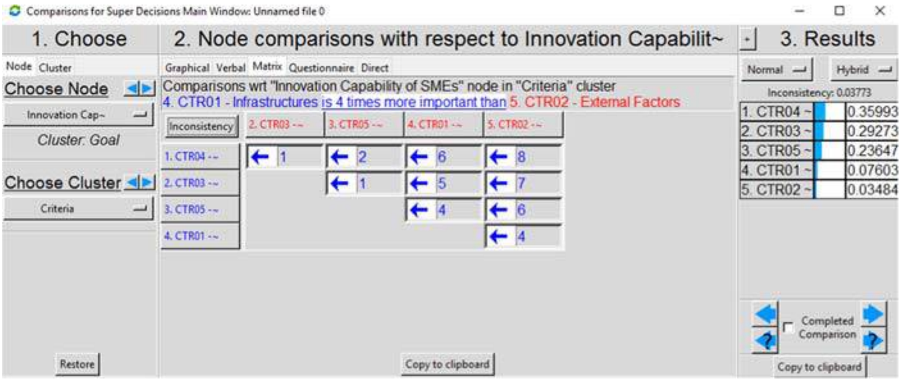


Figure 7.
Judgments matrix and trade-offs between CTRs

which required the group to make pairwise comparisons between the levels of each descriptor and to project value judgments based on Saaty's scale. This technical procedure was essentially similar to the one used to calculate the trade-offs between CTRs. Figure 8 shows an example of the scale of local performance obtained for CTR04. The same procedure was followed for the remaining descriptors, all of which revealed inconsistency indices below 0.10 (for technical details, see Martins *et al.*, 2015).

Having validated the trade-offs between CTRs and obtained local scales of performance for all descriptors, we proceeded to the practical application of the evaluation system created.

4.3 Application of the evaluation system created and recommendations

To assess the consistency of the proposed system of SME innovation capability evaluation, we applied it to a set of 20 SMEs that operate in the Lisbon metropolitan area, in Portugal, and that the participants know. Once the SMEs' partial performances had been assessed, we applied the additive model presented in Equation (7), in which $V(a)$ stands for the overall score of an SME a, w_i is the weight of criterion i, and v_i is the partial performance of the alternative analyzed in criterion i:

$$V(a) = \sum_{i=1}^{n} w_i v_i(a);\ \text{with} \sum_{i=1}^{n} w_i = 1 \text{ and } 0 < w_i < 1 \text{ with } i = 1, \ldots, n. \quad (7)$$

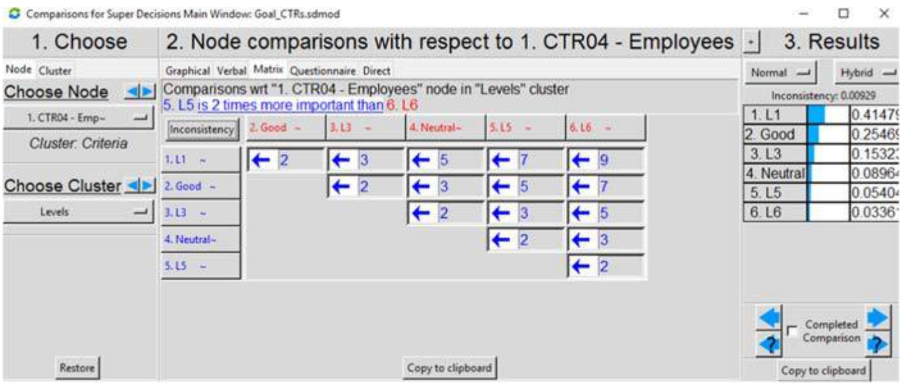


Figure 8.
Judgments and value scale for CTR04

The application of a simple additive model allowed us to calculate an overall score for each SME. Table V shows the impact levels and overall performances of these SMEs, hereafter called "Alphas."

Sensitivity analyses were then conducted to assess the impact of possible changes on the trade-offs, as well as possible changes in the Alphas' relative positions. Table VI provides an example of the sensitivity analysis conducted for CTR04, which was considered the most important criterion by the panel members. The results confirm the stability of the proposed evaluation mechanism in the presence of changes in the weighting of CTR04. As the weight of this criterion increases, there are progressively fewer changes in the Alphas' relative positions (cf. ranking numbers in brackets in Table VI). This exercise was repeated for all the CTRs, which confirmed the robustness of this evaluation system.

The value functions and trade-offs obtained resulted in an overall SME innovation capability index for each Alpha. As shown in Table VII, the SME with highest potential in terms of innovation capability is Alpha 11, with an overall score of 0.39671. Alpha 19 is considered the worst performer, with an overall score of 0.08824.

The assessment mechanism proposed and tested on 20 SMEs (i.e. the Alphas) was thus based on the values and professional experience of a group of experts in SME innovation capability evaluation. Although the sensitivity analyses carried out supported the great satisfaction with the mechanism expressed by the panel members, our framework is, nonetheless, idiosyncratic in nature, meaning that extrapolations without proper adjustments are not recommended. However, the results (i.e. processes followed and ranking obtained) were thoroughly discussed and fully validated by the expert panel, providing a credible, integrative, transparent and well-informed perspective on the decision problem in question.

In addition, by looking at each Alpha's performance profile separately (see Table V), the proposed framework makes the lowest performance levels easily identifiable and, thus, well-focused suggestions for improvement can be formulated. This benefit was considered of extreme importance by the participants involved, one of whom stated that our framework "is more complete than the current approaches to innovation capability evaluation."

	Overall	CTR01	CTR02	CTR03	CTR04	CTR05
Alpha 01	0.33284	0.12898	0.26958	0.25469	0.41479	0.37971
Alpha 02	0.22404	0.12898	0.26958	0.25469	0.25469	0.16329
Alpha 03	0.23411	0.26150	0.26958	0.25469	0.25469	0.16329
Alpha 04	0.18253	0.06338	0.26958	0.25469	0.15323	0.16329
Alpha 05	0.25114	0.26150	0.06381	0.25469	0.25469	0.26559
Alpha 06	0.30780	0.06338	0.46852	0.25469	0.41479	0.26559
Alpha 07	0.13422	0.06338	0.26958	0.08964	0.15323	0.16329
Alpha 08	0.22694	0.26150	0.06381	0.25469	0.25469	0.16329
Alpha 09	0.13169	0.26150	0.06381	0.05404	0.15323	0.16329
Alpha 10	0.17484	0.12898	0.06381	0.15323	0.15323	0.26559
Alpha 11	0.39671	0.26150	0.46852	0.41479	0.41479	0.37971
Alpha 12	0.32286	0.26150	0.46852	0.25469	0.41479	0.26559
Alpha 13	0.32068	0.06338	0.06381	0.25469	0.41479	0.37971
Alpha 14	0.19434	0.12898	0.26958	0.15323	0.25469	0.16329
Alpha 15	0.22694	0.26150	0.06381	0.25469	0.25469	0.16329
Alpha 16	0.18849	0.26150	0.26958	0.15323	0.25469	0.09595
Alpha 17	0.13204	0.12898	0.06381	0.08964	0.15323	0.16329
Alpha 18	0.11112	0.06338	0.06381	0.08964	0.15323	0.09595
Alpha 19	0.08824	0.06338	0.06381	0.08964	0.08964	0.09595
Alpha 20	0.17124	0.12898	0.06381	0.15323	0.25469	0.09595
Weights		0.07603	0.03484	0.29273	0.35993	0.23647

Table V. Impact levels and overall performance for Alphas

Downloaded by UNIVERSITY OF NEW ENGLAND (AUS) At 03:19 05 March 2018 (PT)

Weight	Alpha 01	Alpha 02	Alpha 03	Alpha 04	Alpha 05	Alpha 06	Alpha 07	Alpha 08	Alpha 09	Alpha 10
0.450010	0.076933 (2)	0.051377 (10)	0.053360 (7)	0.042821 (12)	0.058995 (6)	0.070270 (5)	0.031062 (17)	0.052563 (8)	0.030694 (18)	0.042209 (13)
0.500000	0.077187 (2)	0.051275 (10)	0.053135 (7)	0.042019 (12)	0.058419 (6)	0.070938 (5)	0.030991 (17)	0.052387 (8)	0.030646 (18)	0.041445 (13)
0.549990	0.077625 (2)	0.051098 (10)	0.052745 (7)	0.040629 (12)	0.057422 (6)	0.072095 (5)	0.030869 (17)	0.052083 (8)	0.030563 (18)	0.040121 (14)
0.599980	0.078050 (2)	0.050928 (10)	0.052367 (7)	0.039285 (14)	0.056457 (6)	0.073214 (5)	0.030750 (17)	0.051789 (8)	0.030483 (18)	0.038841 (15)
0.649970	0.078461 (2)	0.050762 (10)	0.052002 (7)	0.037984 (14)	0.055523 (6)	0.074297 (5)	0.030636 (17)	0.051504 (8)	0.030406 (18)	0.037601 (15)
0.699960	0.078859 (2)	0.050602 (10)	0.051648 (7)	0.036724 (14)	0.054619 (6)	0.075346 (5)	0.030525 (17)	0.051228 (8)	0.030330 (18)	0.036401 (15)
0.749950	0.079244 (2)	0.050447 (10)	0.051305 (7)	0.035503 (14)	0.053742 (6)	0.076363 (5)	0.030417 (17)	0.050961 (8)	0.030258 (18)	0.035238 (15)
0.799940	0.079618 (2)	0.050297 (10)	0.050973 (7)	0.034319 (14)	0.052893 (6)	0.077348 (5)	0.030313 (17)	0.050702 (8)	0.030187 (18)	0.034111 (15)
0.849930	0.079980 (2)	0.050152 (10)	0.050651 (7)	0.033172 (14)	0.052069 (6)	0.078303 (5)	0.030211 (17)	0.050450 (8)	0.030119 (18)	0.033018 (15)
0.899920	0.080332 (2)	0.050010 (10)	0.050338 (7)	0.032058 (14)	0.051270 (6)	0.079230 (5)	0.030113 (17)	0.050206 (8)	0.030052 (18)	0.031957 (15)
0.949910	0.080674 (2)	0.049873 (10)	0.050035 (7)	0.030977 (14)	0.050494 (6)	0.080130 (5)	0.030018 (17)	0.049970 (8)	0.029988 (18)	0.030927 (15)
Weight	Alpha 11	Alpha 12	Alpha 13	Alpha 14	Alpha 15	Alpha 16	Alpha 17	Alpha 18	Alpha 19	Alpha 20
0.450010	0.091816 (1)	0.073236 (4)	0.075154 (3)	0.044148 (11)	0.052563 (9)	0.035866 (15)	0.031247 (16)	0.026031 (19)	0.021284 (20)	0.038370 (14)
0.500000	0.091144 (1)	0.073719 (4)	0.075518 (3)	0.044496 (11)	0.052387 (9)	0.036729 (15)	0.031165 (16)	0.026274 (19)	0.021049 (20)	0.039077 (14)
0.549990	0.089979 (1)	0.074556 (4)	0.076149 (3)	0.045099 (11)	0.052083 (9)	0.038224 (15)	0.031022 (16)	0.026693 (19)	0.020642 (20)	0.040302 (13)
0.599980	0.088852 (1)	0.075366 (4)	0.076759 (3)	0.045681 (11)	0.051789 (9)	0.039670 (13)	0.030884 (16)	0.027099 (19)	0.020248 (20)	0.041488 (12)
0.649970	0.087761 (1)	0.076150 (4)	0.077349 (3)	0.046245 (11)	0.051504 (9)	0.041070 (13)	0.030751 (16)	0.027492 (19)	0.019867 (20)	0.042635 (12)
0.699960	0.086705 (1)	0.076910 (4)	0.077921 (3)	0.046792 (11)	0.051228 (9)	0.042425 (13)	0.030622 (16)	0.027872 (19)	0.019497 (20)	0.043746 (12)
0.749950	0.085681 (1)	0.077645 (4)	0.078475 (3)	0.047321 (11)	0.050961 (9)	0.043739 (13)	0.030497 (16)	0.028241 (19)	0.019140 (20)	0.044822 (12)
0.799940	0.084689 (1)	0.078358 (4)	0.079012 (3)	0.047834 (11)	0.050702 (9)	0.045012 (13)	0.030375 (16)	0.028598 (19)	0.018793 (20)	0.045865 (12)
0.849930	0.083727 (1)	0.079050 (4)	0.079533 (3)	0.048332 (11)	0.050450 (9)	0.046247 (13)	0.030258 (16)	0.028945 (19)	0.018457 (20)	0.046877 (12)
0.899920	0.082794 (1)	0.079721 (4)	0.080038 (3)	0.048815 (11)	0.050206 (9)	0.047445 (13)	0.030144 (16)	0.029281 (19)	0.018130 (20)	0.047859 (12)
0.949910	0.081887 (1)	0.080372 (4)	0.080528 (3)	0.049283 (11)	0.049970 (9)	0.048608 (13)	0.030033 (16)	0.029608 (19)	0.017814 (20)	0.048812 (12)

Table VI.
Sensitivity analysis for CTR04

5. Conclusion

Given the current global economic climate and the importance of SMEs for national economies, this study sought to develop a multiple criteria framework for the assessment of innovation capability within SMEs. We addressed the first research question posed (i.e. *RQ1*) through the combined use of cognitive mapping and the AHP. This methodological approach was selected because cognitive maps can identify evaluation criteria and the cause-and-effect relationships between them, while the AHP can calculate the trade-offs between these criteria. By following the methodological processes described in this paper, we were also able to answer the second research question (i.e. *RQ2*).

The proposed approach proved a useful way to evaluate SME innovation capability because the resulting collective cognitive map meant that the problem in question was

Downloaded by UNIVERSITY OF NEW ENGLAND (AUS) At 03:19 05 March 2018 (PT)

	Overall score	Ranking
Alpha 11	0.39671	1
Alpha 01	0.33284	2
Alpha 12	0.32286	3
Alpha 13	0.32068	4
Alpha 06	0.30780	5
Alpha 05	0.25114	6
Alpha 03	0.23411	7
Alpha 08	0.22694	8
Alpha 15	0.22694	8
Alpha 02	0.22404	10
Alpha 14	0.19434	11
Alpha 16	0.18849	12
Alpha 04	0.18253	13
Alpha 10	0.17484	14
Alpha 20	0.17124	15
Alpha 07	0.13422	16
Alpha 17	0.13204	17
Alpha 09	0.13169	18
Alpha 18	0.11112	19
Alpha 19	0.08824	20

Table VII. Final ranking of SME innovation capability

Downloaded by UNIVERSITY OF NEW ENGLAND (AUS) At 03:19 05 March 2018 (PT)

structured clearly and the number of omitted criteria reduced. The AHP, in turn, allowed key evaluation criteria to be ordered and weighted. The results included a consensual assignment of the greatest weight (i.e. 35.993 percent) to CTR04 – employees – underlining that innovation processes need to be expanded based on human resources. This is an important point to be taken into consideration. Namely, the economic pressures that companies currently face lead to SME leadership's higher expectations of employees (cf. Mittal and Dhar, 2015).

Although it could be argued that the proposed framework only reflects the perspective of a small group of decision makers, it should be noted that this study is process oriented (see Bell and Morse, 2013; Ferreira, 2016). In addition, the processes followed are flexible enough to accommodate new variables and different weights, allowing the impact of these changes on the overall performance of SMEs to be immediately assessed. Thus, the resulting framework is not only more comprehensive and integrative than many of the evaluation practices currently in use but also better tailored to SMEs, which is often not the case in previous research.

Due to the idiosyncratic nature of the present study's framework, future research could conduct a panel study with a different set of participants and/or in a different country to determine the robustness, reliability and generalizability of the results. Further studies could also use other MCDA methods and carry out comparative analyses (for examples of these methods, see Zavadskas and Turskis, 2011; Dehe and Bamford, 2015). Any improvements or updates of the proposed approach would be a welcome refinement of the process of evaluating the innovation capability of SMEs.

References

Ackermann, F. and Eden, C. (2001), "SODA – journey making and mapping in practice", in Rosenhead, J. and Mingers, J. (Eds), *Rational Analysis for a Problematic World Revisited: Problem Structuring Methods for Complexity, Uncertainty and Conflict*, John Wiley & Sons, Chichester, pp. 43-60.

Bell, S. and Morse, S. (2013), "Groups and facilitators within problem structuring processes", *Journal of the Operational Research Society*, Vol. 64 No. 7, pp. 959-972.

Downloaded by UNIVERSITY OF NEW ENGLAND (AUS) At 03:19 05 March 2018 (PT)

Belton, V. and Stewart, T. (2002), *Multiple Criteria Decision Analysis: An Integrated Approach*, Kluwer Academic Publishers, Dordrecht.

Bhushan, N. and Rai, K. (2004), *Strategic Decision Making: Applying the Analytic Hierarchy Process*, Springer-Verlag, London.

Bullinger, J., Bannert, M. and Brunswicker, S. (2007), "Managing innovation capability in SMEs: the Fraunhofer three-stage approach", *Technology Monitor*, May-June, pp. 17-27.

Canas, S., Ferreira, F. and Meidutė-Kavaliauskienė, I. (2015), "Setting rents in residential real estate: a methodological proposal using multiple criteria decision analysis", *International Journal of Strategic Property Management*, Vol. 19 No. 4, pp. 368-380.

Damart, S. (2010), "A cognitive mapping approach to organizing the participation of multiple actors in a problem structuring process", *Group Decision and Negotiation*, Vol. 19 No. 5, pp. 505-526.

Dehe, B. and Bamford, D. (2015), "Development, test and comparison of two multiple criteria decision analysis (MCDA) models: a case of healthcare infrastructure location", *Expert Systems with Applications*, Vol. 42 No. 19, pp. 6717-6727.

Drucker, F. (1985), *Innovation and Entrepreneurship Practice and Principles*, Harper & Row, New York, NY.

Eden, C. (2004), "Analyzing cognitive maps to help structure issues or problems", *European Journal of Operational Research*, Vol. 159 No. 3, pp. 673-686.

Eden, C. and Ackermann, F. (2001), "SODA – the principles", in Rosenhead, J. and Mingers, J. (Eds), *Rational Analysis for a Problematic World Revisited: Problem Structuring Methods for Complexity, Uncertainty and Conflict*, John Wiley & Sons, Chichester, pp. 21-41.

Eden, C. and Ackermann, F. (2004), "Cognitive mapping expert views for policy analysis in the public sector", *European Journal of Operational Research*, Vol. 152 No. 3, pp. 615-630.

Ensslin, L., Dutra, A. and Ensslin, S. (2000), "MCDA: a constructivist approach to the management of human resources at a governmental agency", *International Transactions in Operational Research*, Vol. 7 No. 1, pp. 79-100.

European Comission (2015), "User guide to the SME definition", available at: http://ec.europa.eu/DocsRoom/documents/10109 (accessed November 17, 2015).

Ferreira, F. (2016), "Are you pleased with your neighborhood? A fuzzy cognitive mapping-based approach for measuring residential neighborhood satisfaction in urban communities", *International Journal of Strategic Property Management*, Vol. 20 No. 2, pp. 130-141.

Ferreira, F. and Jalali, M. (2015), "Identifying key determinants of housing sales and time-on-the-market (TOM) using fuzzy cognitive mapping", *International Journal of Strategic Property Management*, Vol. 19 No. 3, pp. 235-244.

Ferreira, F. and Santos, S. (2016), "Comparing trade-off adjustments in credit risk analysis of mortgage loans using AHP, Delphi and MACBETH", *International Journal of Strategic Property Management*, Vol. 20 No. 1, pp. 44-63.

Ferreira, F., Jalali, M. and Ferreira, J. (2016), "Experience-focused thinking and cognitive mapping in ethical banking practices: from practical intuition to theory", *Journal of Business Research*, Vol. 69 No. 11, pp. 4953-4958.

Ferreira, F., Spahr, R. and Sunderman, M. (2016), "Using multiple criteria decision analysis (MCDA) to assist in estimating residential housing values", *International Journal of Strategic Property Management*, Vol. 20 No. 4, pp. 354-370.

Ferreira, F., Santos, S., Marques, C. and Ferreira, J. (2014), "Assessing credit risk of mortgage lending using MACBETH: a methodological framework", *Management Decision*, Vol. 52 No. 2, pp. 182-206.

Ferreira, F., Spahr, R., Santos, S. and Rodrigues, P. (2012), "A multiple criteria framework to evaluate bank branch potential attractiveness", *International Journal of Strategic Property Management*, Vol. 16 No. 3, pp. 254-276.

Downloaded by UNIVERSITY OF NEW ENGLAND (AUS) At 03:19 05 March 2018 (PT)

Ferreira, F., Jalali, M., Ferreira, J., Stankevičienė, J. and Marques, C. (2015), "Understanding the dynamics behind bank branch service quality in Portugal: pursuing a holistic view using fuzzy cognitive mapping", *Service Business*, Vol. 19 No. 1, pp. 469-487.

Ferreira, F., Marques, C., Bento, P., Ferreira, J. and Jalali, M. (2015), "Operationalizing and measuring individual entrepreneurial orientation using cognitive mapping and MCDA techniques", *Journal of Business Research*, Vol. 68 No. 12, pp. 2691-2702.

Ferretti, V. (2016), "From stakeholders analysis to cognitive mapping and multi attribute value theory: an integrated approach for policy support", *European Journal of Operational Research*, Vol. 253 No. 2, pp. 524-541.

Fiedler, F. (1965), "Engineer the job to fit the manager", *Harvard Business Review*, Vol. 43 No. 5, pp. 115-122.

He, X. (1989), "Application of multiple multivariate statistical analysis to the comprehensive evaluation of economic profits of enterprises (in Chinese)", *Mathematical Statistics and Management*, Vol. 2 No. 1, pp. 14-19.

Hong, Y., Niu, D., Xiao, B. and Wu, L. (2015), "Comprehensive evaluation of the technology innovation capability of China's high-tech industries based on fuzzy borda combination method", *International Journal of Innovation Science*, Vol. 7 No. 3, pp. 215-230.

Howick, S. and Ackermann, F. (2011), "Mixing OR methods in practice: past, present and future directions", *European Journal of Operational Research*, Vol. 215 No. 3, pp. 503-511.

Jalali, M., Ferreira, F., Ferreira, J. and Meidutė-Kavaliauskienė, I. (2016), "Integrating metacognitive and psychometric decision making approaches for bank customer loyalty measurement", *International Journal of Information Technology & Decision Making*, Vol. 15 No. 4, pp. 815-837.

Keeney, R. (1992), *Value-focused Thinking: A Path to Creative Decision Making*, Harvard University Press, Harvard.

Lawson, B. and Samson, D. (2001), "Developing innovation capability in organizations: a dynamic capabilities approach", *International Journal of Innovation Management*, Vol. 5 No. 3, pp. 377-400.

Martins, V., Filipe, M., Ferreira, F., Jalali, M. and António, N. (2015), "For sale… but for how long? A methodological proposal for estimating time-on-the-market", *International Journal of Strategic Property Management*, Vol. 19 No. 4, pp. 309-324.

Mingers, J. and Rosenhead, J. (2004), "Problem structuring methods in action", *European Journal of Operational Research*, Vol. 152 No. 3, pp. 530-554.

Mittal, S. and Dhar, R. (2015), "Transformational leadership and employee creativity: mediating role of creative self-efficacy and moderating role of knowledge sharing", *Management Decision*, Vol. 53 No. 5, pp. 894-910.

Oliveira, M., Ferreira, F., Pérez-Bustamante, G. and Jalali, M. (2017), "Integrating cognitive mapping and MCDA for bankruptcy prediction in small- and medium-sized enterprises", *Journal of the Operational Research Society*, Vol. 68 No. 9, pp. 985-997.

Pawlak, Z. (1982), "Rough sets", *International Journal of Computer & Information Sciences*, Vol. 11 No. 5, pp. 341-356.

Porcaro, D. (2010), "Applying constructivism in instructivist learning cultures", *Multicultural Education & Technology Journal*, Vol. 5 No. 1, pp. 39-54.

Saaty, T. (1980), *The Analytic Hierarchy Process, Planning, Priority Setting, Resource Allocation*, McGraw-Hill, New York, NY.

Saaty, T. (1994), "How to make a decision: the analytic hierarchy process", *Interfaces*, Vol. 24 No. 6, pp. 19-43.

Saaty, T. (2007), "Time dependent decision-making; dynamic priorities in the AHP/ANP: generalizing from points to functions and from real to complex variables", *Mathematical and Computer Modelling*, Vol. 46 No. 7, pp. 860-891.

Downloaded by UNIVERSITY OF NEW ENGLAND (AUS) At 03:19 05 March 2018 (PT)

Saaty, T. (2008), "Relative measurement and its generalization in decision making: why pairwise comparisons are central in mathematics for the measurement of intangible factors – the analytic hierarchy/network process", *Real Academia de Ciencias*, Vol. 102 No. 2, pp. 251-318.

Saaty, T. and Vargas, L. (2006), *Decision Making with the Analytic Network Process, Economic, Political, Social and Technological Applications with Benefits, Opportunities, Costs and Risks*, Springer, New York, NY.

Saaty, T. and Vargas, L. (2012), *Models, Methods, Concepts & Applications of the Analytic Hierarchy Process*, Springer, New York, NY.

Santos, S., Belton, V. and Howick, S. (2008), "Enhanced performance measuring using OR: a case study", *Journal of the Operational Research Society*, Vol. 59 No. 6, pp. 762-775.

Saunila, M. (2016), "Performance measurement approach for innovation capability in SMEs", *International Journal of Productivity and Performance Management*, Vol. 65 No. 2, pp. 162-176.

Weber, M. and Borcherding, K. (1993), "Behavioral influences on weight judgments in multiattribute decision making", *European Journal of Operational Research*, Vol. 67 No. 1, pp. 1-12.

Xu, Y. and Zhang, Y. (2009), "A online credit evaluation method based on AHP and SPA", *Communications in Nonlinear Science and Numerical Simulation*, Vol. 14 No. 7, pp. 3031-3036.

Yang, C., Zhang, Q. and Ding, S. (2015), "An evaluation method for innovation capability based on uncertain linguistic variables", *Applied Mathematics and Computation*, Vol. 256 No. 1, pp. 160-174.

Yin, S., Liu, L. and Hou, J. (2016), "A multivariate statistical combination forecasting method for product quality evaluation", *Information Sciences*, Vol. 356 No. 1, pp. 229-236.

Zavadskas, E. and Turskis, Z. (2011), "Multiple criteria decision making (MCDM) methods in economics: an overview", *Technological and Economic Development of Economy*, Vol. 17 No. 2, pp. 397-427.

Zavadskas, E., Turskis, Z. and Kildienė, S. (2014), "State of art surveys of overviews on MCDM/MADM methods", *Technological and Economic Development of Economy*, Vol. 20 No. 1, pp. 165-179.

Zhang, F. (2011), "Combination evaluation method based on deviation entropy and its application (in Chinese)", *Technology Economics*, Vol. 5 No. 1, pp. 77-79.

Zhao, W. and Zeng, Y. (2011), "Construction and design of evaluation index system of innovative enterprises on innovative capacities", *International Journal of Science and Technology Management Research*, Vol. 21 No. 1, pp. 14-17.

Zopounidis, C., Galariotis, E., Doumpos, M., Sarri, S. and Andriosopoulos, K. (2015), "Multiple criteria decision aiding for finance: an updated bibliographic survey", *European Journal of Operational Research*, Vol. 247 No. 2, pp. 339-348.

About the authors

Bernardo M.S. Castela works in the private sector, where he provides advisory services to help national and international companies and organizations thrive in the varied environments in which they do business. His research interests include sustainability, small- and medium-sized enterprises (SMEs) and decision support systems (DSS).

Fernando A.F. Ferreira is the Vice-Dean for Financial Affairs at the ISCTE Business School of the University Institute of Lisbon, Portugal, and an Adjunct Research Professor at the Fogelman College of Business and Economics of the University of Memphis, TN, USA. He holds a PhD Degree in Quantitative Methods Applied to Economics and Management from the University of Algarve, Portugal. Some of his articles are published by ISI-listed journals such as *Journal of the Operational Research Society*, *Journal of Business Research*, *Management Decision*, *Service Business* and *International Journal of Information Technology & Decision Making*. He has practical experience as group facilitator and his research interests include multiple criteria decision analysis, fuzzy logics and integrated systems for performance measurement.

João J.M. Ferreira is an Associate Professor at the University of Beira Interior (UBI), Portugal. He holds a PhD Degree in Entrepreneurship and Small Business Management from Autonomous University of Barcelona (UAB), Spain. Currently, he is the Scientific Coordinator of the UBI Research

Unit for Business Sciences (NECE), Portugal. He has published over 200 papers in premier international journals, and edited or co-edited several books on innovation and entrepreneurship. His research interests include strategy, competitiveness and entrepreneurship. João J.M. Ferreira is the corresponding author and can be contacted at: jjmf@ubi.pt

Carla S.E. Marques is an Assistant Professor (w/Aggregation) at the Department of Economics, Sociology and Management, University of Trás-os-Montes e Alto Douro (UTAD), Vila Real, Portugal. Currently, she coordinates the "Innovation, Markets and Organization" research group at UTAD's Center for Transdisciplinary Development Studies (CETRAD). Her research on innovation and entrepreneurship has been presented at numerous international conferences and published in premier international journals such as *Service Business*, *Journal of Business Research*, *International Journal of Management and Enterprise Development*, *International Entrepreneurship and Management Journal*, and *Management Research*. Her research interests include innovation, management of change and entrepreneurship.

Downloaded by UNIVERSITY OF NEW ENGLAND (AUS) At 03:19 05 March 2018 (PT)

For instructions on how to order reprints of this article, please visit our website:
www.emeraldgrouppublishing.com/licensing/reprints.htm
Or contact us for further details: **permissions@emeraldinsight.com**