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Measuring SME Resilience Propensity Using Problem Structuring Methods and TOPSIS

Catarina Sofia Dias Vaz

Master in Management

Supervisor:
Doctor Fernando Alberto Freitas Ferreira, Full Professor
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This dissertation has been a journey full of challenges, both intellectual and emotional, yet also full of resilience and perseverance. As I reflect on what led me to this point, I am struck by the lessons learned and the growth experienced along the process. However, this accomplishment would not have been possible without the help and support of some extraordinary people, to whom I am extremely grateful.

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AVALIAÇÃO MULTICRITÉRIO DA RESILIÊNCIA DE PMES COM RECURSO A MÉTODOS DE ESTRUTURAÇÃO DE PROBLEMAS COMPLEXOS E À TÉCNICA TOPSIS

RESUMO

A resiliência desempenha um papel de grande importância nas empresas, permitindo que estas ultrapassem momentos desafiantes e de incerteza. Particularmente para as pequenas e médias empresas (PMEs), a resiliência é crucial, uma vez que estas são mais afetadas devido ao seu tamanho e recursos reduzidos. No entanto, os estudos relacionados com este tópico são ainda limitados e, na sua maioria, não incorporam uma visão holística. Neste sentido, a complexidade e a subjetividade da resiliência nas PME exigem um modelo abrangente para melhor compreender este domínio. No sentido de colmatar esta lacuna, a presente dissertação pretende criar um modelo multicritério para a avaliação da resiliência em PMEs, que permita identificar os critérios que impulsionam e/ou condicionam o seu sucesso. Tendo isso em consideração, foram aplicadas duas metodologias: (1) *Strategic Options Development and Analysis* (SODA), com recurso ao mapeamento cognitivo para estruturar o problema em análise; e (2) a *Technique for Order of Preference by Similarity to Ideal Solution* (TOPSIS) para avaliar alternativas (*i.e.*, PMEs). Os dados necessários para o desenvolvimento deste modelo foram obtidos através das sessões desenvolvidas com um painel de decisores especializados em resiliência nas PMEs. Adicionalmente, para conferir maior robustez ao modelo desenvolvido, o mesmo foi validado por uma entidade externa ao processo com o intuito de obter *feedback* sobre o mesmo e a sua aplicabilidade. É esperado que, para além de colmatar lacunas na literatura, o presente modelo seja utilizado por gestores no processo de tomada de decisão relativamente à resiliência em PMEs.

Palavras-Chave: Mapeamento Cognitivo; Métodos de Estruturação de Problemas Complexos; Pequenas e Médias Empresas (PMEs); Resiliência; *Strategic Options Development and Analysis* (SODA); *Technique for Order of Preference by Similarity to Ideal Solution* (TOPSIS).

Códigos JEL: M10; D81.

MEASURING SME RESILIENCE PROPENSITY USING PROBLEM STRUCTURING METHODS AND TOPSIS

ABSTRACT

Resilience plays a very important role in companies, enabling them to overcome challenging times and uncertainty. Particularly for small- and medium-sized enterprises (SMEs), resilience is crucial as they are more affected in challenging situations due to their reduced size and resources. However, studies related to this topic are still scarce and most of them do not incorporate a holistic perspective. However, the complexity and subjectivity of resilience in SMEs requires a comprehensive model to improve the understanding in this domain. To address this gap, this dissertation aims to create a multi-criteria model for the evaluation of resilience in SMEs, which allows for the identification of the criteria that enhance and constrain their success. In this sense, two combined methodologies were applied: (1) Strategic Options Development and Analysis (SODA), which uses cognitive mapping for problem structuring; and (2) Technique for Order of Preference by Similarity to Ideal Solution (TOPSIS) for evaluation of alternatives (*i.e.*, SMEs). The data needed for the elaboration of this model was obtained through group work sessions with a panel of specialists. In addition, to provide greater robustness to the model developed, it was validated by an external entity to the process to obtain feedback on the model and its applicability. It is expected that, in addition to fill gaps in the literature, this model will be used by managers in their decision-making process regarding resilience in SMEs.

Keywords: Cognitive Mapping (CM); Problem Structuring Methods (PSM); Resilience; Small and Medium Enterprises (SMEs); Strategic Options Development and Analysis (SODA); Technique for Order of Preference by Similarity to Ideal Solution (TOPSIS).

JEL Codes: M10; D81.

EXECUTIVE SUMMARY

The concept of resilience has become increasingly important in business, as this ability assumes a critical role within companies empowering them to navigate and thrive the various challenges and uncertainties faced. In the present business environment, characterized by its dynamics and uncertainties, resilience acts as an indispensable attribute that allows organizations, to not adapt and recover, but even to grow stronger in the face of disruptions. A resilient company possesses the ability to quickly respond to unforeseen circumstances, make strategic adjustments, and seize opportunities, thereby ensuring its sustainability and long-term success. Particularly for small- and medium-sized enterprises (SMEs), being resilient is very important as they face unique challenges due to their size and resources constraints.

Due to the complexity and subjectivity of resilience in SMEs there is the need to find a model that would help enhance the understanding on this topic. Creating a multicriteria analysis model that would assist in the decision-making process is the main objective of this dissertation. The analysis of previous studies allowed us to conclude that there is a limited amount of research focused on the development of resilience in SMEs, and it rarely incorporates a holistic perspective that provides practical insights into the determinants contributing to its success. The model created intends to overcome these limitations using two methodologies (*i.e.*, Strategic Options Development and Analysis (SODA) – based on cognitive mapping – and Technique for Order of Preference by Similarity to Ideal Solution (TOPSIS)) to structure and evaluate the decision problem, respectively.

To achieve the dissertation's primary goal, a panel of specialists with know-how on this study topic was assembled to participate in two sessions. The first session started with a brainstorm kicked off by the following trigger question: *"Considering your knowledge and professional experience, what criteria do you consider relevant in assessing the resilience of SMEs?"*. After several discussions, it was possible to determine 137 criteria for the model, which were divided in seven areas of concern (*i.e.*, clusters), namely: (1) *Human Resources*; (2) *Products and Services Management*; (3) *Finance*; (4) *Relationship with the Market*; (5) *Internal Organization*; (6) *Technological Adaptation*; and (7) *Regulation*. The last step of the session was (re)organize the criteria within each cluster hierarchically. With the data collected,

it was possible to construct a group cognitive map that graphically represents the criteria that influence resilience. The cognitive map was later validated by the experts.

After the conclusion of the structuring phase in the first session, the evaluation phase began in the second session with the panel. The second session started with the specialists defining which cluster was most important for the model, as well as the least important, followed by comparing these clusters with the others, using an importance scale from 1 to 9. This allowed later to calculate the weight of each cluster through Best Worst Method (BWM). Then, choosing the most important criteria within each cluster, we moved on to the application of TOPSIS, with the filling in of eight matrices with 10 SMEs that the panel was aware of. This step was carried out according to the degree of attractiveness of each SME in each cluster/criterion on a scale of 1 to 5. Concluded the second working session, the calculations of the TOPSIS application were made, resulting in a ranking of SMEs, from a global perspective (*i.e.,* inter-cluster analysis) and from a partial perspective of each dimension (*i.e.,* intra-cluster analysis). It should be noted that the model development process and the results obtained were presented to – and validated by – two representatives of *Instituto de Apoio às Pequenas e Médias Empresas e à Inovação – Agência para a Competitividade e Inovação, I.P.* (*i.e.*, IAPMEI), to give obtain feedback on the results and the feasibility of the model. Despite the limitations identified, it is considered that the model developed in this dissertation is relevant to the area and reflects the potential of using multi-criteria techniques in the context of SME resilience.

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MAIN ABBREVIATIONS USED

BWM	– Best Worst Method
CEO	– Chief Executive Officer
DC	– Dynamic Capability
DCV	– Dynamic Capability View
EC	– European Commission
EU	– European Union
GDP	– Gross Domestic Product
GFC	– Global Finance Crisis
IAPMEI	– *Instituto de Apoio às Pequenas e Médias Empresas e à Inovação*
MCDA	– Multi-Criteria Decision Analysis
MS	– Management Science
NGT	– Nominal Group Technique
OECD	– Organization for Economic Co-operation and Development
OR	– Operations Research
PSM	– Problem Structuring Method
RBMI	– Resource-Based Management Initiative
RBV	– Resource-Based View
SAST	− Strategic Assumptions Surfacing and Testing
SC	– Social Capital
SCA	− Strategic Choice Approach
SME	− Small- and Medium-sized Enterprise
SODA	− Strategic Options and Development Analysis
SSM	− Soft Systems Methodology
TOPSIS	− Technique for Order of Preference by Similarity to Ideal Solution
UNDRR	− United Nations Office for Disaster Risk Reduction

CHAPTER 1

INTRODUCTION

1.1. Initial Background

Small- and medium-sized enterprises (SMEs) form the backbone of the European economy (European Commission, 2022), and the Portuguese as well, operating in diverse sectors. They contribute significantly to employment generation, economic growth, and social development. However, they often encounter obstacles that threaten their survival and growth.

In recent years, the business environment has become increasingly complex and volatile, presenting SMEs with numerous obstacles. These challenges can arise from both internal and external factors. More recently, the COVID-19 pandemic has brought unprecedented disruptions to businesses worldwide that tested the resilience of all business, including SMEs.

SMEs are typically characterized by limited resources, thus facing greater vulnerability to these challenges compared to larger corporations. In response to these challenges, resilience has emerged as a key concept for SMEs to thrive, referring to their ability to adapt, recover, and transform in the face of adversity (Saad, Hagelaar, Van der Velde, & Omta, 2021). Resilient SMEs are better equipped to anticipate and respond to market fluctuations, capitalize on emerging opportunities, and mitigate risks.

This dissertation focuses on the development of a comprehensive multicriteria model for assessing resilience in SMEs. The primary objective is to analyze and evaluate the potential of SMEs to develop resilience, while identifying the key determinants and constraints that influence it. By employing a combination of qualitative and quantitative techniques within a constructivist approach, this study aims to overcome the limitations of previous research in this area and design a model that provides SMEs with a holistic view of their performance in resilience.

1.2. Objectives

As explained in the previous point, resilience is crucial for SMEs when facing challenges that threaten their survival and growth, due to their limited resources. This ability allows SMEs to

overcome challenges ensuring long-term viability and success. However, there are not many studies about the assessment of SMEs' ability to develop resilience.

Therefore, the present study aims ***to develop an evaluation model that enables the identification and analysis of the determinants needed to develop resilience in SMEs, through the combined application of complex structuring problems (i.e., Strategic Options and Development Analysis (SODA) (combined with cognitive mapping), and Technique for Order of Preference by Similarity to Ideal Solution (TOPSIS***). Thus, with the application of the mentioned techniques, it will be possible to identify the criteria that will be part of the evaluation model and the measures that enhance or condition the success of resilience in an SME. In fact, these methodologies will allow for the structuring and analysis of the problem in a clear and transparent way, reflecting on possible improvement actions.

In addition to the main objective, several secondary objectives have been outlined to support the achievement of the primary goal. These objectives include: (1) conducting a comprehensive literature review on the topic, providing an overview of the relevant concepts, and identifying previous studies along with their limitations; (2) assembling a panel of experts who has the necessary expertise and are willing to contribute with know-how to the evaluation model; (3) organizing group sessions with the panel of experts to combine their knowledge and construct a cognitive map; (4) applying TOPSIS to prioritize and compare the criteria identified; and (5) consolidating the findings with an external entity, through a session aimed at assessing the applicability of the developed model and formulating recommendations based on the results obtained.

By pursuing these objectives (*i.e.,* primary, and secondary) this study seeks to address the current research gap in evaluating SMEs' resilience, providing practical insights and recommendations to enhance SMEs ability to be resilient.

1.3. Methodology

As stated in the previous points, the complexity of the subject of analysis (*i.e*., SME resilience) seems to be evident. Thus, there is a need to use methodologies that address resilience in a qualitative and quantitative way, also considering subjective and objective aspects, to support the decision-making process in a clear and transparent way. In this sense, SODA and TOPSIS will be combined and applied, based on the knowledge of experts in the area.

In the first phase, with the aim of structuring the decision problem, the SODA approach will be applied in combination with cognitive mapping, through debate within the panel, in which the criteria for the evaluation model will be identified. In the second phase, with the aim of evaluating alternatives (*i.e.*, SMEs), TOPSIS will be applied to prioritize the criteria, enabling the evaluation of the performance of SMEs in terms of resilience development.

It is important to highlight that, to implement the methodologies correctly, it will be necessary to conduct two group sessions with a panel of specialists in the area, to collect the necessary information to develop the model, which will be derived from their knowledge, professional experience, and the ideas arising from the collective discussion. This will allow to build a simple evaluation model to assess different SMEs.

1.4. Structure

This dissertation is formally organized in five chapters. It also includes a list of references and appendices.

In this chapter (*i.e.*, *Chapter 1*), the initial framework of the dissertation is made, the research objectives, the methodological aspects used, as well as the structure defined are presented, and the main results expected. In *Chapter 2*, the literature review is developed, starting with the basic concepts (*i.e.*, SMEs, resilience and SMEs resilience), also identifying the importance of the SME resilience analysis. Additionally, it focuses on the contributions and limitations of some studies already conducted on this topic, and concludes by identifying the general methodological limitations. *Chapter 3* presents the methodological framework of this dissertation, addressing the fundamentals of the techniques that will be applied (*i.e.*, PSM, cognitive mapping and TOPSIS) and elucidating on their application. Also, the contributions of adopting these methodologies in the assessment of resilience in SMEs are identified. Therefore, in *Chapter 4*, the practical application of the techniques will be explained. Furthermore, the two group sessions held with the panel of specialists, the treatment of the data collected, and the analysis of the results obtained will be described in detail. Then, the opinion and improvement suggestions of an external entity to the process will be presented, arising from the third and last session of the study (*i.e.*, consolidation session). This session will be important to analyze the feasibility of applying the designed model in a real context. Finally, *Chapter 5* contains the conclusion, which reflects the results obtained in this study and presents its

limitations, in addition to analyzing the implications of the research for SME management and formulating suggestions for future research.

1.5. Expected Results

Considering the methodological stance of this dissertation, it is expected to result in an evaluation model, clear and concise, based on a multi-criteria decision-making approach, to identify the determinants of resilience in SMEs. This model can support managers by providing a holistic view of SME resilience performance, with useful insights on the dimensions where improvements can be made.

At first, it is expected to get a better understanding of resilience and its importance for SMEs. Then, to develop this model, it is expected to enhance the understanding on the topic, during the process, through the knowledge of the experts, benefiting from their experience and different points of view, to develop realistic solutions that can be adapted to the context of each SME. In addition, it is expected that this dissertation will fill part of the existing gaps regarding the topic of resilience in SMEs, as well as highlight how the combined approach (*i.e.*, SODA and TOPSIS) contributed to the resolution of this complex decision problem (*i.e.*, the analysis of resilience in SMEs). Beyond the academic field, this model is expected to provide a better understanding in the business field, contributing to decision-making processes with clear and adaptable solutions. Finally, we look forward to publishing the results obtained, as a research article, in a scientific journal within the field.

CHAPTER 2

LITERATURE REVIEW

In this chapter, we intend to explore the baseline concepts essential to the topic of this dissertation (*i.e.*, SME resilience evaluation). This will be achieved by performing an analysis of the following concepts: (1) SMEs; (2) resilience; and (3) SME resilience. We will also review previous studies with various methodologies and analyze their limitations and contributions to the overall objective of this dissertation. The results of this study will allow for a better understanding of resilience in SMEs.

2.1. Resilience in Small- and Medium-sized Enterprises

The first formal definition of SME, used in the European Union (EU), was introduced in 1996. In 2003, the definition originally proposed in 1996 was revised and became the definition we know today. In this sense, according to the European Commission (2022, p. 16), SMEs are *"enterprises which have fewer than 250 employees and an annual turnover of less than 50 million euros, and whose balance sheet total is less than 43 million euros"*. This definition only came into effect on the 1st of January 2005 (European Commission, 2015). Since then, the definition of SMEs has been evaluated when relevant, with the last analysis being made in 2021, where it was concluded that *"the definition remains relevant, fit for its purpose, and has been effective in reaching its objectives"* (European Commission, 2021, p. 4).

Despite all the (re)evaluations, the definition has never changed since 2003. Within SMEs, we can divide them in three categories: (1) micro; (2) small; or (3) medium-sized enterprises. Micro-enterprises employ fewer than 10 employees and their annual turnover or annual balance sheet total does not exceed 2 million euros. Small enterprises, in turn, employ fewer than 50 people and their annual turnover or annual balance sheet total does not exceed 10 million euros. Lastly, medium-sized enterprises employ fewer than 250 employees and either have an annual turnover that does not exceed 50 million euros, or an annual balance sheet not exceeding 43 million euros (European Commission, 2015).

It is important to highlight the fact that SMEs constitute a considerable share of the gross domestic product (GDP) and impact the well-being of numerous individuals worldwide (Saad

et al., 2021). The European Commission (2022) also considers them the backbone of the European economy as they contribute significantly to add value, job creation and employment, the last one being 64.4% in Europe. In more detail, SMEs also have a huge impact in the Portuguese economy as they represent 99.9% of the existing firms (Pordata, 2022). With the SMEs comprising most of the Portuguese firms, it becomes crucial to understand their resilience.

In the existing literature, there is a wide variety of definitions regarding resilience. According to Garcia-Dia, DiNapoli, Garcia-Ona, Jakubowski and O'Flaherty (2013, p. 1), *"resilience is a concept that has been applied to research and practice in nearly every possible area of life and academia - from science to sociology, psychology, nursing, and medicine to business and ecology"*. The first ever known definition of resilience was mentioned for the first time in the ecology field by Holling (1973) (*cf.* Gomes, 2015), which contributed to many studies being carried out around the concept. Later, Werner and Smith (1992) (*cf.* Garcia-Dia *et al.*, 2013) conducted studies in the field of psychology, which developments had a significant impact on the concept of resilience. Since then, various definitions have continued to emerge and develop in different areas. However, Williams and Vorley (2017) declare that there is still no agreement on a definition for resilience in the sector of business and management (*cf.* Saad *et al*., 2021).

More recent studies define resilience as *"the ability of systems to absorb and recover from shocks, while transforming their structures and means for functioning in the face of long-term stresses, change, and uncertainty"* (Van der Vegt, Essens, Wahlström, & George, 2015, p. 972). Additionally, after the pandemic hit in 2020, the United Nations Office for Disaster Risk Reduction (UNDRR, 2020, p. 14) released a new report about SME resilience and defined the concept of resilience as *"the ability of a system, community or society exposed to hazards to resist, absorb, accommodate, adapt to, transform and recover from the effects of a hazard in a timely and efficient manner, including through the preservation and restoration of its essential basic structures and functions through risk management"*. Moreover, according to the Organization for Economic Co-operation and Development (*in* Bianchini, & Kwon, 2021, p. 10), *"for businesses, being resilient means having the flexibility to adapt to disruptions and continue their operations"*. Overall, despite small differences between definitions, Garcia-Dia *et al.* (2013, p. 1) states that the common ground between all the definitions can lead us to defining resilience as *"the ability to recover from an altered state"*.

O'Leary (1998), O'Leary and Ickovics (1995), Rutter (1987), Sutcliffe and Vogus (2003) agree that *"resilience is a critical resource for individuals and organizations facing adversity"*

(*cf.* Powley, 2009, p. 1291). We can affirm that resilience is a highly desirable characteristic for companies, whether they are SMEs or not. Although its importance becomes even more pronounced when they are SMEs, as they are particularly affected when exposed to the risks inherent to the environment. Therefore, developing and cultivating resilience becomes crucial for SMEs long-term success and sustainability. The definition of SMEs resilience is stated by Saad *et al.* (2021, p.13) as *"the SME's adaptability to disruptions, growth (positive performance), and their ability to seize the business opportunity amid a challenging business environment"*. According to Tanner, Prayag and Kuntz (2022, p. 1), resilience "can emerge from entrepreneurial and organizational factors". In the next topic, all the reasons for evaluating SMEs resilience will be described and characterized.

2.2. Reasons for SME Resilience Evaluation

During crisis, enterprises are faced with aggravated challenging scenarios, *"such discontinuities can prompt 'emergency' or 'crisis' decision making that is shaped by higher perceived levels of uncertainty, urgency to act, narrowing options, and high-stakes implications for organizational survival"* (Vaaler & McNamara, 2004, p. 687). Nevertheless, Reeves and Whitaker (2020) and Reeves, Hansell, Whitaker and Deegan (2020) hold the conviction that resilience can create the advantage needed during moments of crisis, influencing positively various aspects of a business. The benefits mentioned by the authors are anticipation, lower impact, high recovery speed and, finally, greater recovery extent/outcomes.

First, anticipation is key, as it enables companies to get prepared for a possible crisis scenario, which might help them identify threats faster and possibly act in an earlier stage. Defining proactive measures will prepare them to respond quickly and effectively in a moment of urgency, which can help mitigate the impact and minimize potential damage to the businesses. During a critical situation, the companies who have developed their resilience will have a lower initial impact from the shock compared to other companies because they will be more prepared to resist this kind of events (due to the anticipation mentioned previously). After the crisis, during its recovery process, resilient companies are shown to have the capability to recover from unexpected disruptions rapidly and effectively by promptly recognizing the necessary adaptations required to restore their previous operational performance. This ability is commonly attributed to the presence of diverse organizational structures, an adaptive strategic approach, and a framework that fosters agility. Ultimately, resilient companies will have a

positive outcome: a greater recovery extent demonstrated by their enhanced ability to thrive in a post-crisis environment (Reeves & Whitaker, 2020; Reeves *et al*., 2020). *Figure 2.1* represents the benefits of resilience, by comparing a company that uses resilience principles compared to one that does not.

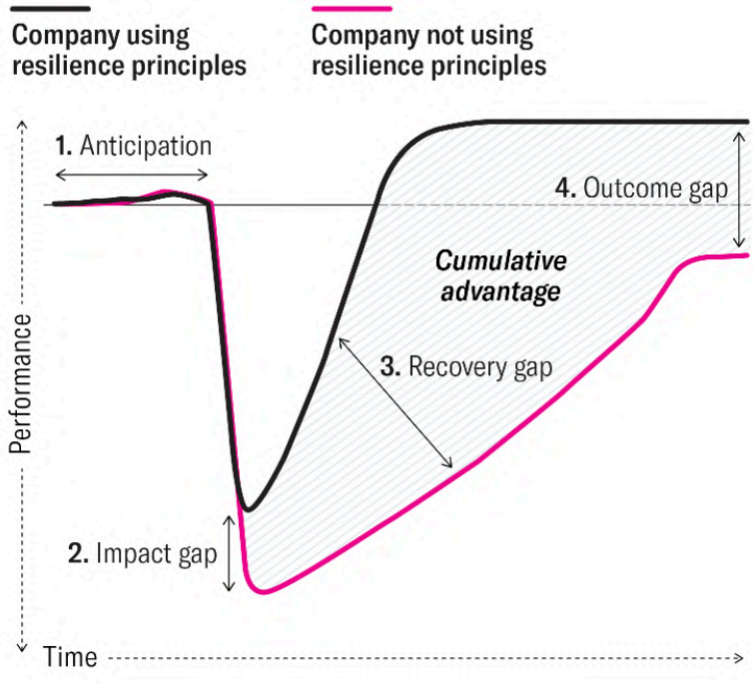


Figure 2.1: Benefits of Resilience.
Source: Reeves & Whitaker (2020).

According to an article published by McKinsey & Company, the challenges of the COVID-19 pandemic made business leaders realize the importance of resilience in moments of crisis as well as the crucial role that strategies play when dealing with unforeseen events. Additionally, this unexpected situation made them acknowledge the effectiveness of their protocols and practices, and what could be improved (Natale, Poppensieker, & Thun, 2022). Further in the same article, the authors Natale *et al.* (2022) confirm the importance of resilience for businesses as *"nearly two-thirds of responding companies said that resilience is central to their organizations' strategic process"*. As per other author perspective, they also agree that the COVID-19 pandemic has significantly influenced the emphasis placed by companies on resilience, as they state, *"made the idea of investing for unforeseen risks less of a sunk cost and more of a necessity — it has given shape, substance and urgency to worst-case-scenario planning"* (Budd, 2020).

Additionally, Natale *et al.* (2022) are aligned with Sheffi and Rice (2005), supporting the idea that being resilient should be a strategic initiative which benefits companies by changing the way they operate in the market, thus increasing its competitive advantage. Similarly, in an article of Harvard Business Review it was stated that *"resilience is not merely an operational consideration — it's a potential strategic advantage that enables companies to capitalize on opportunities when competitors are least prepared"* (Reeves, O'Dea, & Carlsson-Szlezak, 2022).

As mentioned in the previous topic, the effects of challenging and unexpected events are even more evident in the case of SMEs as it is believed that they lack resilience, which makes them more vulnerable to risks and disasters (Branicki, Sullivan-Taylor, & Livschitz, 2018). Besides, their limited capacity, such as financial and human resources, leaves them little room for action in challenging circumstances (Bianchini & Kwon, 2021). For this reason, and given the importance of SMEs in the economy, evaluating their resilience and preparing them for unpredictable events should be a priority.

We have recognized the significance of resilience and its evaluation. In the next topic, we will analyze the studies conducted on the subject and identify their contributions and limitations, which will be considered in this dissertation.

2.3. Previous Contributions and Respective Limitations

According to Alberti, Ferrario and Pizzurn (2018), the topics of resilience and SMEs, both individually and combined (*i.e.*, resilience of SMEs), have gained significant attention from scholars. Nonetheless, these authors stress that this is still an underdeveloped topic for SMEs and that this should be changed. Similarly, Saad *et al.* (2021) agree that researching resilience is essential as it explores vulnerable situations. SMEs are commonly encountered in these circumstances, emphasizing the importance of developing this topic in the business field, especially in the context of SMEs.

In 2008, with the beginning of the global financial crisis (GFC), that lasted until 2012, the frequency of articles published about resilience increased (Annarelli & Noninon, 2016). Due to its severity and extent, GFC was compared to a shocking event where resilience began to develop (Alberti *et al*., 2018). After that, the most critical event that has challenged companies on their resilience is the COVID-19 pandemic, that hit in 2020. This was a triggering point for new articles on this topic to be written. The analysis of resilience in SMEs can be done in several

possible ways. However, the variables highlighted as most relevant diverge from author to author.

Aleksić, Stefanović, Arsovski and Tadić (2013) note that the assessment of organizational potential in SMEs is something that did not exist and there is no widely accepted mathematical model to assess organizational resilience potential. Iborra, Safón and Dolz (2020) analyzed the ability of SMEs to be resilient through ambidexterity and strategic consistency, taking advantage of the most recent crisis event at the time (*i.e.*, GFC that started in 2008) to gather information for their study. After the pandemic, Do, Budhwar, Shipton, Nguyen, and Nguyen (2022), Morris, Morris and Bowen (2022), Khurana, Dutta and Ghura (2022), and Ozanne, Chowdhury, Prayag, and Mollenkopf (2022) examined the resilience of SMEs in this critical scenario. Due to the lockdown which resulted in remote work, the importance of digitalization in businesses has increased exponentially. For that reason, Morris *et al.* (2022) studied the effects of the digital divide on the capacity of SMEs to survive in challenging times. Additionally, Do *et al*. (2022) analyzed the resilience and innovation of SMEs during the coronavirus pandemic and its relationship with resource-based management initiatives (RBMI), taking into consideration the resource-based view (RBV) and dynamic capability view (DCV). Similarly, Ozanne *et al.* (2022) study dynamic capabilities (DC) and social capital (SC) as well as their influence in resilience. Lastly, Khurana *et al.* (2022) combine both topics, the DC and the importance of digital. *Table 2.1* summarizes different studies about resilience, including the name of the author(s) and the year of publication, methods used, and their contributions and limitations.

Table 2.1: Previous Studies About Resilience in SMEs: Contributions and Limitations.

Author(s)	Method	Contributions	Authors' Recognized Limitations
Aleksić e*t al*. (2013)	Fuzzy set approach	▪ The model assesses the relative importance of organizational resilience: (1) factors; (2) values; and (3) potential. ▪ The proposed model identifies the weakest organizational elements that must be improved to create a better business strategy for SMEs.	▪ The model requires well-structured business processes. ▪ Results only represent SMEs in the process industry
Iborra *et al.* (2020)	Hypothesis testing model	▪ Organizational ambidexterity and strategic consistency facilitate the resilience of SMEs. ▪ Organizational ambidexterity has a positive effect on SMEs resistance under critical events and in the recovery of SMEs, when coping and adapting to a new situation. ▪ Strategic consistency does provide a feeling of perseverance, to maintain the strategic identity by helping to achieve the stability needed for resilience.	▪ It was not investigated how SMEs can become and learn to be ambidextrous which, according to the study, is what will help them achieve resilience.
Do *et al*. (2022)	Online survey and statistical analysis	▪ SMEs should invest in RBMI so they can develop organizational learning, as a DC, that helps to innovate and overcome the challenges they might face. ▪ Environmental dynamism is an important tool for structuring a successful organizational learning model. Therefore, SMEs must take this into account in pursuing their RBMI. ▪ Organizational learning, resilience, and innovation are very important for SMEs survival and long-term development.	▪ It was only analyzed data provided directly by the SME highest executives (chief executive officers (CEOs) or managers) so there could be measurement errors or biases. ▪ The generalizability of the results is limited because the study was only applied to Vietnamese SMEs. ▪ Only the subjective measure of firm innovation was used, the objective one was not considered.

Morris *et al.* (2022)	Online questionnaires	▪ Digital divide still exists, rural SMEs can be seen to be disadvantaged competitively against urban SMEs, where there is a greater likelihood of resource availability. ▪ Digital connectivity is essential for businesses to conduct daily tasks, as well as seeking business growth. This is essential at a time of economic difficulty, such as the COVID-19 pandemic, and need to adapt to remote work. ▪ SMEs with less reliable access to digital connectivity and lacking an online presence are likely to be more constrained in their ability to be resilient.	▪ Sample of the survey, variation in the number of answers for rural and non-rural SMEs.
Khurana *et al.* (2022)	Interviews	▪ The research helps defining resilience as a DC at: (1) entrepreneurial level; (2) organizational level; and (3) ecosystem level. ▪ It also contributes to the knowledge about SMEs transformation through digital technologies.	▪ Lack of generalizability in the qualitative research. The data collected was only from India, it is limited to only one region. Given the heterogeneity across ecosystems, both within and across countries, the model should be more generalized. ▪ It was adopted purposeful sampling and only selected organizations that transformed digitally and built resilience. However, it was not examined the absence of which dynamic capability limits the process of digital transformation and inhibits resilience during a period of crisis. ▪ Small sample size.
Ozanne *et al.* (2022)	Cross-sectional survey	▪ Importance of role of both internal and external SC. ▪ Importance of customer-focused SC for SMEs navigating a crisis, whereas previous research has focused on supplier-based SC. ▪ DCs play a key mediating role in SMEs' ability to mobilize SC resources to enhance their organizational resilience. ▪ The study also shows that specifically internal SC has a direct effect on organizational resilience. ▪ The study provides evidence that DCs fully mediate the relationship between external SC and organizational resilience, *i.e.*, there is no direct effect of external SC on organizational resilience.	▪ Primary focus on organizational resilience in the pandemic, which limited the possibility to consider the implications of organizational resilience to enhance the competitiveness of SMEs. ▪ Framed the measurement of internal and external SC in the context of pre COVID-19. ▪ The method used limits generalizability of the results to other types of organizations and disruptions.

As shown in *Table 2.1*, there are some recent studies about resilience, which suggests that it is a topic of interest. Both qualitative and quantitative approaches were adopted in the methodologies used in these studies, contributing in different ways to the topic of resilience. However, after analyzing the articles, it is noticeable that there is a lack of studies that measure SME resilience propensity, since the existing studies do not focus on identifying the determinants that are important for companies' resilience and how to enhance them. Thus, it is important to analyze the general limitations of the existing studies related to this theme.

2.4. Overall Limitations

As mentioned previously, it is possible to perceive that the presented models have some limitations. The limitations of each study have been identified and are specified in the *Table 2.1*.

Saad *et al.* (2021, p. 1) *"conclude that resilience literature is very much varied in its definitions and measurements, and is inconclusive about its influencing factors"*. Hence, there are two limitations that were not identified in the articles above but are relevant and should be addressed: (1) it is not always clear how the determinants (*i.e.*, influencing factors) of SME resilience are identified and integrated in the evaluation mechanisms; and (2) there is some criticism on the way these resilience determinants are calibrated and how the trade-offs of those determinants are calculated. To overcome these limitations, it is important to search for new approaches and methodologies that can overcome this gap in the literature. Taking that into consideration, this dissertation will make use of a combined approach of cognitive mapping and TOPSIS, which will be addressed and developed in the next chapter.

SYNOPSIS OF CHAPTER 2

The challenges of the COVID-19 pandemic made business leaders realize the importance of resilience in moments of crisis and unforeseen events. Nevertheless, enterprises are faced with challenging scenarios every day to which resilience can create the advantage needed. The advantages are even more apparent for SMEs which are more vulnerable to risks than bigger companies and therefore face unique challenges due to their size and limited capacity. For this reason and given the importance of SMEs in the Portuguese and European economy, evaluating the resilience of SMEs and preparing them for unpredictable events should be a priority. Given the relevance of this topic for businesses, especially for SMEs, *Chapter 2* presented a brief theoretical explanation and literature review on the concepts of SME, resilience, and SME resilience, on which this dissertation is based. In this sense, *point 2.1.* began by defining the concepts of resilience and SMEs, both individually and combined (*i.e.*, resilience of SMEs). The definition of resilience has been evolving since 1973 to what we can define as the ability to recover after experiencing changes or disruptions. SMEs are businesses that operate within a defined size range in terms of employees, revenue, and assets. Therefore, resilience in SMEs is characterized as their ability to adapt to disruptions, grow and capitalize on business opportunities in a challenging environment. *Point 2.2.* delved into the reasons for SME resilience evaluations. As described, resilience can create the advantage needed during moments of crisis, positively influencing various aspects of a business. The benefits created by resilience are anticipation, lower impact, high recovery speed, and greater recovery outcomes. Furthermore, in *Point 2.3*, several articles on resilience evaluation were analyzed and their contributions and limitations were presented, concluding that there is a very limited amount of articles on this specific topic. Finally, *point 2.4* aimed to define the overall limitations of these studies. It was determined that these were mainly lack of generalizability and methodological limitations. For the purpose of mitigating the lack of studies along with the methodological limitations encountered, the aim of this dissertation is to develop a model to evaluate the resilience in SMEs. Therefore, this dissertation will adopt a comprehensive approach that combines cognitive mapping and TOPSIS. *Chapter 3* will detail the description of this combined methodology.

CHAPTER 3

METHODOLOGICAL BACKGROUND

To study the resilience in SMEs, it is necessary to create a model that will help structure and evaluate those effects. To overcome the general limitations presented in the previous chapter, this dissertation will use the following methodologies: (1) Problem Structuring Methods (PSMs), namely cognitive mapping; and (2) TOPSIS. After deepening the characteristics and the application of these methodologies, we will evaluate the value that they add to SME resilience evaluation.

3.1. Problem Structuring Methods

In the modern world, the dynamic and uncertainty of our days make planning and management increasingly challenging. Therefore, the challenges that arise are complex and demand the implementation of effective problem-solving methods. Among these, PSMs have gained considerable popularity to address such complex problems. However, the concept of PSMs only emerged in the 1970s as a response to a crisis in the research fields of management science (MS) and operations research (OR). Since it was held as a belief that the existing quantitative OR techniques were inadequate to address the complex social issues encountered by organizations (Kirby, 2007).

The traditional OR, also called "hard OR", were used to solve well-structured problems that could be expressed through mathematical expressions, to achieve optimization and objectivity. However, not every problem can be transformed into a mathematical formula (Júnior & Schramm, 2021). More complex problems with *"multiple actors, differing perspectives, partially conflicting interests, significant intangibles and perplexing uncertainties"* (Rosenhead, 2006, p. 762) and less well-structured (Hall & Hess, 1978) could no longer be solved by "hard OR". In line with this belief, Ackoff (1979, p. 103) states that OR will not survive if the methods do not change radically, because *"there is a greater need for decision-making systems that can learn and adapt effectively than there is for optimising systems that cannot"*.

As mentioned, the traditional OR needed a change, and that change was the implementation of PSMs, a new branch in OR also known as "soft OR" (Júnior & Schramm, 2021). Contrarily to the traditional quantitative approach, PSMs introduced an alternative framework for problem-solving as they emphasize a qualitative perspective (Rosenhead, 1989; Rosenhead & Mingers, 2001). Focused on understanding the complexity and context of the problem at hand, this alternative perspective adopts a holistic approach (Checkland, 1981) that prioritizes the examination of multiple perspectives. According to Rosenhead (1996), decisions-makers may be more predisposed to resort to these methods, as they accommodate multiple alternative perspectives that can facilitate the negotiation of several individuals and function through interaction and iteration.

Usually, these approaches are based on the active involvement of individuals directly affected by the problem, relying on the input and engagement of those who have firsthand experience with the issue at hand. By being adaptable and open to different viewpoints, PSMs create a formal framework that can effectively capture and integrate the varied perspectives of stakeholders involved. As participants internalize and adjust to each other's contributions, new formulations of the problematic situation will emerge, leading to further modeling and structuring activities. A successful implementation of a PSM will lead to the group of decision-makers to have: (1) the confidence and capability to take action; (2) enhanced understanding of the problem area; and (3) improved relations within the group (Rosenhead, 2013).

As *"a broad group of model-based problem handling approaches"* (Rosenhead, 1996, p. 117), the "soft OR" gives managers different alternatives to solve their decision problems with the opportunity to alternate between methods or even combine more than one when solving a problem, this last practice is known as multimethodology (Mingers & Rosenhead, 2004). Among the many existing PSMs, Soft Systems Methodology (SSM), Strategic Choice Approach (SCA) and SODA have gained significant popularity and widespread adoption (Rosenhead, 2013).

SODA, in particular, is a PSM that uses cognitive mapping as a modelling tool (*cf.* Eden & Ackermann, 2010). This approach will be particularly relevant for this dissertation, as it leverages cognitive mapping techniques that facilitates the structuring and comprehension of decision problems by promoting dialogue and collaboration among decision-makers (Eden & Ackermann, 2004; Ackermann, 2012). Moreover, it allows for the reorganization and integration of diverse ideas and perspectives, enabling a more comprehensive understanding of the problem at hand. In the upcoming topic, we will delve deeper into the concepts of human

cognition and cognitive mapping as they will play a crucial role in the structuring phase of this dissertation.

3.2. Human Cognition and Cognitive Mapping

Understanding how individuals process information, make choices, and interpret data is crucial for businesses striving to optimize their operations, as human cognition is a vital factor that significantly impacts decision-making, problem-solving, and overall performance in the business area.

Human cognition can be defined as *"a complex process that results from the interaction between the sensorimotor system and neurological structures responsible for individuals' cognitive system"* (Grillo, Ferreira, Marques, & Ferreira, 2018, p. 699) or simply *"the mechanism through which human beings acquire, organize, and learn to use knowledge"* (Rodrigues, Ferreira, Teixeira, & Zopounidis, 2022, p. 5). At first, it was assumed that human cognition existed exclusively at the individual level. However, it was found that it could also exist at the organizational level and has proven to be very important in strategic management (Rodrigues *et al*., 2022). Nevertheless, the transition from abstract cognition to tangible reality necessitates an effective mechanism, thus cognitive mapping assumes a crucial role. The outcome of this technique is used as a visual tool (*i.e.*, cognitive maps) in the process of transforming thoughts and mental models into actionable steps and concrete outcomes (Ferreira, Jalali, Zavadskas, & Meidutė-Kavaliauskienė, 2017).

The concept of cognitive mapping was first mentioned in the field of psychology by Tolman (1948), who intended to understand how cognitive maps helped humans to find their way in challenging environments using laboratory rats (*cf.* Fu, Lomas, & Inskip, 2022). Although the conceptual foundation of cognitive mapping can be traced back to an earlier period, it wasn't until the late 1970s that the concept was studied in other areas (Eden, 1988). Axelrod (1976) played a crucial role in exploring the representation of concepts and their interconnectedness through graphical models (*i.e.*, cognitive maps), used to describe knowledge in political and social sciences and illustrate the cause-and-effect relationships among different elements within that specific context. Cognitive mapping can now be defined as *"a process of using past knowledge and experience to understand and deal with current and future situations"* (Fu *et al.*, 2022, p. 2), promoting brainstorming. Renowned as a powerful structuring tool, it addresses the complexity and subjectivity associated with decision-making

processes (Ferreira, Meidutė-Kavaliauskienė, Zavadskas, Jalali, & Catarino, 2018). This mental process consists of five steps: (1) acquiring; (2) coding; (3) storing; (4) recalling; and (5) decoding knowledge, ultimately resulting in the creation of a cognitive map (Fu *et al.*, 2022).

Eden (2004, p. 673) defines cognitive map as *"the representation of thinking about a problem that follows from the process of mapping"*. Carlucci, Schiuma, Gavrilova and Linzalone (2013) propose that cognitive maps serve two primary purposes. First, they serve a descriptive function by visually representing information, helping to structure decision-making processes and create possible solutions. Second, cognitive maps act as a support system for decision-making, facilitating the generation and elaboration of ideas (*cf.* Santos, Ferreira, Zavadskas, & Meidutė-Kavaliauskienė, 2018).

The visual representation of individuals' beliefs (*i.e.*, cognitive maps) uses nodes to represent concepts and arrows to illustrate the cause-and-effect relationships between those concepts. When there is a positive influence between concepts, it is represented by a plus sign (+). Contrarily, when there is a negative influence, it is represented by a minus sign (–) on the arrow (Eden, 2004; Ferreira *et al.*, 2017). Moreover, Eden (2004) suggests that cognitive maps should be structured hierarchically and divided in three parts. On the top of the map are the objectives, in the middle the strategic issues, and in the bottom are the potential actions. *Figure 3.1* exemplifies part of a cognitive map.

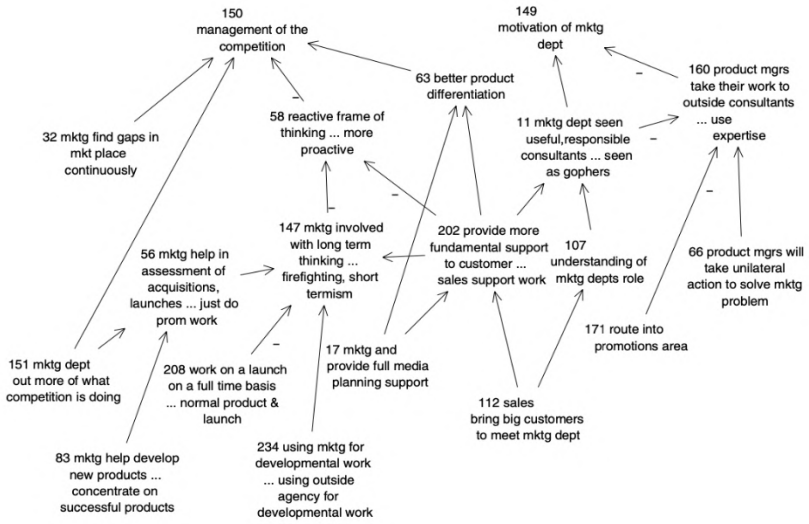


Figure 3.1: Partial example of a cognitive map.

Source: Eden (2004, p. 675).

To obtain a map similar to the one shown in *Figure 3.1*, Lee and Kim (1997) suggest that there are three steps that must be followed: (1) clarify and understand the purpose for building

the map; (2) determine the relevant factors, which may influence the decision; and (3) find causal relationships among the factors identified in the previous step. According to Rosenhead (2013), this method can be implemented through individual interviews or group workshops. In the individual interview approach, stakeholders are interviewed separately to obtain their perspectives on the problem. During these interviews, participants are asked to express the concepts they use to understand the problem and the causal links they perceive between those concepts. The information collected from these interviews is then translated into individual maps that represent each participant's cognitive understanding of the problem. The maps drawn from separate interviews are merged into a single map that reflects the collective understanding of the stakeholders about the problematic situation. Notably, there is a faster version commonly known as the "post-its technique" that is performed in group (Ackermann & Eden, 2001). The participants use post-it notes to write their concepts, which are then collectively organized by the moderator into a structure (*i.e.*, cognitive map) agreed upon by the workshop members.

Certainly, cognitive maps have their limitations. According to Eden (2004), the subjectivity of the interviewees could be perceived as a potential drawback. However, the benefits of using this technique outweigh the existing disadvantages. Overall, cognitive maps have proven to be extremely useful in clarifying the decision-making process as they can: (1) facilitate and promote the debate between decision-makers involved in the process; (2) reduce the likelihood of omitting important criteria; and (3) promote progressive learning, based on an in-depth understanding of the causal relationships between the criteria (Ferreira, Spahr, Santos, & Rodrigues, 2012). The interactive nature through which cognitive maps are created, their flexibility and ease of use are also particularly valuable (Ferreira *et al*., 2017).

Is important to highlight that the elaboration of cognitive maps should not be the last step in the decision-making process. The maps are used as a structuring method to enable a more transparent process of selecting and/or defining evaluation criteria (Silva, Ferreira, Carayannis, & Ferreira, 2021). The following topic will detail the next step in the decision-making process, the evaluation phase, as well as the technique chosen to be implemented in this phase.

3.3. The TOPSIS Method

The decision-making process consists of three main phases: (1) structuring; (2) evaluation; and (3) recommendations (Bana e Costa, Ensslin, Cornêa, & Vansnick, 1999). Having covered the structuring phase in the two previous points, now this topic will describe the evaluation phase.

The TOPSIS takes part of a major group of methods, known as Multi-Criteria Decision Analysis (MCDA) methods. These methods are grounded on a constructivist stance, which acknowledges the importance of incorporating both subjective and objective aspects when addressing complex and multidimensional decision problems (Silva *et al*., 2021). Nevertheless, out of the many MCDA methods that exist, TOPSIS stands out as one of the most widely recognized and commonly employed (Magableh & Mistarihi, 2022).

TOPSIS was developed by Hwang and Yoon (1981) and later improved by Yoon (1987), with the aim of enabling decision-makers to measure and compare the performance of various alternatives, through simple and direct calculations, leading them to the optimal solution (Jiang, Lin, Luo, & Shao, 2022). The distinctive characteristic of this technique involves the identification of two reference points: (1) a positive solution (closest to the ideal solution); and (2) a negative solution (farthest from the ideal solution). TOPSIS then determines the best alternatives by minimizing the distance to the positive ideal solution and maximizing the distance to the negative ideal solution. Afterwards, the order of preference among alternatives is determined by comparing their Euclidean distances. Lastly, the alternatives are ranked and the optimal solution is found (Ramasamy, Subramanian, Varadarajan, Ramaswamy, Kaliappan, Arulmozhi, Srinivasan, & Gubendiran, 2020).

To compute the TOPSIS method, it is necessary to follow some steps (Ramasamy *et al.*, 2020; Magableh & Mistarihi, 2022), outlined below:

Step 1: Build the decision matrix (D) of the alternatives and criteria, $m \times n$, where the elements in the matrix are denoted by x_{ij}. The elements of the matrix (x_{ij}) represent the performance of a specific criteria (C_j) for a specific alternative (A_i), where $i = 1, 2, \ldots, m$ and $j = 1, 2, \ldots, n$. The matrix created by the decision maker(s) is presented as in *Equation* (1):

$$D = \begin{bmatrix} x_{11} & x_{12} & \cdots & x_{1n} \\ x_{21} & x_{22} & \cdots & x_{2n} \\ \vdots & \vdots & \ddots & \vdots \\ x_{m1} & x_{m2} & \cdots & x_{mn} \end{bmatrix}. \quad (1)$$

Step 2: Normalize the decision matrix D, using *Equation* (2) to compute the normalized values (r_{ij}). R represents the normalized decision matrix, presented as *Equation* (3):

$$r_{ij} = \frac{x_{ij}}{\sqrt{\sum_{i=1}^{n} (x_{ij})^2}}, \quad (2)$$

$$\mathrm{R} = \begin{bmatrix} r_{11} & r_{12} & \cdots & r_{1\mathrm{n}} \\ r_{21} & r_{22} & \cdots & r_{2\mathrm{n}} \\ \vdots & \vdots & \ddots & \vdots \\ r_{\mathrm{m}1} & r_{\mathrm{m}2} & \cdots & r_{\mathrm{mn}} \end{bmatrix}. \quad (3)$$

Step 3: Construct the weighted normalized decision matrix (*V*), presented as in *Equation* (5), by multiplying the normalized decision matrix values (r_{ij}) by its related importance weights ($\sum_{i=1}^{n} w_i = 1$). The weighted normalized value (v_{ij}) is computed as indicated in *Equation* (4):

$$v_{ij} = w_{ij} \times r_{ij}, \quad (4)$$

$$\mathrm{V} = \begin{bmatrix} v_{11} & v_{12} & \cdots & v_{1\mathrm{n}} \\ v_{21} & v_{22} & \cdots & v_{2\mathrm{n}} \\ \vdots & \vdots & \ddots & \vdots \\ v_{\mathrm{m}1} & v_{\mathrm{m}2} & \cdots & v_{\mathrm{mn}} \end{bmatrix}. \quad (5)$$

Step 4: Determine the positive ideal (A^{+}) and negative ideal (A^{-}) solutions, as provided in *Equation* (6) and (7) respectively.

$$A^{+} = \{v_1^{+}, v_2^{+}, \ldots, v_n^{+}\} = \left\{ \left(max\ v_{ij} | j \epsilon J \right) \right\}, \quad (6)$$

$$A^{-} = \{v_1^{-}, v_2^{-}, \ldots, v_n^{-}\} = \left\{ \left(min\ v_{ij} | j \epsilon J \right) \right\}, \quad (7)$$

The set of positive ideal (A^{+}) and negative ideal (A^{-}) solutions are, respectively, the bigger and smaller weighted normalized values (v_{ij}) in each column of matrix V.

Step 5: Use the Euclidean approach to determine the distance from the weighted normalized values (*i.e.*, values of matrix *V*) to the positive ideal solution ($S_i{}^{+}$) and the distance from the values of matrix *V* to the negative ideal solution ($S_i{}^{-}$) ideal solutions, illustrated in *Equation* (8) and *Equation* (9), respectively:

$$S_i{}^{+} = \sqrt{\sum_{i=1}^{n} (v_{ij} - v_j{}^{+})^2}, \quad (8)$$

$$S_i{}^{-} = \sqrt{\sum_{i=1}^{n} (v_{ij} - v_j{}^{-})^2}. \quad (9)$$

Step 6: Calculate the relative closeness to the ideal solution (C_i^+), using the Euclidean distances from the ideal best and ideal worst. The relative closeness of A_i with respect to A^+ is defined as in by *Equation* (10):

$$C_i^+ = \frac{S_i^-}{(S_i^+ + S_i^-)}, 0 \leq C_i^+ \leq 1. \quad (10)$$

Step 7: Rank the alternatives in descending order, where the alternative having the highest relative closeness value receives the best rank. The bigger the C_i^+ value, the better performance of the alternatives. When $C_i^+ = 1$, it means that the corresponding alternative is in absolute proximity to the ideal solution. On the other hand, when $C_i^+ = 0$, it indicates that the alternative is in absolute proximity to the negative ideal solution.

After describing the computing process, let us now delve into the advantages TOPSIS offer. This technique has proven to be a very valuable evaluation tool when ranking alternatives due to: (1) its simplicity, the process is simple and logical; (2) its basic mathematized form that is easy to compute; (3) its efficiency, regardless the number of alternatives, the number of steps remains the same; (4) its application in different areas; and (5) its ability to overcome the ambiguity inherent in decision-making (Amorocho & Hartmann, 2022; Velasquez & Hester, 2013; Magableh & Mistarihi, 2022; Ramasamy *et al.*, 2020). However, from Velasquez and Hester's (2013) perspective, the use of Euclidean distance is a disadvantage because it does not consider the correlation of attributes. Despite that, the TOPSIS method has been successfully applied in numerous studies addressing complex problems, and has consistently produced outstanding results (Ramasamy *et al.*, 2020). The next topic will address the added value that the discussed decision-making techniques (*i.e.*, cognitive mapping and TOPSIS) bring to the evaluation of SME resilience.

3.4. Added Value to SME Resilience Evaluation

As discussed in *Chapter 2*, resilience in SMEs can be considered a complex decision problem. It is characterized by uncertainty, since resilience is influenced by numerous factors that are subject to constant change. Moreover, the complexity of this topic is further heightened by the diverse types and contexts in which SMEs operate, along with the range of stakeholders involved.

Throughout this *Chapter 3*, it has been noticeable that both PSMs as well as TOPSIS offer numerous advantages when applied in complex decision-making situations. Therefore, the application of these techniques could be beneficial for this field of study, specifically for the creation of a model to assess the resilience in SMEs. To develop this model, it is crucial to have a constructivist perspective, considering both subjective elements (*i.e.*, cognitive maps) and objective elements (*i.e.*, TOPSIS analysis) of the decision-making process.

The selected PSM technique for the model building process (*i.e.*, SODA) uses cognitive maps to facilitate decision-making. It is highly effective tool that enables the structuring of problems and visual representation of the information, considering various perspectives. Through the utilization of cognitive mapping, it becomes possible to identify the evaluation criteria to assess resilience in SMEs. TOPSIS, in turn, transforms subjective evaluation criteria into concrete values. This evaluation technique enables the identification of an optimal solution, considering the best and worst solutions. In this case, TOPSIS identifies both the most favorable and unfavorable evaluation criteria that impact resilience. As a result, the optimal criteria required to achieve resilience is determined. Furthermore, TOPSIS enables the ranking of SMEs based on their performance, facilitating the identification of superior SMEs in terms of resilience. By combining the cognitive mapping capabilities of SODA and the features of TOPSIS, this model will allow managers to have a holistic understanding of the factors influencing resilience. As a result, this knowledge will empower them to leverage resilience effectively and take proactive measures to prepare for potential crisis situations. Once the theoretical and methodological framework have been established, the next chapter materializes the empirical component, involving the development of the model that has been described.

SYNOPSIS OF CHAPTER 3

In today's dynamic and interconnected world, we often find ourselves confronted with complex problems that defy simple solutions. These complex problems are characterized by multiple perspectives, involving numerous interdependent factors and unpredictable outcomes. They require a holistic approach to understanding and overcome them. Therefore, *Chapter 3* described two methodologies that will be used to support the decision-making process, when structuring and evaluating the problem. Additionally, is presented their added value to the study of resilience in SMEs. In *point 3.1*, PSMs are described as a qualitative approach to problem-solving that prioritizes the examination of multiple perspectives and is focused on understanding the complexity and context. This approach emerged due to a crisis in the traditional OR, filling the gap that quantitative approach (*i.e.*, traditional OR) had in solving complex-problems. Among the many existing PSMs, SODA was the chosen method. *Point 3.2* delves in human cognition and the cognitive mapping capabilities of SODA. Human cognition is defined as a complex neurological process through which individuals acquire, organize, and learn how to use knowledge. This being an abstract process, it is necessary a mechanism to make the process tangible. Thus, cognitive mapping assumes a crucial role with cognitive maps being used as a visual tool in the process of transforming thoughts into actionable concrete outcomes. This methodology will be used to structure the problem by enhancing the brainstorm between the decision-makers and visually representing the problem. The next step is evaluating the criteria defined in the structuring phase. In *point 3.3*, the methodology used in the evaluation phase is described. TOPSIS was the chosen methodology that aims to enable decision-makers to measure and compare the performance of various alternatives, through simple and direct calculations (*i.e.*, 7 steps) leading them to the optimal solution. This evaluation tool has proven to be valuable when ranking alternatives due to its simplicity and efficiency. Finally, in *point 3.4*, the value that cognitive mapping and TOPSIS add to the assessment of resilience in SMEs was discussed. Overall, this model is constructed based on a constructivist perspective, considering both the subjective elements (*i.e.*, cognitive maps) and the objective elements (*i.e.*, TOPSIS analysis) of the decision-making process which allows decision-makers to have a holistic understanding of the factors influencing resilience. *Chapter 4* will begin the empirical component of this dissertation, focused on the resilience evaluation of SMEs.

CHAPTER 4

RESULTS AND ANALYSIS

After presenting the methodology of the study in the previous chapter, the empirical component will now be presented. As the objective of this dissertation is the creation of an evaluation model concerning the resilience of SMEs, it is now important to refer the steps followed for the development of this model. In this sense, the model is developed through two group sessions with a panel of specialists, applying: (1) cognitive mapping, in the problem structuring phase; and (2) TOPSIS, in the evaluation phase. Finally, a consolidation session of the results will also be presented, carried out with the objective of evaluating the results and the model's practical applicability.

4.1. Cognitive Structure and Criteria Selection

As mentioned in *Chapter* 3, PSMs are a valuable tool to structure complex decision problems. This dissertation applies the SODA methodology, that use cognitive mapping as a graphical representation to obtain and record the perspective of individuals regarding a specific problem (Ackermann, 2012). Commonly known as the structuring phase, this stage is of great importance within the entire process, as this is where the elements that will be evaluated during the decision-making process (*i.e.*, criteria) are defined (*cf.* Ferreira, 2011).

According to Eden and Ackermann (2004, p. 618), *"SODA workshops are designed for small groups (ideally of 6–10 key individuals) to work on taking forward the issue(s) as defined by the participants through their [cognitive] maps"*. Grounded on this guideline, it was created a panel of specialists composed of seven experts: (1) *"who operate, supervise, or 'know' the system* [of SMEs] *and how it behaves under different circumstances"* (Yaman & Polat, 2009, p. 386); (2) heterogeneous in terms of gender, age and professional experience; and (3) were available to participate in two sessions to share their know-how. To simplify the process of scheduling the sessions and make it more convenient for the participants, both meetings were held online (*i.e.*, Microsoft Teams).

The first session had a duration of four hours and was divided into three phases, which were developed in the *Miro* platform (www.miro.com). Besides the seven members of the panel, two

facilitators were present in the session to assist in the debate if needed, as well as to record some moments. Before starting the debate, the specialists introduced themselves to the group, who were then provided with a brief explanation about the aim of the study and the methodologies that were going to be used (*i.e.*, cognitive mapping), as well as some instructions on how to navigate the Miro platform, enabling them to edit the document.

The first phase of the session kicked off with a trigger question to initiate the brainstorming: *"Considering your knowledge and professional experience, what criteria do you consider relevant in assessing the resilience of SMEs?"*. The participants were encouraged to express their personal ideas and share professional experiences, using virtual post-it notes on the *Miro* platform. The application of the "post-its technique" (Ackermann & Eden, 2010) provided a collaborative and interactive environment for gathering insights and knowledge. Each post-it note could only have one concept/idea and a positive (+) or negative (–) sign, depending on whether the criterion would, respectively, promote or condition SMEs resilience (Faria, Ferreira, Jalali, Bento, & António, 2018). At the end of this phase, the decision-makers gathered a total of 137 criteria that, in their opinion, influence resilience in SMEs.

During the second phase of this group session, the decision-makers were requested to collaborate to assemble the post-its (*i.e.*, decision criteria) with similar characteristics into groups (*i.e.*, clusters). Based on an extensive discussion process, this exercise resulted in the definition of seven clusters, namely: (1) *Human Resources*; (2) *Products and Services Management*; (3) *Finance*; (4) *Relationship with the Market*; (5) *Internal Organization*; (6) *Technological Adaptation*; and (7) *Regulation*.

Lastly, in the third phase, the specialists collaborated once more – this time to reorganize the criteria within each cluster according to their perceived level of importance, *"following a means-end-based logic following a means-end-based logic (i.e., taking into account each criterion's relevance and impact on the others)"* (Ferreira, Marques, Bento, Ferreira, & Jalali, 2015, p. 2693). Based on this logic, the clusters were organized in three distinct parts: (1) the most important criteria at the top; (2) the intermediate criteria in the center; and (3) the least important criteria at the bottom. The session ended when the clusters were finally reorganized. *Figure 4.1.* shows some moments of the three phases of the first group session.

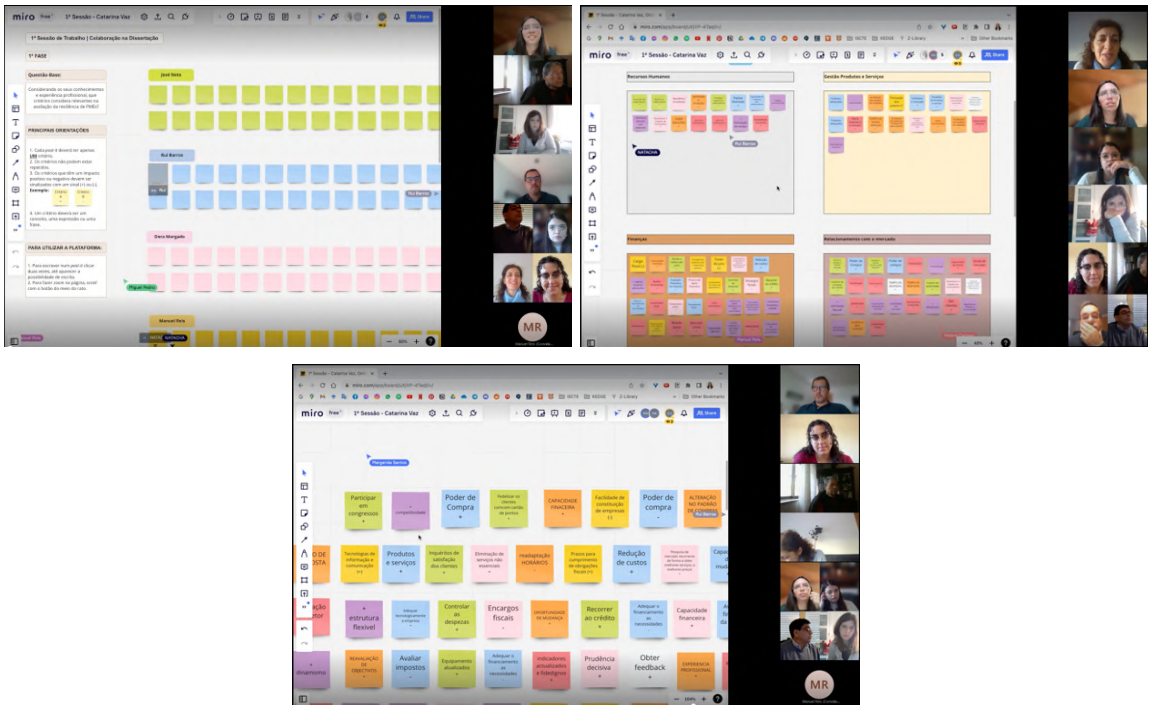


Figure 4.1: Moments of the First Group Session.

After the first session, the post-its were reviewed to correct spelling mistakes and eliminate criteria written in the same way and/or with the same meaning, without ever changing the meaning of what had been written by the specialists. Once the changes were made, the *Decision Explorer* software (www.banxia.com) was used to create the group cognitive map.

At the beginning of the second group session, the panel of experts was presented with the group's cognitive map for validation, with the possibility of making changes if they considered it necessary. The map presented in *Figure 4.2* is the final version approved by the panel.

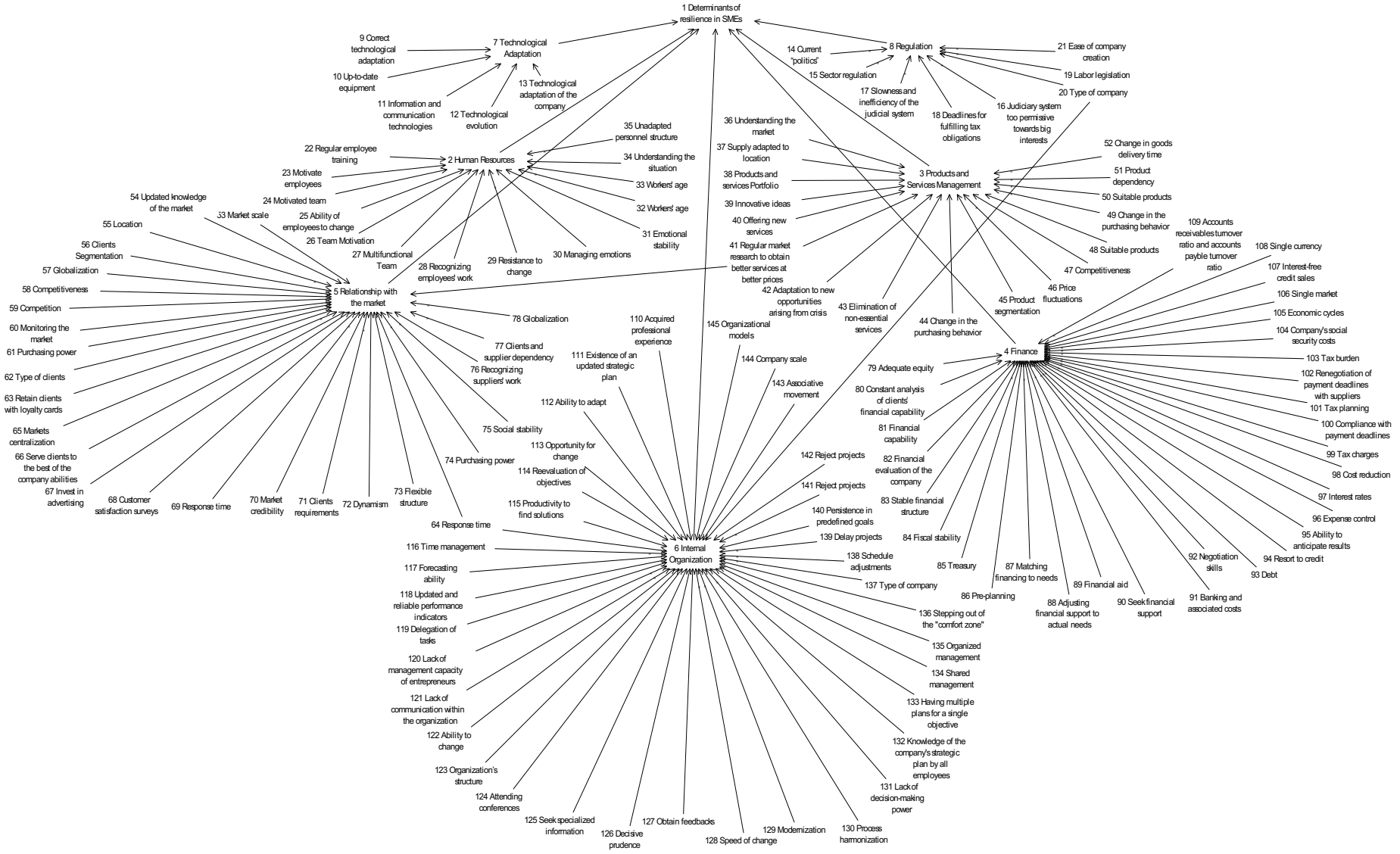


Figure 4.2: Group Cognitive Map.

The map presented in *Figure 4.2* illustrates the seven clusters, along with the 137 criteria and the causal relationships between them. It is worth noting that some criteria are present in multiple clusters, suggesting their relevance in more than one area. Furthermore, the causal relations that have a negative impact on resilience are identified with a minus sign (–) next to the corresponding arrows. This visual representation is the result of shared knowledge and debates between the specialists in the first group session. Therefore, it represents the collective agreement within the group regarding the factors that can influence the resilience in SMEs, whether this is positive or negative. Nevertheless, it is important to note that the process of developing a cognitive map is subjective. Thus, the final version of the map could have been different if other specialists were involved.

As mentioned previously, the cognitive map is a subjective process that represents the qualitative approach of this study. Given that the current model follows the principles of constructivist, which combines subjectivity and objectivity, in the next phase TOPSIS will be applied – a quantitative approach that brings objectivity to the model in the evaluation phase.

4.2. TOPSIS Application

During the structuring phase, the criteria necessary for the evaluation phase were defined. Once the structuring phase was completed, the evaluation of the identified criteria (*i.e.*, the evaluation phase) began, which took place during the second group session. The second session, much like the first one, had a duration of approximately three and a half hours and included the presence of the seven panel members, who had participated in the initial session. Additionally, there were two facilitators present, whose responsibilities remained the same – *i.e.*, offering support in the discussion, if needed, and capturing key moments.

In the beginning of the second session, the panel members were presented with the revised cognitive map for their consideration and approval. Once the cognitive map was validated, the evaluation phase began. Like the structuring phase conducted in the first session, the evaluation phase is also structured into three parts.

Initially, the experts were requested to specify which cluster, in their opinion, was the most important for the success of resilience in SMEs, as well as the least important. Furthermore, they proceeded to compare the chosen clusters with the remaining ones, using an importance scale from “1” to “9”, where “1” corresponds to “equal importance” and “9” corresponds to “absolutely more important than”. These contributions reflect the first four steps of five in the

best-worst method (BWM). *"BWM is a vector-based method that requires fewer comparisons compared to* [other] *matrix-based* [methods]*"* (Rezaei, 2015, p. 56). This aspect contributes to a relatively easier understanding and implementation of this technique in contrast with others, presenting decision-makers with a more straightforward approach. Furthermore, the fifth and last step (*i.e.*, calculation of the weight of each cluster in the model) will be performed later considering the information acquired from the panel members during the previous steps.

Afterwards, the group of experts were prompted to identify the most important criteria within each cluster, using the Nominal Group Technique (NGT) and multi-voting, where each expert voted on the criteria that, in their opinion, are most important to the cluster. The NGT ensures that all ideas are discussed by providing an opportunity for participants to express their opinions, enabling them to make an informed decision when they come to voting on ideas (McMillan, King, & Tully, 2016). Multi-voting technique, in turn, enhances the structure of the voting process, thereby minimizing the number of criteria until there is an appropriate number of criteria (*i.e*., 5 or 7 criteria according to the size of the cluster) to be included and discussed in the model (Renno, Barbato, Barbarino, Guarino, Guida, & Papa, 2020). In the end, the criteria chosen by the majority were the criteria included in the model.

In the last phase, the TOPSIS method was briefly described to the pannel. Following that, a new request was made to the decision-makers, in this case, to identify ten SMEs that they all knew. Once the ten SMES were defined, the next requirement was to fill in 8 matrices, according to the degree of attractiveness of each SME in each cluster/criterion, thus creating decision matrices that will later be considered in the first step of the TOPSIS technique. To fill in the matrices a scale from "1" to "5" was used, where "1" corresponds to a "very low degree of attractiveness" and "5" to a "very high degree of attractiveness". The first matrix refers to the degree of attractiveness of SMEs in each cluster and the remaining 7 matrices to the degree of attractiveness of SMEs in each of the criteria (*i.e.*, the criteria considered important by the experts). *Figure 4.3* presents some moments of the second session.

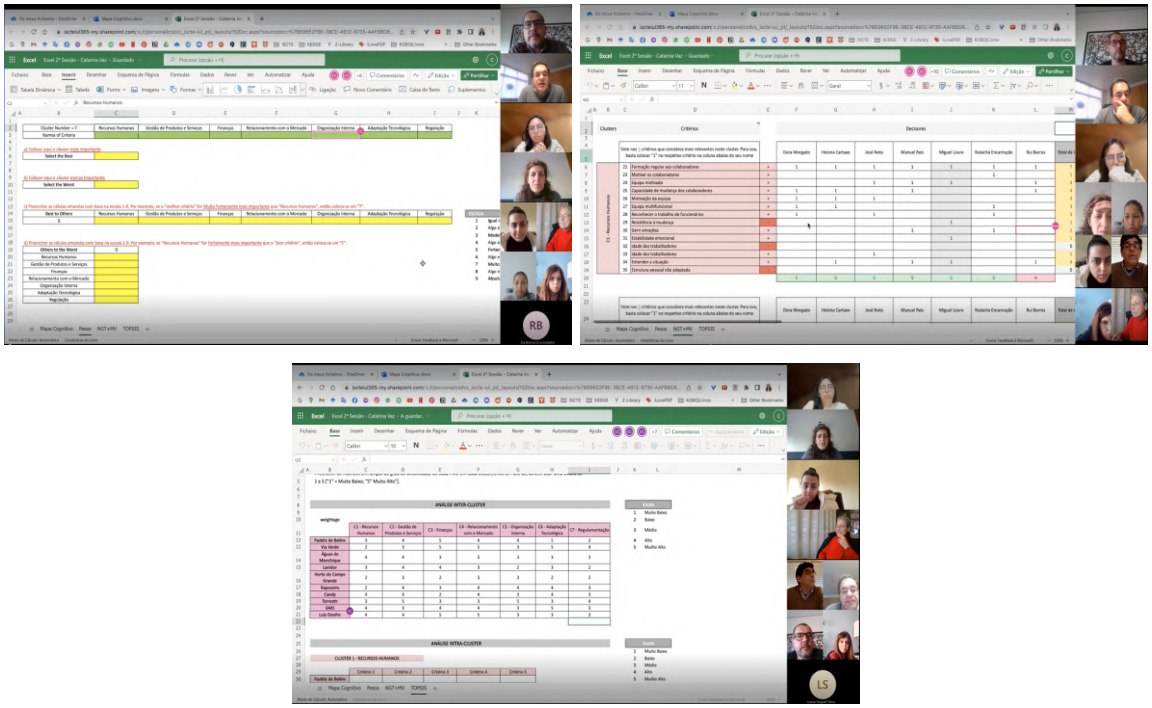


Figure 4.3: Moments of the Second Group Session.

Before starting the TOPSIS calculations, it is important to enumerate the clusters identified by the specialist's pannel during the first session (see *Table 4.1*). Furthermore, throughout the calculations of each individual cluster, the criteria chosen as the most important by the specialists during the second session will be mentioned.

Table 4.1: Clusters Identified in the First Group Session.

Clusters	
C1	Human Resources
C2	Products and Services Management
C3	Finance
C4	Relationship with the Market
C5	Internal Organization
C6	Technological Adaptation
C7	Regulation

With the conclusion of the second session, all the necessary data was collected to start the TOPSIS calculations. As described in *Chapter 3*, the first step of TOPSIS consists in the creation of a decision matrix (*i.e.*, matrix *D*). These matrices were the result of the last stage of the second session, in total, eight matrices (*i.e.*, one inter-cluster matrix and seven intra-cluster matrices). In this way, we will use the data available in the matrices mentioned to proceed with

TOPSIS analysis. Starting with the calculations of the inter-cluster matrix, presented in *Table 4.2*, we will then advance to the rest of TOPSIS steps. It is important to note that, for confidentiality reasons, the SMEs identified by the decision makers in the second session are represented by Alpha (*n*).

Table 4.2: Decision Matrix (*D*) obtained in the second group session – Inter-Cluster.

	C1	C2	C3	C4	C5	C6	C7
Alpha 1	3	4	5	4	4	1	2
Alpha 2	2	3	5	5	3	5	4
Alpha 3	4	4	3	3	3	3	3
Alpha 4	3	4	4	3	2	3	2
Alpha 5	2	3	2	3	3	2	2
Alpha 6	2	4	3	4	4	4	3
Alpha 7	4	4	2	4	3	4	3
Alpha 8	3	5	3	3	5	3	4
Alpha 9	4	3	4	4	3	5	3
Alpha 10	4	4	5	5	3	3	3

The second step of TOPSIS consists in the normalization of matrix *D* using *Equation (2)* (see *Chapter 3*) to create a new matrix R (*i.e.*, normalized decision matrix), as shown in *Table 4.3*.

Table 4.3: Normalized Decision Matrix (*R*) – Inter-Cluster.

	C1	C2	C3	C4	C5	C6	C7
Alpha 1	0.2956	0.3288	0.4196	0.3266	0.3730	0.0902	0.2120
Alpha 2	0.1971	0.2466	0.4196	0.4082	0.2798	0.4508	0.4240
Alpha 3	0.3941	0.3288	0.2518	0.2449	0.2798	0.2705	0.3180
Alpha 4	0.2956	0.3288	0.3357	0.2449	0.1865	0.2705	0.2120
Alpha 5	0.1971	0.2466	0.1678	0.2449	0.2798	0.1803	0.2120
Alpha 6	0.1971	0.3288	0.2518	0.3266	0.3730	0.3607	0.3180
Alpha 7	0.3941	0.3288	0.1678	0.3266	0.2798	0.3607	0.3180
Alpha 8	0.2956	0.4110	0.2518	0.2449	0.4663	0.2705	0.4240
Alpha 9	0.3941	0.2466	0.3357	0.3266	0.2798	0.4508	0.3180
Alpha 10	0.3941	0.3288	0.4196	0.4082	0.2798	0.2705	0.3180

The following step consists in the computation of the weighted normalized decision matrix (*V*). However, to compute matrix *V*, the weights (w_i) of each cluster need to be identified. With this purpose, the fifth and final step of BWM (Rezaei, 2015) was performed resulting in the final weights of each cluster in the model. The weight reflects the importance of each custer in the model (*i.e.*, how each cluster affects the resilience of the SMEs). It is important to note that

the results obtained with the BWM method are usually highly reliable since they provide more consistent comparisons in contrast to other approaches. Nevertheless, it is important to compute the consistency ratio to verify the reliability of the comparison made by the panel. The higher the consistency ratio, the less reliable is the comparison (Rezaei, 2015). The consistency ratio of the application of BWM in the second group session is 0.0957, which implies a very good consistency. *Table 4.4* shows the weights of each cluster in the model.

Table 4.4: Weight (w_i) of each cluster – Inter-Cluster.

	C1	C2	C3	C4	C5	C6	C7
w_i	0.2106	0.1053	0.0842	0.1053	0.3255	0.1404	0.0287

Upon the calculations of the weight of each cluster, the matrix *V* was computed by multiplying the elements of matrix *R* by the value of the corresponding weight (w_i) (see *Equation (4)*). *Table 4.5* presents the matrix *V*.

Table 4.5: Weighted Normalized Decision Matrix (*V*) – Inter-Cluster.

	C1	C2	C3	C4	C5	C6	C7
Alpha 1	0.0623	0.0346	0.0353	0.0344	0.1214	0.0127	0.0061
Alpha 2	0.0415	0.0260	0.0353	0.0430	0.0910	0.0633	0.0122
Alpha 3	0.0830	0.0346	0.0212	0.0258	0.0910	0.0380	0.0091
Alpha 4	0.0623	0.0346	0.0283	0.0258	0.0607	0.0380	0.0061
Alpha 5	0.0415	0.0260	0.0141	0.0258	0.0910	0.0253	0.0061
Alpha 6	0.0415	0.0346	0.0212	0.0344	0.1214	0.0506	0.0091
Alpha 7	0.0830	0.0346	0.0141	0.0344	0.0910	0.0506	0.0091
Alpha 8	0.0623	0.0433	0.0212	0.0258	0.1517	0.0380	0.0122
Alpha 9	0.0830	0.0260	0.0283	0.0344	0.0910	0.0633	0.0091
Alpha 10	0.0830	0.0346	0.0353	0.0430	0.0910	0.0380	0.0091

The following step consists in determining the positive ideal solutions (A^+) (see *Equation (6)*) and negative ideal solutions (A^-) (see *Equation (7)*). *Table 4.6* presents both set of solutions, A^+ represents the bigger weighted normalized values (v_{ij}) in each column of matrix *V*, and contrarily, A^- represents the smaller values.

Table 4.6: Positive ideal Solutions (A^+) and Negative Ideal Solutions (A^-) – Inter-Cluster.

	C1	C2	C3	C4	C5	C6	C7
A^+	0.0830	0.0433	0.0353	0.0430	0.1517	0.0633	0.0122
A^-	0.0415	0.0260	0.0141	0.0258	0.0607	0.0127	0.0061

Moreover, the fifth step involves using the Euclidean approach to determine the distances from matrix *V* values to the positive (S_i^+) and negative (S_i^-) ideal solutions (see *Equation (8)* and *Equation (9)*, respectively). The following step is the calculation of the relative closeness to the ideal solution (C_i^+) (*i.e.*, performance score), using the Euclidean distances calculated previously (see *Equation (10)*). Lastly, the alternatives (*i.e.*, SMEs referred as Alpha (*n*)) are ranked in descending order, where the higher performance score corresponds to the best SME. *Table 4.7* presents both Euclidean distances (S_i^+ and S_i^-), the performance score (C_i^+) and the rank of the SMEs.

Table 4.7: Distances to the Positive (S_i^+) and Negative (S_i^-) Ideal Solutions; Relative Closeness to the Ideal Solution (C_i^+); and Rank – Inter-Cluster.

	S_i^+	S_i^-	C_i^+	Rank
Alpha 1	0.0640	0.0687	0.5174	4
Alpha 2	0.0755	0.0653	0.4637	7
Alpha 3	0.0700	0.0585	0.4550	8
Alpha 4	0.0991	0.0367	0.2702	9
Alpha 5	0.0891	0.0329	0.2697	10
Alpha 6	0.0562	0.0730	0.5650	2
Alpha 7	0.0667	0.0651	0.4940	5
Alpha 8	0.0396	0.0987	0.7138	1
Alpha 9	0.0642	0.0741	0.5359	3
Alpha 10	0.0664	0.0641	0.4913	6

Having completed the inter-cluster calculations, the next step is to perform the equivalent calculations for each cluster (*i.e.*, intra-cluster calculations), evaluating the selected criteria (SCs) identified by the panel of experts during the second session. It is noteworthy that the SCs were selected based on NGT and multi-voting, so it was considered that each SC had equal weight, maintaining uniform importance for every sub-criterion within each cluster. In this sense, the weight of each criterion was calculated by dividing 1 by the number of criteria considered in each cluster.

Starting the analysis with the first cluster defined by the experts (*i.e.*, C1 – *Human Resources)*, *Table 4.8* shows the SCs chosen during the last group session, where the decision matrix *A* was also filled (see *Table A1* in *Appendix A*). We proceeded to normalize its values, resulting in the matrix normalized decision matrix (see *Table A2* in *Appendix A*). After identifying the weights of the SCs (see *Table A3* in *Appendix A*), the weighted normalized decision matrix was obtained (see *Table A4* in *Appendix A*), from which it was possible to identify the sets of positive and negative ideal solutions (see *Table A5* in *Appendix A*). With

these values, we proceeded to calculate the Euclidean distance to the positive and negative ideal solutions, the relative closeness to the ideal solution and the ranking (see *Table A6* in *Appendix A*).

Table 4.8: Sub-Criteria selected in the Second Group Session – Cluster 1.

Sub-Criteria in C1	
SC22	Regular employee training
SC24	Motivated team
SC25	Ability of employees to change
SC34	Understanding the situation
SC27	Multifunctional team

The following cluster to be analyzed is C2 – *Products and Services Management*. After identifying the most important SCs, present in the *Table 4.9*, as well as filling in the decision matrix (see *Table B1* of *Appendix B*), the matrix *A* was normalized originating the matrix *R* (see *Table B2* of *Appendix B*). After determining the weight of the SCs (see *Table B3* in *Appendix B*), the matrix V was obtained (see *Table B4* in *Appendix B*), from which it was possible to identify the sets of solutions A^+ and A^- (see *Table B5* in *Appendix B*). With these values, we progressed to the calculation of the distances ${S_i}^+$and ${S_i}^-$, which allows the calculation of ${C_i}^+$, as well as the determination of the rankings (see *Table B6* in *Appendix B*).

Table 4.9: Sub-Criteria selected in the Second Group Session – Cluster 2.

Sub-Criteria in C2	
SC36	Understanding the market
SC41	Regular market research to obtain better services at better prices
SC47	Competitiveness
SC38	Products and services portfolio
SC37	Supply adapted to location

In the same line of thinking, the next cluster is C3 – *Finance*. Its SCs were identified (see *Table 4.10*) and the decision matrix *A* was filled previously (see *Table C1* of *Appendix C*). Thus, the normalization of the matrix was done which resulted in the matrix *R* (see *Table C2* of *Appendix C*). Then, the weight of the SCs was computed (see *Table C3* in *Appendix C*), which resulted in the matrix V (see *Table C4* in *Appendix C*) and culminated in the identification of both sets of solutions A^+ and A^- (see *Table C5* in *Appendix C*). Using these data, both Euclidean distances to the best and worst ideal solutions were computed, then the proximity to the ideal solution and, finally, the ranking (see *Table C6* in *Appendix C*).

Table 4.10: Sub-Criteria selected in the Second Group Session – Cluster 3.

Sub-Criteria in C3	
SC95	Ability to anticipate results
SC79	Adequate equity
SC98	Cost reduction
SC84	Fiscal stability
SC86	Pre-planning
SC83	Stable financial structure
SC96	Expense control

Regarding the cluster C4 – *Relationship with the Market*, the experts chose the SCs enumerated in *Table 4.11* and completed the decision matrix *A* (see *Table D1* of *Appendix D*). Through the normalization of the previous matrix A, matrix *R* was computed (see *Table D2* of *Appendix D*). Therefore, the ponderation of the SCs was calculated (see *Table D3* in *Appendix D*) leading to matrix V being created (see *Table D4* in *Appendix D*), where the sets of solutions A^+ and A^- were defined (see *Table D5* in *Appendix D*). The last calculations were determined: both Euclidean distances, the proximity and the rank (see *Table D6* in *Appendix D*).

Table 4.11: Sub-Criteria selected in the Second Group Session – Cluster 4.

Sub-Criteria in C4	
SC56	Clients' segmentation
SC73	Flexible structure
SC64	Response time
SC66	Serve clients to the best of the company abilities
SC54	Updated knowledge of the market
SC59	Competition
SC60	Monitoring the market

Similarly, to the previous clusters, the SCs from the cluster C5 – *Internal Organization* are presented in *Table 4.12* and the decision matrix *A* was already computed (see *Table E1* of *Appendix E*). Then, matrix *R* was computed by standardizing matrix *A* (see *Table E2* of *Appendix E*) and used to calculate the weighted standard decision matrix (see *Table E4* in *Appendix E*), along with the weights of the criteria (see *Table E3* in *Appendix E*). The optimal solution sets were then identified (see *Table E5* in *Appendix E*), and the final calculations (*i.e.*, S_i^+, S_i^-, C_i^+ and ranking) could be made (see *Table E6* in Appendix *E*).

Table 4.12: Sub-Criteria selected in the Second Group Session – Cluster 5.

Sub-Criteria in C5	
SC119	Delegation of tasks
SC110	Acquired professional experience
SC111	Existence of an updated strategic plan
SC112	Ability to adapt
SC114	Reevaluation of objectives
SC125	Seek specialized information
SC129	Modernization

Despite C6 – *Technological Adaptation* being the smallest cluster and having a reduced number of SCs, there was a minimum of five SCs that had to be defined. Thus, all the SCs that constitute C6 had to be considered (see *Table 4.13*). Besides the list, the decision matrix *A* was filled (see *Table F1* of *Appendix F*), and the next step is normalizing it resulting in the matrix *R* (see *Table F2* of *Appendix F*). Afterwards, the importance of the SCs was determined (see *Table F3* in *Appendix F*) and enabled the computation of matrix V (see *Table F4* in *Appendix F*), in which we can determine the maximum and minimum values that constitute A^+ and A^- (see *Table F5* in *Appendix F*). Lastly, the Euclidean distance to the positive and negative ideal solutions, the relative closeness to the ideal solution and the ranking were defined (see *Table F6* in *Appendix F*).

Table 4.13: Sub-Criteria selected in the Second Group Session – Cluster 6.

Sub-Criteria in C6	
SC9	Correct technological adaptation
SC10	Up-to-date equipment
SC11	Information and communication technologies
SC12	Technological evolution
SC13	Technological adaptation of the company

The last cluster to be analyzed is C7 – *Regulation*. As a relatively small cluster, the experts did not have much trouble defining the SCs (see *Table 4.14*) and completing the decision matrix A (see *Table G1* of *Appendix G*). Subsequently, matrix *A* was standardized which resulted in matrix R (see *Table G2* in *Appendix G*). Once the weights were identified (see *Table G3* in *Appendix G*), the weighted normalized decision matrix was calculated (see *Table G4* in *Appendix G*), from which it was possible to determine the sets of positive and negative ideal solutions (see *Table G5* in *Appendix G*). With this information, we can define the Euclidean distance to the positive and negative ideal solutions and determine the relative closeness to the ideal solution and the ranking (see *Table G6* in *Appendix G*).

Table 4.14: Sub-Criteria selected in the Second Group Session – Cluster 7.

Sub-Criteria in C7	
SC14	Current "politics"
SC15	Sector regulation
SC19	Labor legislation
SC18	Deadlines for fulfilling tax obligations
SC17	Slowness and inefficiency of the judicial system

Finally, after completing all calculations, three graphics (*Figures 4.4.*, *4.5* and *4.6.*) were developed to effectively visualize and analyze the inter-cluster and intra-cluster aspects of the data and compare both analyses.

The first graphic, shown in *Figure 4.4,* illustrates the final calculations of inter-cluster analysis, the relative closeness to the ideal solution. This kind of analysis enhances our understanding of the relationships between the different clusters. In this specific case, the inter-cluster analysis enables us to determine the best and worst SMEs based on their performance score (see the C_i^+ and rank in *Table 4.7*), taking into consideration that each cluster has a different weight (*i.e.*, influence) in the model.

It is important to acknowledge the importance of each cluster in the model (*i.e.*, how much each cluster affects the resilience of the SMEs) (see *Table 4.4*). The most important cluster is C5, followed by C1, the third in the level of importance is C6, then C2 and C4 are at the same level, followed by C3, and lastly C7.

In terms of performance, the highest performance score (C_i^+) indicates the best SME and the lowest the worst SME in terms of resilience. In other words, the most and least resilient SMEs. When analyzing the graphic (see *Figure 4.4*), *Alpha 8* stands out from the other SMEs in terms of performance score with the higher value (*i.e.*, 0,714). Therefore, *Alpha 8* is the most resilient SME. It is worth noting that, *Alpha 8* stands out exactly in dimension C5, considered the most important cluster, being the highest (and only) SME with a "very high degree of attractiveness" (*i.e.*, "5" in a scale from "1" to "5"), in the matrix which values were filled by the panel of specialists (see *Table 4.2*). Additionally, it seems clearly visible in the graphic (see *Figure 4.4*) that *Alphas 4* and *5* stand out from the other SMEs in a negative way, having the lower values in terms of performance (*i.e.*, 0.270). It is worth mentioning that *Alpha 4* has the lowest value in dimension C5 (*i.e.*, low degree attractiveness in the most important cluster) and *Alpha 5* has lower values in dimension C6 and C1 (*i.e.*, clusters among the top 3 of importance).

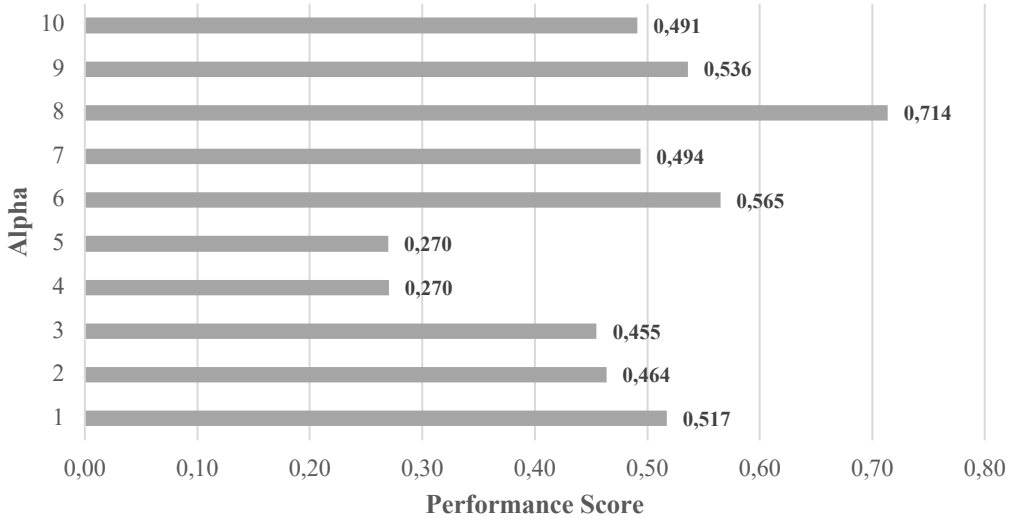


Figure 4.4: Inter-Clusters Analysis.

The graphic presented in *Figure 4.5* illustrates the last calculations of intra-cluster analysis, the proximity to the ideal solution. This kind of analysis focuses on exploring the internal structure and patterns within the clusters individually. In this circumstance, the intra-cluster analysis facilitates the comparison of the Alphas in each dimension, making it possible to differentiate the dimensions in which each Alpha stands out in a positive and/or negative way.

In an initial analysis of the graph (see *Figure 4.5*), it is possible to state that SMEs in general have a homogeneous performance amongst them. However, it is noticeable that *Alpha 1* has lower scores in several dimensions, namely a performance score of zero in the three most important clusters (*i.e.*, C1, C5, and C6) and a low performance in C4. Consequently, *Alpha 1* is positioned last in the ranking of all these clusters (see *Appendix A*, *Appendix D*, *Appendix E* and *Appendix F*). Notably, *Alpha 2* has the highest scores (*i.e.*, first place in the ranking) in the clusters C5 and C6. It is important to note that all SCs in C6 obtained the maximum ranking attributed by the decision makers, and the score reached the maximum value as well (*i.e.*, C_i^+ = 1), which means that this SME is in absolute proximity to the ideal solution (*i.e.*, represents the ideal solution for this cluster) (see *Appendix F*). When it comes to C5, although most of the SCs could be improved, they all have good scores. Nevertheless, SC119 – *Delegation of tasks* (see *Table 4.12*) has the lowest score of all, so there should be a higher priority in this area (see *Appendix E*). Despite having the highest scores in the clusters that most influence resilience, *Alpha 2* still has improvements to be made, namely in dimensions C4 and C7, where it is the ninth position in the ranking.

Alpha 10 is also worth mentioning because, although it is not in first place in the ranking of the most important clusters (*i.e.*, is in second place in C1 and C5, and in third place in C6), the performances of the clusters are homogeneous among themselves since they are all higher than 0,6 and there is no great discrepancy between the values.

As a final note, it is relevant to mention that despite the analysis that was made, all SMEs have areas to be improved. Thus, the decision matrices of each cluster can be analyzed in greater detail, perceiving specifically the SCs in which the company can improve or in which it excels (see *Appendix A* to *G*).

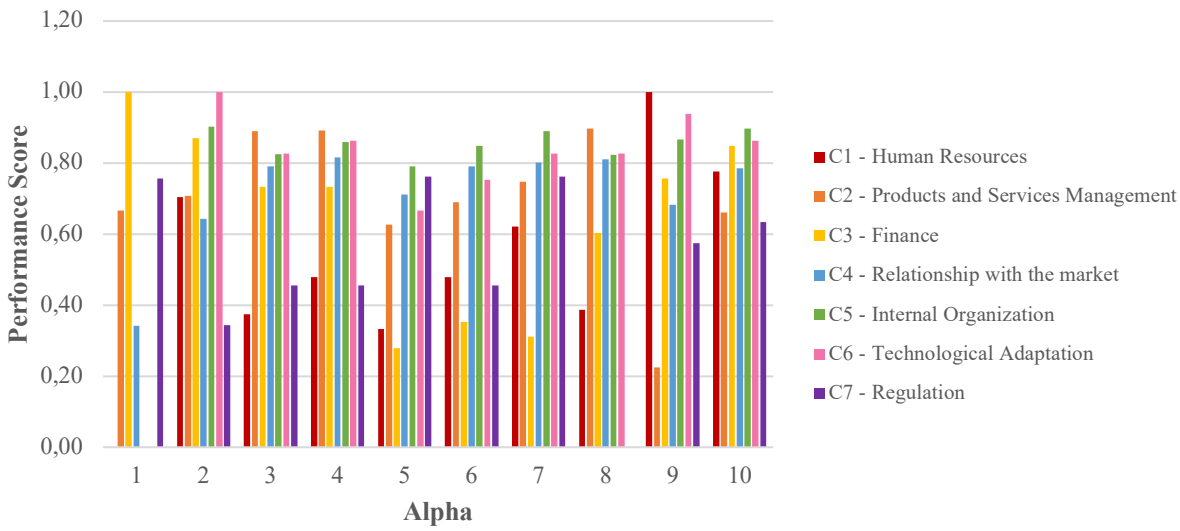


Figure 4.5: Intra-Clusters Analysis.

To conclude, it was elaborated a graph, presented in *Figure 6.6*, to compare the calculations of the two analyses performed (*i.e.*, the inter-cluster analysis and the intra-cluster analysis). Through the comparison of both analyses represented in the graph, we can gain a simultaneous understanding of the performance of each SME as well as their performance within each cluster. In the analysis between clusters (*i.e.*, inter-cluster analysis), the SME with the best results is *Alpha 8*, with a performance score of 0.714. Nonetheless, upon completion of the intra-cluster analysis, it became evident that there are certain dimensions that require improvement in terms of performance. These dimensions include: C7, since the performance in this cluster is zero, as well as clusters C1 and C3, which present low performance scores when compared with other clusters of *Alpha 8*. Thus, despite the excellent inter-cluster performance there are improvements to be made intra-cluster.

Furthermore, in the context of inter-cluster analysis, *Alphas 4* and *5* were considered the worst performing SMEs, both with a score of 0.270. When analyzed in greater detail (*i.e.*, intra-cluster analysis), *Alpha 5* remains poorly positioned in the rankings across all clusters, except for C 7, where it takes the first position. Therefore, we can conclude that *Alpha 5* has a poor inter and intra-cluster performance. Despite its lower inter-cluster performance, *Alpha 4* presents a greater intra-cluster performance. It performs well in most dimensions, except for C1 and C7, and its ranking stands out positively in several of these dimensions (see rank in *Appendix A* to *G*). Therefore, although there are some improvements to be made inter-cluster, *Alpha 4* it is well positioned intra-cluster.

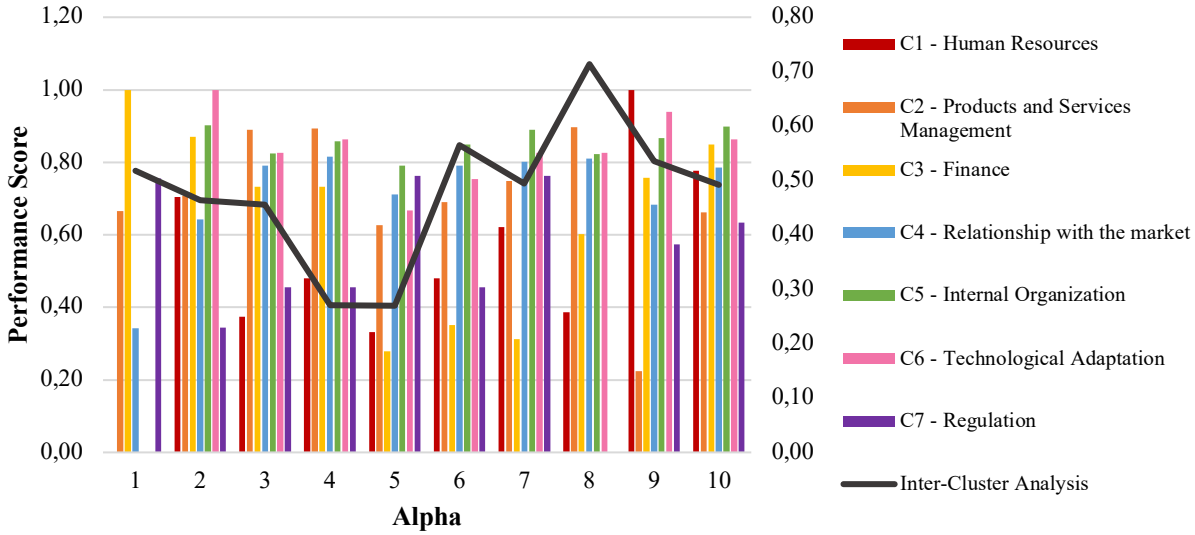


Figure 4.6: Inter and Intra-Clusters Analysis.

Once the evaluation phase was completed, a consolidation session was held with two impartial experts who were not involved in the development of the evaluation model. This is important to obtain an unbiased opinion on the study conducted. The next topic presents the consolidation of results and recommendations.

4.3. Analysis of Results and Discussion

After completing the structuring phase, in which the group cognitive map was developed, and the evaluation phase, in which TOPSIS was applied to determine the optimal solution, the subsequent phase, known as the recommendation phase, included a consolidation session with

the aim of gathering feedback on the results and assessing the feasibility of implementing the model.

Similarly to the two previous sessions, the consolidation session was conducted online (*i.e.*, Microsoft Teams) and had a duration of approximately two hours. This session was held with two specialists from *Instituto de Apoio às Pequenas e Médias Empresas e à Inovação* (IAPMEI), who did not participate in any of the previous sessions. Therefore, their opinion was impartial. The insights provided by the experts from IAPMEI were highly valuable, given that this governmental entity plays a crucial role in assisting SMEs, supporting their growth, and assisting them overcome market challenges.

The session was structured in the following phases: (1) brief description of the concepts related to the topic of study; (2) presentation of the decision-making phases (*i.e.*, structuring and evaluation phases) and methodologies (*i.e.*, cognitive map and TOPSIS calculations); (3) request for feedback on the methodologies used and the applicability of the model; and (4) suggestions for improvement. *Figure* 4.7 shows some moments of the session.



Figure 4.7: Moments of the Consolidation Session.

Following the overview of the concepts, methodologies, and results, the expert initiated the discussion by inquiring about the sector/industry in which the companies associated with the panel of decision-makers operated. In response to that, the expert was informed that the panel of experts was constituted by seven specialists in SMEs, namely: two managing-partners in the optics business; two managing-partners in the pharmaceutical business; one founder of a logistics company; one accountant; and, lastly, one bank manager. In response, he commented that based on the clusters displayed on the cognitive map, it was obvious that the decision-makers all belonged to the same sector of activity (*i.e.*, service sector). He acknowledged that while it has its advantages, it also had its drawbacks. As an improvement to this aspect, he

suggests that a future study should consider a greater heterogeneity on sectors in the panel of decision-makers, so that the inputs can be even more varied, since *"the origin of the decision-maker affects the valuation of the criteria"* (his own words). Nonetheless, he emphasized that there were also notable advantages to this sector. He mentioned that the services sector holds a prominent position compared to other sectors, and the decision-makers within it tend to be highly knowledgeable individuals. He further noted that this expertise was evident in the quality of the criteria presented on the cognitive map. Additionally, it is also mentioned the relevance of the clusters of *Internal Organization*, *Human Resources*, and *Technological Adaptation* clusters to create resilience. Thus, it was expected they would be included in the model.

When asked about the techniques, the experts stated that they had only a general knowledge of the methodologies used but never applied them. However, there is a consensus between the two that the model is well structured and that the methodologies adopted are relevant, resulting in the creation of a *"scientifically robust model"* (their own words). Some highlighted advantages of the model include its objectivity and ease of understanding.

In their final remarks, they agree that SMEs should use the methodologies presented. However, they acknowledged that most SMEs lack the necessary structure, knowledge and skills to implement these methodologies effectively. They believe that SMEs that are better structured, better adapted and/or technological updated would recognize the importance and value of these models and successfully apply them. Furthermore, they highlighted SMEs within the tourism sector as an excellent example where this model would find significant applicability. The consolidation session ended on a positive note, as the experts expressed their satisfaction and commended the entire process, as well as the relevance of the research topic.

Throughout this dissertation, it was demonstrated the need to develop a model to evaluate the resilience in SMEs. In *Chapter 4*, the process of developing this model was then presented, through the methodologies mentioned in *Chapter 3*, along with the analysis of the results obtained and the formulation of recommendations. *Point 4.1* describes the structuring phase. A group session was held with a panel of seven specialists, available to share their knowledge on the subject (*i.e.*, resilience in SMEs). In this session, it was possible to determine the criteria needed to build the model and defining which criterion promoted or conditioned SMEs resilience. Then the criteria were organized into groups (*i.e.*, clusters) by the specialist and, lastly, the criteria were reorganized in a hierarchical order within each cluster. After the session ended, a cognitive map was built with the data collected, a visual representation which reflects the knowledge of each specialist and the collective throughout the group session. The panel of experts was presented with the group's cognitive map for validation. *Point 4.2* describes the evaluation phase. This phase began with a second group session, that started with the pannel of specialists (*i.e.*, same experts from the first sessions) selecting the clusters they considered the most and least important, and comparing the chosen clusters with the remaining using the BWM approach. Then, the panel was prompted to select the most important criteria within each cluster, using the NGT and multi-voting technique. In the last phase of the second session, the specialists were requested to identify 10 SMEs that they all knew. The following requirement was to fill in 8 matrices, according to the degree of attractiveness of each SME in each cluster/criterion. Once the second session was concluded, the calculation phase was initiated (*i.e.*, the application of TOPSIS), in which the seven steps of the technique were conducted, starting with the matrixes filled out by the decision makers. TOPSIS was conducted inter-cluster and intra-cluster, resulting in a final ranking of SMEs according to their resilience performance. After all the calculations were completed, the results from the inter-cluster and intra-cluster analyses, as well as the comparison between the two, were visually represented through graphs for a better understanding and interpretation of the findings. Finally, *point 4.3* describes the last stage of the decision-making (*i.e.*, recommendations formulation), in which a consolidation session was held with two experts that were not involved in the development of the model, to obtain their impartial opinion about the results and the model's practical applicability. *Chapter 5* will present the main conclusions of this study.

CHAPTER 5

CONCLUSION

5.1. Results and Limitations

Resilience plays a critical role in companies as it enables them to navigate and thrive among various challenges and uncertainties. In today's dynamic business environment, resilience acts as a crucial attribute that allows organizations, to adapt, recover, and even grow stronger in the face of disruptions. A resilient company possesses the ability to quickly respond to unforeseen circumstances, make strategic adjustments, and seize opportunities, thereby ensuring its sustainability and long-term success. Specially for SMEs, being resilient is very important as they face unique challenges due to their size and limited resources. In this sense, it is important to develop a model that assists SMEs in identifying and quantifying the areas for improvement to enhance their resilience. To address the limitations identified in the literature, the main objective of this dissertation was to develop an ***evaluation model that enables the identification and analysis of the determinants needed to develop resilience in SMEs, through the combined application of SODA and TOPSIS.***

This dissertation is structured into five parts: (1) *Chapter 1* – Introduction includes a brief background on the topic, identification of the research objectives and methodologies chosen and a description of the expected results of the research; (2) *Chapter 2* – Literature Review includes the fundamentals of resilience, analysis of its importance for SMEs and the identification of previous studies on this subject, as well as both their contributions and their limitations; (3) *Chapter 3* – Methodological Background, describes the methodologies applied in the construction of the evaluation model, namely cognitive mapping and TOPSIS, and the contributions of these techniques to resilience in SMEs; (4) *Chapter 4* – Empirical Development and Result Analysis, describes the development of the evaluation model (*i.e.*, panel sessions, construction of the cognitive map and TOPSIS calculations), the analysis of the results and the formulation of recommendations; and (5) *Chapter 5* – presents the main results and limitations of the study, its implications in the management of SMEs and some guideline for future research.

As mentioned previously, the complexity of resilience necessitated the selection of appropriate methodologies to address this type of problem and evaluate the resilience of SMEs.

To achieve this, a constructivist perspective was taken into account, and methodologies such as cognitive mapping and TOPSIS were used, allowing for a holistic view of the problem. Thus, this model facilitates the decision-making process by identifying the dimensions that should be considered to enhance resilience in SMEs and describing what should be done (*i.e.*, dimensions that can be improved).

Overall, the outcomes of the employed methodologies yielded positive results, in the sense that a holistic and realistic multicriteria model was developed, which assists SMEs in assessing resilience. Despite this, the present dissertation is not without limitations, namely: (1) challenge of assembling a panel of specialists available to participate in the study; (2) long duration of the group sessions; and (3) subjectivity in determining the criteria. It should be noted that in the last limitation, the criteria obtained were determined by the panel members. Thus, if the specialists panel was different, possibly the results could be different. However, subjectivity is considered in the constructivist perspective that the model incorporates. Finally, despite the limitations mentioned, this model enabled an informed understanding of the determinants that influence the resilience of SMEs.

5.2. Managerial Implications and Concluding Remarks

Based on the literature review conducted in *Chapter 2*, there is a limited amount of research focused on the development of resilience in SMEs, and it rarely incorporates a holistic perspective that provides practical insights into the determinates contributing to its success. Therefore, this dissertation offers a new approach by providing a combination of SODA and TOPSIS.

By using SODA with cognitive mapping tools, managers can structure their decision problems and gain a deeper understanding of the factors influencing resilience in SMEs. The cognitive map obtained in this study provides a visual representation of valuable information about the decision problem, enabling managers to identify the criteria that enhance or condition resilience in their specific context. This process supports decision-making and strategic planning by offering a comprehensive view of the factors influencing resilience.

Furthermore, the application of TOPSIS allows managers to prioritize the identified criteria and assess the resilience performance of SMEs. TOPSIS is a well-established methodology for comparing and ranking alternatives based on their similarity to an ideal solution. By using TOPSIS, managers can objectively evaluate the performance of their SMEs in different

dimensions of resilience. This assessment facilitates the identification of areas that require improvement and helps in setting priorities for resource allocation and action planning.

Overall, this model provides SMEs with a comprehensive view of their resilience performance. By integrating SODA, cognitive mapping, and TOPSIS, managers can gain a deeper understanding of the factors influencing resilience, prioritize their actions, and develop targeted strategies for enhancing resilience in their organizations. This approach fills the research gaps identified in the literature and offers a practical tool for SMEs to build and improve their resilience capabilities.

5.3. Future Research

Considering the results achieved with the present dissertation, it seems clear that the combination of multicriteria methodologies (*i.e.*, SODA and TOPSIS) for developing subjective and complex problem-solving models is a great advantage. Specifically, these methodologies bring greater simplicity and transparency to the analyses made, presenting information in a clear, structured and coherent way.

Given that limitations can be an open opportunity for new developments, it is important to highlight some future research suggestions for other researchers who intend to focus on resilience in SMEs. In this regard, it is important to note the significance of conducting similar analyses with diverse panels, which will certainly generate different criteria and contribute to a more comprehensive understanding of the topic. It would also be interesting, as discussed in the consolidation session, to apply this methodology to the tourism sector, since the experts consider that it would have great applicability. Given the importance of the sector in Portugal and the challenges it faced during the pandemic of COVID-19 (*i.e.*, how resilient they had to be), the experts suggested that conducting, in a future study, the resilience assessment of a tourism SME would be highly relevant.

To conclude, resilience in SMEs is an immensely vast topic. Any future progress that is documented in this field will be highly appreciated as a valuable contribution.

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APPENDICES

Appendix A – Cluster 1 – Human Resources

Table A1: Decision Matrix (*D*) obtained in the Second Group Session – Cluster 1

	SC22	SC24	SC25	SC34	SC27
Alpha 1	2	2	1	1	2
Alpha 2	4	3	4	3	2
Alpha 3	2	2	3	2	2
Alpha 4	3	3	3	2	2
Alpha 5	3	2	2	2	2
Alpha 6	3	3	3	2	2
Alpha 7	4	3	4	2	2
Alpha 8	3	3	2	2	2
Alpha 9	5	4	4	3	3
Alpha 10	3	4	3	2	3

Table A2: Normalized Decision Matrix (*R*) – Cluster 1

	SC22	SC24	SC25	SC34	SC27
Alpha 1	0.1907	0.2120	0.1037	0.1459	0.2828
Alpha 2	0.3814	0.3180	0.4148	0.4376	0.2828
Alpha 3	0.1907	0.2120	0.3111	0.2917	0.2828
Alpha 4	0.2860	0.3180	0.3111	0.2917	0.2828
Alpha 5	0.2860	0.2120	0.2074	0.2917	0.2828
Alpha 6	0.2860	0.3180	0.3111	0.2917	0.2828
Alpha 7	0.3814	0.3180	0.4148	0.2917	0.2828
Alpha 8	0.2860	0.3180	0.2074	0.2917	0.2828
Alpha 9	0.4767	0.4240	0.4148	0.4376	0.4243
Alpha 10	0.2860	0.4240	0.3111	0.2917	0.4243

Table A3: Weight (w_i) of each Sub-Criteria – Cluster 1

	SC22	SC24	SC25	SC34	SC27
$\boldsymbol{w_i}$	0.2000	0.2000	0.2000	0.2000	0.2000

Table A4: Weighted Normalized Decision Matrix (V) – Cluster 1

	SC22	SC24	SC25	SC34	SC27
Alpha 1	0.0381	0.0424	0.0207	0.0292	0.0566
Alpha 2	0.0763	0.0636	0.0830	0.0875	0.0566
Alpha 3	0.0381	0.0424	0.0622	0.0583	0.0566
Alpha 4	0.0572	0.0636	0.0622	0.0583	0.0566
Alpha 5	0.0572	0.0424	0.0415	0.0583	0.0566
Alpha 6	0.0572	0.0636	0.0622	0.0583	0.0566
Alpha 7	0.0763	0.0636	0.0830	0.0583	0.0566
Alpha 8	0.0572	0.0636	0.0415	0.0583	0.0566
Alpha 9	0.0953	0.0848	0.0830	0.0875	0.0849
Alpha 10	0.0572	0.0848	0.0622	0.0583	0.0849

Table A5: Positive ideal Solutions (A^+) and Negative Ideal Solutions (A^-) – Cluster 1

	SC22	SC24	SC25	SC34	SC27
$\boldsymbol{A^+}$	0.0953	0.0848	0.0830	0.0875	0.0849
$\boldsymbol{A^-}$	0.0381	0.0424	0.0207	0.0292	0.0566

Table A6: Distances to the Positive (S_i^+) and Negative (S_i^-) Ideal Solutions; Relative Closeness to the Ideal Solution (C_i^+); and Rank – Cluster 1

	$\boldsymbol{S_i^+}$	$\boldsymbol{S_i^-}$	$\boldsymbol{C_i^+}$	Rank
Alpha 1	0.1147	0.0000	0.0000	10
Alpha 2	0.0402	0.0958	0.7046	3
Alpha 3	0.0846	0.0507	0.3749	8
Alpha 4	0.0631	0.0582	0.4796	5
Alpha 5	0.0814	0.0406	0.3326	9
Alpha 6	0.0631	0.0582	0.4796	5
Alpha 7	0.0496	0.0814	0.6212	4
Alpha 8	0.0726	0.0458	0.3865	7
Alpha 9	0.0000	0.2016	1.0000	1
Alpha 10	0.0523	0.1817	0.7765	2

Appendix B – Cluster 2 – Products and Services Management

Table B1: Decision Matrix (*D*) obtained in the Second Group Session – Cluster 2

	SC36	SC41	SC47	SC38	SC37
Alpha 1	2	1	1	1	5
Alpha 2	3	1	2	2	5
Alpha 3	4	4	4	4	5
Alpha 4	4	4	5	5	4
Alpha 5	3	2	3	5	2
Alpha 6	4	3	4	4	2
Alpha 7	5	4	5	4	2
Alpha 8	4	5	5	4	4
Alpha 9	3	2	2	2	1
Alpha 10	4	4	2	4	2

Table B2: Normalized Decision Matrix (*R*) – Cluster 2

	SC36	SC41	SC47	SC38	SC37
Alpha 1	0.1715	0.0962	0.0880	0.0848	0.4490
Alpha 2	0.2572	0.0962	0.1761	0.1696	0.4490
Alpha 3	0.3430	0.3849	0.3522	0.3393	0.4490
Alpha 4	0.3430	0.3849	0.4402	0.4241	0.3592
Alpha 5	0.2572	0.1925	0.2641	0.4241	0.1796
Alpha 6	0.3430	0.2887	0.3522	0.3393	0.1796
Alpha 7	0.4287	0.3849	0.4402	0.3393	0.1796
Alpha 8	0.3430	0.4811	0.4402	0.3393	0.3592
Alpha 9	0.2572	0.1925	0.1761	0.1696	0.0898
Alpha 10	0.3430	0.3849	0.1761	0.3393	0.1796

Table B3: Weight (w_i) of each Sub-Criteria – Cluster 2

	SC36	SC41	SC47	SC38	SC37
$\boldsymbol{w_i}$	0.2000	0.2000	0.2000	0.2000	0.2000

Table B4: Weighted Normalized Decision Matrix (V) – Cluster 2

	SC36	SC41	SC47	SC38	SC37
Alpha 1	0.0343	0.0192	0.0176	0.0170	0.0898
Alpha 2	0.0514	0.0192	0.0352	0.0339	0.0898
Alpha 3	0.0686	0.0770	0.0704	0.0679	0.0898
Alpha 4	0.0686	0.0770	0.0880	0.0848	0.0718
Alpha 5	0.0514	0.0385	0.0528	0.0848	0.0359
Alpha 6	0.0686	0.0577	0.0704	0.0679	0.0359
Alpha 7	0.0857	0.0770	0.0880	0.0679	0.0359
Alpha 8	0.0686	0.0962	0.0880	0.0679	0.0718
Alpha 9	0.0514	0.0385	0.0352	0.0339	0.0180
Alpha 10	0.0686	0.0770	0.0352	0.0679	0.0359

Table B5: Positive ideal Solutions (A^+) and Negative Ideal Solutions (A^-) – Cluster 2

	SC36	SC41	SC47	SC38	SC37
A^+	0.0857	0.0962	0.0880	0.0848	0.0898
A^-	0.0343	0.0192	0.0176	0.0170	0.0180

Table B6: Distances to the Positive (S_i^+) and Negative (S_i^-) Ideal Solutions; Relative Closeness to the Ideal Solution (C_i^+); and Rank – Cluster 2

	S_i^+	S_i^-	C_i^+	Rank
Alpha 1	0.1347	0.2680	0.6656	7
Alpha 2	0.1117	0.2697	0.7071	5
Alpha 3	0.0355	0.2859	0.8895	3
Alpha 4	0.0314	0.2607	0.8924	2
Alpha 5	0.0930	0.1564	0.6271	9
Alpha 6	0.0726	0.1612	0.6894	6
Alpha 7	0.0597	0.1775	0.7483	4
Alpha 8	0.0301	0.2618	0.8970	1
Alpha 9	0.1227	0.0355	0.2246	10
Alpha 10	0.0815	0.1593	0.6615	8

Appendix C – Cluster 3 – Finance

Table C1: Decision Matrix (*D*) obtained in the Second Group Session – Cluster 3

	SC95	SC79	SC98	SC84	SC86	SC83	SC96
Alpha 1	4	5	5	5	4	5	5
Alpha 2	4	5	4	5	4	5	4
Alpha 3	4	4	3	4	4	4	3
Alpha 4	4	4	3	4	4	4	3
Alpha 5	3	3	3	3	3	3	3
Alpha 6	3	4	3	3	3	4	3
Alpha 7	3	4	2	4	3	4	2
Alpha 8	4	3	2	2	4	3	2
Alpha 9	4	3	4	4	4	3	4
Alpha 10	4	5	4	4	4	5	4

Table C2: Normalized Decision Matrix (*R*) – Cluster 3

	SC95	SC79	SC98	SC84	SC86	SC83	SC96
Alpha 1	0.3393	0.3881	0.4623	0.4056	0.3393	0.3881	0.4623
Alpha 2	0.3393	0.3881	0.3698	0.4056	0.3393	0.3881	0.3698
Alpha 3	0.3393	0.3105	0.2774	0.3244	0.3393	0.3105	0.2774
Alpha 4	0.3393	0.3105	0.2774	0.3244	0.3393	0.3105	0.2774
Alpha 5	0.2545	0.2328	0.2774	0.2433	0.2545	0.2328	0.2774
Alpha 6	0.2545	0.3105	0.2774	0.2433	0.2545	0.3105	0.2774
Alpha 7	0.2545	0.3105	0.1849	0.3244	0.2545	0.3105	0.1849
Alpha 8	0.3393	0.2328	0.1849	0.1622	0.3393	0.2328	0.1849
Alpha 9	0.3393	0.2328	0.3698	0.3244	0.3393	0.2328	0.3698
Alpha 10	0.3393	0.3881	0.3698	0.3244	0.3393	0.3881	0.3698

Table C3: Weight (w_i) of each Sub-Criteria – Cluster 3

	SC95	SC79	SC98	SC84	SC86	SC83	SC96
$\boldsymbol{w_i}$	0.1429	0.1429	0.1429	0.1429	0.1429	0.1429	0.1429

Table C4: Weighted Normalized Decision Matrix (V) – Cluster 3

	SC95	SC79	SC98	SC84	SC86	SC83	SC96
Alpha 1	0.0485	0.0554	0.0660	0.0579	0.0485	0.0554	0.0660
Alpha 2	0.0485	0.0554	0.0528	0.0579	0.0485	0.0554	0.0528
Alpha 3	0.0485	0.0444	0.0396	0.0463	0.0485	0.0444	0.0396
Alpha 4	0.0485	0.0444	0.0396	0.0463	0.0485	0.0444	0.0396
Alpha 5	0.0364	0.0333	0.0396	0.0348	0.0364	0.0333	0.0396
Alpha 6	0.0364	0.0444	0.0396	0.0348	0.0364	0.0444	0.0396
Alpha 7	0.0364	0.0444	0.0264	0.0463	0.0364	0.0444	0.0264
Alpha 8	0.0485	0.0333	0.0264	0.0232	0.0485	0.0333	0.0264
Alpha 9	0.0485	0.0333	0.0528	0.0463	0.0485	0.0333	0.0528
Alpha 10	0.0485	0.0554	0.0528	0.0463	0.0485	0.0554	0.0528

Table C5: Positive ideal Solutions (A^+) and Negative Ideal Solutions (A^-) – Cluster 3

	SC95	SC79	SC98	SC84	SC86	SC83	SC96
A^+	0.0485	0.0554	0.0660	0.0579	0.0485	0.0554	0.0660
A^-	0.0364	0.0333	0.0264	0.0232	0.0364	0.0333	0.0264

Table C6: Distances to the Positive (S_i^+) and Negative (S_i^-) Ideal Solutions; Relative Closeness to the Ideal Solution (C_i^+); and Rank – Cluster 3

	S_i^+	S_i^-	C_i^+	Rank
Alpha 1	0.0000	0.1326	1.0000	1
Alpha 2	0.0187	0.1259	0.8708	2
Alpha 3	0.0421	0.1157	0.7331	5
Alpha 4	0.0421	0.1157	0.7331	5
Alpha 5	0.0567	0.0220	0.2795	10
Alpha 6	0.0497	0.0270	0.3519	8
Alpha 7	0.0618	0.0280	0.3118	9
Alpha 8	0.0730	0.1107	0.6026	7
Alpha 9	0.0383	0.1191	0.7568	4
Alpha 10	0.0220	0.1232	0.8486	3

Appendix D – Cluster 4 – Relationship with the Market

Table D1: Decision Matrix (*D*) obtained in the Second Group Session – Cluster 4

	SC56	SC73	SC64	SC66	SC54	SC59	SC60
Alpha 1	5	1	4	4	2	1	2
Alpha 2	5	1	5	4	3	2	3
Alpha 3	3	3	3	4	4	4	4
Alpha 4	3	4	3	4	4	5	4
Alpha 5	4	4	3	4	3	3	3
Alpha 6	3	3	3	4	4	4	4
Alpha 7	3	3	3	4	4	5	4
Alpha 8	2	2	5	4	5	5	5
Alpha 9	4	3	4	4	3	2	3
Alpha 10	4	4	2	4	5	2	5

Table D2: Normalized Decision Matrix (*R*) – Cluster 4

	SC56	SC73	SC64	SC66	SC54	SC59	SC60
Alpha 1	0.4256	0.1054	0.3495	0.3162	0.1661	0.0880	0.1661
Alpha 2	0.4256	0.1054	0.4369	0.3162	0.2491	0.1761	0.2491
Alpha 3	0.2554	0.3162	0.2621	0.3162	0.3322	0.3522	0.3322
Alpha 4	0.2554	0.4216	0.2621	0.3162	0.3322	0.4402	0.3322
Alpha 5	0.3405	0.4216	0.2621	0.3162	0.2491	0.2641	0.2491
Alpha 6	0.2554	0.3162	0.2621	0.3162	0.3322	0.3522	0.3322
Alpha 7	0.2554	0.3162	0.2621	0.3162	0.3322	0.4402	0.3322
Alpha 8	0.1703	0.2108	0.4369	0.3162	0.4152	0.4402	0.4152
Alpha 9	0.3405	0.3162	0.3495	0.3162	0.2491	0.1761	0.2491
Alpha 10	0.3405	0.4216	0.1747	0.3162	0.4152	0.1761	0.4152

Table D3: Weight (w_i) of each Sub-Criteria – Cluster 4

	SC56	SC73	SC64	SC66	SC54	SC59	SC60
$\boldsymbol{w_i}$	0.1429	0.1429	0.1429	0.1429	0.1429	0.1429	0.1429

Table D4: Weighted Normalized Decision Matrix (V) – Cluster 4

	SC56	SC73	SC64	SC66	SC54	SC59	SC60
Alpha 1	0.0608	0.0151	0.0499	0.0452	0.0237	0.0126	0.0237
Alpha 2	0.0608	0.0151	0.0624	0.0452	0.0356	0.0252	0.0356
Alpha 3	0.0365	0.0452	0.0374	0.0452	0.0475	0.0503	0.0475
Alpha 4	0.0365	0.0602	0.0374	0.0452	0.0475	0.0629	0.0475
Alpha 5	0.0486	0.0602	0.0374	0.0452	0.0356	0.0377	0.0356
Alpha 6	0.0365	0.0452	0.0374	0.0452	0.0475	0.0503	0.0475
Alpha 7	0.0365	0.0452	0.0374	0.0452	0.0475	0.0629	0.0475
Alpha 8	0.0243	0.0301	0.0624	0.0452	0.0593	0.0629	0.0593
Alpha 9	0.0486	0.0452	0.0499	0.0452	0.0356	0.0252	0.0356
Alpha 10	0.0486	0.0602	0.0250	0.0452	0.0593	0.0252	0.0593

Table D5: Positive ideal Solutions (A^+) and Negative Ideal Solutions (A^-) – Cluster 4

	SC56	SC73	SC64	SC66	SC54	SC59	SC60
A^+	0.0608	0.0602	0.0624	0.0452	0.0593	0.0629	0.0593
A^-	0.0243	0.0151	0.0250	0.0452	0.0237	0.0126	0.0237

Table D6: Distances to the Positive (S_i^+) and Negative (S_i^-) Ideal Solutions; Relative Closeness to the Ideal Solution (C_i^+); and Rank – Cluster 4

	S_i^+	S_i^-	C_i^+	Rank
Alpha 1	0.0852	0.0442	0.3416	10
Alpha 2	0.0678	0.1220	0.6430	9
Alpha 3	0.0434	0.1641	0.7909	4
Alpha 4	0.0387	0.1708	0.8153	1
Alpha 5	0.0503	0.1242	0.7118	7
Alpha 6	0.0434	0.1641	0.7909	4
Alpha 7	0.0415	0.1674	0.8013	3
Alpha 8	0.0473	0.2025	0.8106	2
Alpha 9	0.0555	0.1195	0.6829	8
Alpha 10	0.0545	0.1991	0.7850	6

Appendix E – Cluster 5 – Internal Organization

Table E1: Decision Matrix (*D*) obtained in the Second Group Session – Cluster 5

	SC119	SC110	SC111	SC112	SC114	SC125	SC129
Alpha 1	3	2	1	1	1	1	2
Alpha 2	3	4	4	4	4	4	5
Alpha 3	3	3	3	3	4	4	4
Alpha 4	4	4	4	3	4	4	3
Alpha 5	4	3	3	2	4	4	3
Alpha 6	3	4	4	3	4	4	3
Alpha 7	3	4	4	4	4	4	4
Alpha 8	4	4	3	2	4	4	4
Alpha 9	3	4	3	4	4	4	5
Alpha 10	3	5	5	3	4	4	4

Table E2: Normalized Decision Matrix (*R*) – Cluster 5

	SC119	SC110	SC111	SC112	SC114	SC125	SC129
Alpha 1	0.2847	0.1672	0.0891	0.1037	0.0830	0.0830	0.1661
Alpha 2	0.2847	0.3345	0.3563	0.4148	0.3322	0.3322	0.4152
Alpha 3	0.2847	0.2509	0.2673	0.3111	0.3322	0.3322	0.3322
Alpha 4	0.3797	0.3345	0.3563	0.3111	0.3322	0.3322	0.2491
Alpha 5	0.3797	0.2509	0.2673	0.2074	0.3322	0.3322	0.2491
Alpha 6	0.2847	0.3345	0.3563	0.3111	0.3322	0.3322	0.2491
Alpha 7	0.2847	0.3345	0.3563	0.4148	0.3322	0.3322	0.3322
Alpha 8	0.3797	0.3345	0.2673	0.2074	0.3322	0.3322	0.3322
Alpha 9	0.2847	0.3345	0.2673	0.4148	0.3322	0.3322	0.4152
Alpha 10	0.2847	0.4181	0.4454	0.3111	0.3322	0.3322	0.3322

Table E3: Weight (w_i) of each Sub-Criteria – Cluster 5

	SC119	SC110	SC111	SC112	SC114	SC125	SC129
$\boldsymbol{w_i}$	0.1429	0.1429	0.1429	0.1429	0.1429	0.1429	0.1429

Table E4: Weighted Normalized Decision Matrix (V) – Cluster 5

	SC119	SC110	SC111	SC112	SC114	SC125	SC129
Alpha 1	0.0407	0.0239	0.0127	0.0148	0.0119	0.0119	0.0237
Alpha 2	0.0407	0.0478	0.0509	0.0593	0.0475	0.0475	0.0593
Alpha 3	0.0407	0.0358	0.0382	0.0444	0.0475	0.0475	0.0475
Alpha 4	0.0542	0.0478	0.0509	0.0444	0.0475	0.0475	0.0356
Alpha 5	0.0542	0.0358	0.0382	0.0296	0.0475	0.0475	0.0356
Alpha 6	0.0407	0.0478	0.0509	0.0444	0.0475	0.0475	0.0356
Alpha 7	0.0407	0.0478	0.0509	0.0593	0.0475	0.0475	0.0475
Alpha 8	0.0542	0.0478	0.0382	0.0296	0.0475	0.0475	0.0475
Alpha 9	0.0407	0.0478	0.0382	0.0593	0.0475	0.0475	0.0593
Alpha 10	0.0407	0.0597	0.0636	0.0444	0.0475	0.0475	0.0475

Table E5: Positive ideal Solutions (A^+) and Negative Ideal Solutions (A^-) – Cluster 5

	SC119	SC110	SC111	SC112	SC114	SC125	SC129
A^+	0.0542	0.0597	0.0636	0.0593	0.0475	0.0475	0.0593
A^-	0.0407	0.0239	0.0127	0.0148	0.0119	0.0119	0.0237

Table E6: Distances to the Positive (S_i^+) and Negative (S_i^-) Ideal Solutions; Relative Closeness to the Ideal Solution (C_i^+); and Rank – Cluster 5

	S_i^+	S_i^-	C_i^+	Rank
Alpha 1	0.0992	0.0000	0.0000	10
Alpha 2	0.0221	0.2053	0.9028	1
Alpha 3	0.0420	0.1977	0.8248	7
Alpha 4	0.0330	0.2002	0.8586	5
Alpha 5	0.0516	0.1954	0.7912	9
Alpha 6	0.0357	0.1998	0.8486	6
Alpha 7	0.0251	0.2035	0.8903	3
Alpha 8	0.0425	0.1976	0.8229	8
Alpha 9	0.0312	0.2033	0.8669	4
Alpha 10	0.0233	0.2054	0.8980	2

Appendix F – Cluster 6 – Technological Adaptation

Table F1: Decision Matrix (*D*) obtained in the Second Group Session – Cluster 6

	SC9	SC10	SC11	SC12	SC13
Alpha 1	1	3	2	2	1
Alpha 2	5	5	5	5	5
Alpha 3	4	4	3	4	4
Alpha 4	4	4	4	4	4
Alpha 5	3	3	2	2	3
Alpha 6	3	4	4	3	3
Alpha 7	4	4	3	4	4
Alpha 8	4	4	3	4	4
Alpha 9	5	5	4	5	5
Alpha 10	4	4	4	4	4

Table F2: Normalized Decision Matrix (*R*) – Cluster 6

	SC9	SC10	SC11	SC12	SC13
Alpha 1	0.0819	0.2343	0.1796	0.1650	0.0819
Alpha 2	0.4096	0.3904	0.4490	0.4124	0.4096
Alpha 3	0.3277	0.3123	0.2694	0.3299	0.3277
Alpha 4	0.3277	0.3123	0.3592	0.3299	0.3277
Alpha 5	0.2458	0.2343	0.1796	0.1650	0.2458
Alpha 6	0.2458	0.3123	0.3592	0.2474	0.2458
Alpha 7	0.3277	0.3123	0.2694	0.3299	0.3277
Alpha 8	0.3277	0.3123	0.2694	0.3299	0.3277
Alpha 9	0.4096	0.3904	0.3592	0.4124	0.4096
Alpha 10	0.3277	0.3123	0.3592	0.3299	0.3277

Table F3: Weight (w_i) of each Sub-Criteria – Cluster 6

	SC9	SC10	SC11	SC12	SC13
$\boldsymbol{w_i}$	0.2000	0.2000	0.2000	0.2000	0.2000

Table F4: Weighted Normalized Decision Matrix (V) – Cluster 6

	SC9	SC10	SC11	SC12	SC13
Alpha 1	0.0164	0.0469	0.0359	0.0330	0.0164
Alpha 2	0.0819	0.0781	0.0898	0.0825	0.0819
Alpha 3	0.0655	0.0625	0.0539	0.0660	0.0655
Alpha 4	0.0655	0.0625	0.0718	0.0660	0.0655
Alpha 5	0.0492	0.0469	0.0359	0.0330	0.0492
Alpha 6	0.0492	0.0625	0.0718	0.0495	0.0492
Alpha 7	0.0655	0.0625	0.0539	0.0660	0.0655
Alpha 8	0.0655	0.0625	0.0539	0.0660	0.0655
Alpha 9	0.0819	0.0781	0.0718	0.0825	0.0819
Alpha 10	0.0655	0.0625	0.0718	0.0660	0.0655

Table F5: Positive ideal Solutions (A^+) and Negative Ideal Solutions (A^-) – Cluster 6

	SC9	SC10	SC11	SC12	SC13
A^+	0.0819	0.0781	0.0898	0.0825	0.0819
A^-	0.0164	0.0469	0.0359	0.0330	0.0164

Table F6: Distances to the Positive (S_i^+) and Negative (S_i^-) Ideal Solutions; Relative Closeness to the Ideal Solution (C_i^+); and Rank – Cluster 6

	S_i^+	S_i^-	C_i^+	Rank
Alpha 1	0.1221	0.0000	0.0000	10
Alpha 2	0.0000	0.2760	1.0000	1
Alpha 3	0.0484	0.2307	0.8266	5
Alpha 4	0.0371	0.2328	0.8626	3
Alpha 5	0.0921	0.1840	0.6665	9
Alpha 6	0.0617	0.1888	0.7538	8
Alpha 7	0.0484	0.2307	0.8266	5
Alpha 8	0.0484	0.2307	0.8266	5
Alpha 9	0.0180	0.2730	0.9383	2
Alpha 10	0.0371	0.2328	0.8626	3

Appendix G – Cluster 7 – Regulation

Table G1: Decision Matrix (*D*) obtained in the Second Group Session – Cluster 7

	SC14	SC15	SC19	SC18	SC17
Alpha 1	5	3	3	3	2
Alpha 2	3	2	3	3	2
Alpha 3	3	3	3	3	2
Alpha 4	3	3	3	3	2
Alpha 5	4	4	3	3	2
Alpha 6	3	3	3	3	2
Alpha 7	4	4	3	3	2
Alpha 8	2	2	2	3	2
Alpha 9	3	4	3	3	2
Alpha 10	4	3	3	3	2

Table G2: Normalized Decision Matrix (*R*) – Cluster 7

	SC14	SC15	SC19	SC18	SC17
Alpha 1	0.4527	0.2985	0.3254	0.3162	0.3162
Alpha 2	0.2716	0.1990	0.3254	0.3162	0.3162
Alpha 3	0.2716	0.2985	0.3254	0.3162	0.3162
Alpha 4	0.2716	0.2985	0.3254	0.3162	0.3162
Alpha 5	0.3621	0.3980	0.3254	0.3162	0.3162
Alpha 6	0.2716	0.2985	0.3254	0.3162	0.3162
Alpha 7	0.3621	0.3980	0.3254	0.3162	0.3162
Alpha 8	0.1811	0.1990	0.2169	0.3162	0.3162
Alpha 9	0.2716	0.3980	0.3254	0.3162	0.3162
Alpha 10	0.3621	0.2985	0.3254	0.3162	0.3162

Table G3: Weight (w_i) of each Sub-Criteria – Cluster 7

	SC14	SC15	SC19	SC18	SC17
$\boldsymbol{w_i}$	0.2000	0.2000	0.2000	0.2000	0.2000

Table G4: Weighted Normalized Decision Matrix (V) – Cluster 7

	SC14	SC15	SC19	SC18	SC17
Alpha 1	0.0905	0.0597	0.0651	0.0632	0.0632
Alpha 2	0.0543	0.0398	0.0651	0.0632	0.0632
Alpha 3	0.0543	0.0597	0.0651	0.0632	0.0632
Alpha 4	0.0543	0.0597	0.0651	0.0632	0.0632
Alpha 5	0.0724	0.0796	0.0651	0.0632	0.0632
Alpha 6	0.0543	0.0597	0.0651	0.0632	0.0632
Alpha 7	0.0724	0.0796	0.0651	0.0632	0.0632
Alpha 8	0.0362	0.0398	0.0434	0.0632	0.0632
Alpha 9	0.0543	0.0796	0.0651	0.0632	0.0632
Alpha 10	0.0724	0.0597	0.0651	0.0632	0.0632

Table G5: Positive ideal Solutions (A^+) and Negative Ideal Solutions (A^-) – Cluster 7

	SC14	SC15	SC19	SC18	SC17
$\boldsymbol{A^+}$	0.0905	0.0796	0.0651	0.0632	0.0632
$\boldsymbol{A^-}$	0.0362	0.0398	0.0434	0.0632	0.0632

Table G6: Distances to the Positive (S_i^+) and Negative (S_i^-) Ideal Solutions; Relative Closeness to the Ideal Solution (C_i^+); and Rank – Cluster 7

	$\boldsymbol{S_i^+}$	$\boldsymbol{S_i^-}$	$\boldsymbol{C_i^+}$	Rank
Alpha 1	0.0199	0.0618	0.7564	3
Alpha 2	0.0538	0.0283	0.3443	9
Alpha 3	0.0413	0.0346	0.4555	6
Alpha 4	0.0413	0.0346	0.4555	6
Alpha 5	0.0181	0.0580	0.7621	1
Alpha 6	0.0413	0.0346	0.4555	6
Alpha 7	0.0181	0.0580	0.7621	1
Alpha 8	0.0708	0.0000	0.0000	10
Alpha 9	0.0362	0.0488	0.5741	5
Alpha 10	0.0269	0.0467	0.6343	4