



# “Why do we need them?”: Digital technologies and small and medium-sized enterprises’ performance

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## Abstract

In an increasingly digitalized world, enterprises that neglect to adapt and innovate risk losing their competitive edge and lagging behind industry trends. Recognizing the unique challenges that small and medium-sized enterprises (SMEs) encounter in this transformative process, there is a pressing need for an evaluation system to aid decision-making regarding digital technology factors that can enhance the performance of these firms. This study employs a multiple-criteria decision analysis (MCDA) approach that integrates cognitive mapping and the Best–Worst Method (BWM) to systematically identify evaluation criteria and their intricate interactions. To ensure the relevance and applicability of the research findings, a panel of experts was recruited from among professionals with knowledge and experience in this area, who were able to provide added value to the research. The results include a proposed decision-support model, the practical potential of which was discussed and validated by both the panel members and a project manager from COTEC Portugal—a leading think-and-action network dedicated to advancing technology diffusion and business innovation cooperation. Due to its process-oriented nature, this research contributes to bridging the gap between theoretical insights and practical applications. Its contributions and limitations are also analyzed, offering valuable insights for researchers, practitioners and policymakers alike. Overall, this comprehensive and unique approach addresses the critical need for understanding the nuanced interplay between digital technologies and SME performance in today’s dynamic business environment.

**Keywords** Best–Worst Method (BWM) · Cognitive mapping · Digital technologies · Firm performance · Small and medium-sized enterprises (SMEs)

## 1 Introduction

Companies are currently dealing with demanding and worrying business scenarios generated by rapid technological development. The imperative to undergo digital transformations has emerged, compelling firms to align technologies with their business activities and equip employees to navigate daily challenges (Zapata et al., 2020; Farinha et al., 2025). Adopting

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digital technologies is a complex process that requires not only investment in operational resources but also a willingness to change traditional mindsets and organizational culture. In this context, managers need to design appropriate plans for digital technology implementation to ensure these changes are successful (Martínez-Caro et al., 2020; Tariq et al., 2025). Incorporating digital tools has become an especially urgent issue for small and medium-sized enterprises (SMEs), recognized as the engine of the European economy for job creation and economic growth (European Commission, 2020; Farinha et al., 2025).

Two aspects of SMEs need to be analyzed in this area. On the one hand, the implementation of new digital technologies is hindered by specific organizational characteristics, where limited resources and strong ownership influence contribute to a more centralized power structure (Milici et al., 2023; Ćirović et al., 2025). On the other hand, the inherent flexibility of SMEs, stemming from their smaller size, allows for agile responses to changes. Therefore, SMEs must discern the benefits of digital transformation to strategically implement tools and comprehend their impact on existing company structures. Managers play a pivotal role in assessing the capacity for adopting digital technologies, identifying current limitations and recognizing areas for improvement. This strategic approach enables SMEs to reduce process costs, enhance service delivery, increase effectiveness and competitiveness and access new opportunities (Frogeri et al., 2019; Lykountzou et al., 2025).

Despite the critical importance of digital technologies for SMEs, a paucity of studies specifically focused on these firms remains (cf. Silva et al., 2021; Ćirović et al., 2025), exacerbating the challenge faced by managers who often lack the necessary know-how for informed decision-making (cf. Simões et al., 2020). Recognizing this, it becomes imperative not only to identify determining factors influencing digital technologies in SMEs but also to comprehend the dynamics of their causal relationships (Lemos et al., 2022). This holistic understanding is crucial for developing comprehensive strategies, ensuring that decision-makers consider the interconnected nature of various elements in the adoption of digital technologies within SMEs (Gonçalves et al., 2024). This depth of comprehension brings forth several advantages, namely: informed decision-making; predictive capabilities; optimized resource allocation; and enhanced innovation and adaptability (Rodrigues et al., 2024). In addition, this understanding fosters a culture of innovation and adaptability within SMEs, encouraging the exploration of synergies between different factors (Rocha et al., 2022). As an attempt to address existing gaps and contribute to this research field, the present study seeks to answer two interrelated questions:

- What key determinants influence the adoption of digital technologies in SME contexts?
- How are these factors interrelated, and how do they affect these companies' performance?

Given the complexity and subjectivity inherent in this topic, the present study sought to develop a comprehensive evaluation system for digital technologies in SME contexts. This system relies on a combination of cognitive mapping techniques and the Best–Worst Method (BWM), aiming to identify determinants that significantly improve SME business performance and analyze their cause-and-effect relationships, thereby providing answers to the two research questions presented. Four additional key objectives guide our research, encompassing the integration of subjectivity into decision-making processes, the creation of a tool supporting SME decision-makers, the promotion of awareness regarding well-

planned digital transformations and the identification and prioritization of crucial variables relevant to the usefulness of digital technologies for SMEs.

The combination of cognitive mapping and the BWM emerges as a valuable tool, addressing limitations associated with more statistical approaches. Specifically, cognitive mapping encourages active participation from decision-makers, facilitating the structuring of complex decision problems involving diverse perspectives (Eden & Ackermann, 2004). The BWM allows experts to calculate trade-offs for both objective and subjective criteria (Rezaei, 2015, 2016). A comprehensive review of the literature confirmed the novelty of applying cognitive mapping and the BWM in this research context, contributing to the extant knowledge about digital technology, SME performance evaluation and operational research/management science (OR/MS).

The results have some important implications for decision-making processes, of which the first is a transparent evaluation model. The second is a cognitive map that groups 173 evaluation criteria and their cause-and-effect relationships into clusters, while the third is the integration of objective and subjective elements into the decision-making process. The fourth is a shared cognitive structure based on the experience, values and know-how of a panel of decision makers specializing in the subject under analysis. The fifth implication is a tool to support decision making and raise awareness of the decision problem, and the last is a way to structure future action plans to improve SMEs' adoption of useful digital technologies.

The subsequent sections of this paper are organized as follows. The next section presents a focused literature review on digital technologies in SME contexts. Section three discusses the theoretical framework underpinning the selected methodologies. Section four comprises an analysis of the results, including the application of the developed model in a real-life context. The final section encapsulates the study's main conclusions and limitations, along with suggestions for future research.

## 2 Literature review

Technology has evolved in surprising ways over time, so keeping up with technological change can be challenging (Simões et al., 2020; Farinha et al., 2025). Despite the associated benefits and impacts on business performance, adopting digital technologies can be quite complex for companies whose activities are extremely limited, as is the case with SMEs (Fletcher & Griffiths, 2020; Ćirović et al., 2025). Currently, digital technology is not just an option, but a necessity for firms seeking to adapt and reach a specific level of maturity in their business operations (Martins et al., 2020; Ramos et al., 2025).

The present Fourth Industrial Revolution is driven by new technologies that create digital solutions, such as the Internet of Things (IoT), cloud services, big data and analytics, artificial intelligence (AI) and blockchain technology (Papadopoulos et al., 2020; Ramos et al., 2025). These technologies facilitate access to global markets and knowledge networks at a lower cost, allowing companies to create new and improved products, services and production processes, thereby increasing firms' competitiveness (Rodrigues et al., 2022). According to Coccia and Watts (2020), technology can achieve the objectives of—and/or solve problems faced by—those who implement digital tools, which must be adapted to

specific environments and companies' technical, economic and social characteristics (see also Freire et al. (2023)).

The ongoing evolution of technology plays a pivotal role in maintaining competitive advantages, with innovative technologies progressively becoming decisive factors for firms (Gonçalves et al., 2019; Farinha et al., 2025). However, a common trend among many companies is to concentrate primarily on implementing desired technologies (Halicka, 2017), often neglecting investments in developing their organizational capability to adeptly respond to evolving changes (Ladeira et al., 2019). This narrow focus poses a challenge, as sustaining competitiveness requires more than just adopting new technologies (Çipi et al., 2023). To navigate this challenge successfully and avoid unsuccessful attempts at integrating digital tools, managers must take the lead in transforming workforce mindsets and processes (Lykourantzou et al., 2025). It also involves fostering an organizational culture that not only embraces innovations but also nurtures the adaptability needed to navigate the dynamic technological landscape (Gonçalves et al., 2024). This strategic approach goes beyond mere technology adoption. It encompasses the broader organizational readiness to effectively leverage the advantages offered by technology in the long run. By investing in the development of a resilient organizational capability, companies can position themselves to thrive amidst technological advancements and secure enduring competitive advantages (Martínez-Caro et al., 2020).

Digital transformation is a *“process that aims to improve an entity by triggering significant changes to its properties through combinations of information, computing, communication, and connectivity technologies”* (Vial, 2019, p. 118). Ulas (2019) further asserts that digital transformation is a restructuring of technology, business models and processes that facilitate the creation of value for customers and employees in a constantly changing and developing digital economy. Genzorova et al. (2019, p. 1055) also point out that digital transformation is a long process during which human resources can feel *“in the shadow”*, so leaders must be as transparent as possible and keep employees updated about the alterations.

Digitalization thus allows companies to generate revenue, improve business practices, transform business processes, reduce costs and obtain competitive advantages in markets that are increasingly demanding (Rodrigues et al., 2022). Companies, in general, are well aware of the potential value of new technologies (Sousa & Rocha, 2019; Lykourantzou et al., 2025), so their main challenge is to understand what digital transformation means for them and how they can translate this process into appropriate strategies that help them achieve their business goals (Zapata et al., 2020; Silva et al., 2025).

SMEs, however, are subject to great uncertainties and high risks (Li et al., 2012; Ćirović et al., 2025). These firms' limitations mean they do not have the same opportunities as large companies do (Milici et al., 2023). The above restrictions affect, for example, SMEs' ability to adopt technology that can solve problems or make operations more efficient, which is cause for concern given the present digital era. Many SMEs have difficulty perceiving technology benefits (Seyal & Abdrahman, 2003; Simões et al., 2020; Ćirović et al., 2025), so these firms have a much lower technology adoption rate than that of large companies (Meath et al., 2016). Thus, SMEs' characteristics and available resources are crucial factors that strongly affect technological implementations. These firms must currently deal with complex scenarios generated by rapid technological development and the well-designed digital transformations needed to meet challenges (Zapata et al., 2020; Milici et al., 2023).

Ulas (2019) identified a set of SME characteristics that are determining factors in technology adoption. These variables are: (1) small management teams; (2) owners' strong influence and centralized power combined with specialized teams' lack of control; (3) limited market shares; (4) low employee turnover; and (5) reluctance to take risks. In other words, these companies' limited resources and dependence on a few key individuals often create barriers to the development and implementation of digital tools (Seyal & Abdrahman, 2003). In addition, experts need to consider and examine varied factors for SME successful adoption of technologies (Ferreira et al., 2019; Ćirović et al., 2025). These determinants encompass various factors crucial to the successful adoption of technology by SMEs: (1) the motivation, experience and competence of owners; (2) maintaining close contact with customers; (3) securing access to resources; (4) leveraging competitive advantages; (5) demonstrating flexibility; (6) focusing on profits rather than sales; and (7) operating in growing markets (Meath et al., 2016). Despite the well-documented limitations of SMEs, these characteristics can serve as valuable assets in specific contexts. For example, SMEs often exhibit greater flexibility in adapting to changes in their environment (Aragón-Correa et al., 2008), possess a capacity for innovation to effectively respond to competitors' actions (Milici et al., 2023), and benefit from the proximity of employees, fostering increased interaction and collaboration (Ulas, 2019; Farinha et al., 2025).

When SMEs are able to overcome their limitations and challenges, their effective adoption of technologies allows them to reduce process costs, improve the provision of services to customers and suppliers and increase organizational effectiveness (Bastos et al., 2023). In addition, new digital tools provide access to fresh opportunities for business, market knowledge and greater competitiveness and capacity for internationalization (Frogeri et al., 2019; Ćirović et al., 2025). Thus, to succeed in a digital age, all firms—but especially SMEs—must use technology to create value, adapting organizational structure, processes and culture (Vial, 2019; Ćirović et al., 2025) to meet their relevant strategic objectives.

SMEs seeking to improve their business performance, therefore, need to adopt not only new digital technologies but also a digital organizational culture and systems that facilitate the process of digitization and create value through digital tools (Barata et al., 2024). In this regard, the development of performance evaluation systems is instrumental in guiding and optimizing the digital transformation journey for SMEs. It offers a structured framework for assessing the impact of digital technologies, aligning organizational efforts, promoting transparency and fostering a culture of continuous improvement, ultimately contributing to enhanced business performance and competitiveness (Gonçalves et al., 2024). This complex transformation requires in-depth analyses of the relationships between digital technologies and SME performance. Table 1 provides examples of prior research conducted in this field.

The analysis of existing research, as exemplified by Table 1, underscores different types of challenges in assessing SME performance related to digital technology factors. However, according to Santos et al. (2024) and Silva et al. (2024), these limitations can be categorized into two primary groups. First, challenges arise in identifying and integrating decision criteria into evaluation systems (cf. Santos et al., 2024). Second, difficulties are encountered in quantifying the interrelationships among these criteria to generate trade-offs (cf. Silva et al., 2024). To address these overarching challenges identified in previous research, our study endeavors to develop a comprehensive evaluation system. This system not only identifies decision criteria pertinent to digital technology factors influencing SME performance based on cognitive mapping but also tackles the critical aspects of establishing causal relationships

**Table 1** Contributions and limitations of studies focused on digital technology development and SME performance

Authors	Methods	Contributions and results	Limitations
Bruque and Moyano (2007)	Qualitative analysis	Identified factors related to information technology (IT) adoption in SMEs: (1) management role; (2) technological leader role; (3) technology strategy, training and socialization; and (4) firm size and/or need for growth. Defined factors related to IT implementation: (1) management role; (2) training and socialization; and (3) impact on power and/or hierarchical structure.	Problems arose that are commonly associated with qualitative research (e.g., generalizability of results). The model's exhaustiveness was not verified. The approach applied prevents the measurement of the intensity of variables' interrelationships. The model was developed for a specific geographical context.
Anggadwita and Mustafid (2014)	Quantitative analysis	Developed a conceptual framework for measuring SME performance.	The analysis only included SMEs' internal factors.
Ferreira et al. (2019)	Binary regression model	Analyzed factors that lead companies to adopt new digital processes (e.g., increased market share and service quality) and their consequences in terms of innovation and performance. Contributed to a better understanding of digital transformation.	The sample was limited to Portugal and sectors in a specific context.
Hansen and Bøgh (2020)	Literature review	Investigated how widespread AI and the IoT are among manufacturing SMEs.	The review failed to identify the main characteristics that drive SME adoption of technologies. Few articles focused on AI because of its complexity, especially for SMEs.
Li et al. (2020)	Online survey and nonparametric bootstrapping	Analyzed digital technologies' implications for performance.	The focus was restricted to economic and environmental performance. Digital technologies are limited to the IoT, cloud computing, and big data and analytics. The survey was conducted in China (i.e., an emerging market), so the model should also be tested in developed markets.
Martínez-Caro et al. (2020)	Survey	Found that, when companies adopt digital technologies, they gain: (1) operational benefits through business digitalization; and (2) strategic benefits through digital technologies' value development. Determined that a digital organizational culture is an important prerequisite to digital technologies' adoption.	The data were collected from one organization from a specific business sector. The survey was answered by managers and not by all employees.

and calculating trade-offs among these criteria, employing the BWB. Through the combination of these methodologies, our study aims to overcome the two broad categories of limitations revealed by the existing literature, presenting an empirically robust and transparent model for SME performance assessment related to digital technology factors.

### 3 Methodological background

The main goal is to develop a model that supports decision-making processes related to both digital technologies and SME performance. This research thus relied on a multiple-criteria decision analysis (MCDA) approach, which follows constructivist and process-oriented principles. The selected approach splits the decision process into three phases: (1) structuring; (2) evaluation; and (3) recommendations (Belton & Stewart, 2002; Castanho et al., 2021). These phases require the participation of decision makers who are professionals with knowledge about and specialized experience in the area under study.

#### 3.1 Cognitive mapping

Cognitive mapping was developed by Tolman (1948) as a tool that has been widely used to structure decision problems and represent decision makers' interpretation of these problems (Ackermann & Eden, 2001). Eden (2004, p. 673) describes this technique as *"the task of mapping a person's thinking about a problem or issue"*. The resulting cognitive representations can be changed during the mapping development so that cognitive mapping can be used *"as a tool to help understand how different people involved in a situation made sense of it, or understood it, for themselves"* (Mingers, 2008, p. 6). Two important features of this method are that it facilitates the inclusion of subjectivity in decision-making processes and identifies cause-and-effect relationships between concepts (Weck et al., 2022). Each cognitive map is a network of concepts or nodes linked to form chains of argumentation (Hjortsø, 2004). These concepts are joined by arrows with positive (+) or negative (−) signs that indicate the direction of cause-and-effect relationships (i.e., the concepts' implications) (Eden & Ackermann, 2004).

Cognitive maps thus bring together different points of view on a given problem through decision makers' sharing of knowledge, values and experiences during the map-making process (Oliveira et al., 2017). These maps also stimulate group discussions that, in turn, allow participants to express value judgments that the decision makers would be unable to identify otherwise (cf. Ferreira et al., 2016). In addition, the facilitators play an important role by adopting a transparent, intellectually honest posture and creating a comfortable environment as intervening agents in decision-making processes. Ferreira et al. (2016) add that cognitive mapping is based on constructivism. The maps represent the concepts that decision makers consider relevant and these variables' respective relationships, but the participants can subsequently analyze the criteria's representation and propose changes that could be useful (Vaz et al., 2022). This process provides opportunities for the decision makers' thinking to evolve in faster and more convergent ways (Natividade et al., 2021).

Cognitive mapping has proven to be an extremely useful tool in terms of structuring complex decision problems. This technique can: (1) *"deal with both qualitative and quantitative factors"*; (2) *"structure difficult or complex decision problems"*; and (3) *"provide support for the work group, so that it can be of use for the development and implementation of strategic directions"* (Oliveira et al., 2017, p. 988). This methodology's multiple advantages seem evident, but the individuals involved must be convinced that a well-constructed map is crucial to correct problem structuring, which is commonly seen as the most important phase in the decision-making process (Nunes et al., 2021).

### 3.2 Best–Worst Method

Decision making consists of identifying and selecting an alternative from a range of options based on decision makers' preferences. This process also often involves checking different criteria (i.e., multicriteria decision-making problems) (Rezaei, 2016). This type of problem can be solved using many different methods (cf. Belton & Stewart, 2002; Carayannis et al., 2020), with the BWM being one of the most recent.

The BWM was developed by Rezaei (2015) in order to evaluate a set of alternatives and select the best one with reference to multiple decision criteria. Weights are assigned to the criteria, and the value of each alternative is estimated to rank the options (Rezaei et al., 2018). According to Rezaei (2015), the method assigns weights based on pairwise comparisons with the best and worst criteria, so it uses less comparison data compared to other MCDA methods and corrects inconsistency problems. Rezaei (2016) outlines five steps in the application of BWM.

#### 3.2.1 Step one

The first step is to determine the set of evaluation criteria to be considered. In the present study, these variables were identified by developing a group cognitive map that contained  $\{c_1, c_2, \dots, c_n\}$ .

#### 3.2.2 Step two

The decision makers next identify the best (e.g., most desirable or important) and worst (e.g., least desirable or important) criteria.

#### 3.2.3 Step three

The third step is to quantify the decision makers' preference for the best criterion over all the other criteria on a 9-point scale (1=criterion  $B$  is indistinguishable from criterion  $j$ ; 9=criterion  $B$  is much more preferable than criterion  $j$ ). This step produces a best-to-others vector, as shown in Eq. (1):

$$A_B = (a_{B1}, a_{B2}, \dots, a_{Bn}) \quad (1)$$

in which  $a_{Bj}$  represents the degree to which the best criterion  $B$  is preferred over all the other criteria  $j$ . In this case,  $a_{BB} = 1$ .

#### 3.2.4 Step four

The decision makers then specify their preference for all the criteria over the worst criterion on the same 9-point scale (1=criterion  $j$  is indistinguishable from criterion  $W$ ; 9=criterion  $j$  is much more preferable than criterion  $W$ ). The result is an others-to-worst vector expressed as Eq. (2):

$$A_W = (a_{1W}, a_{2W}, \dots, a_{nW})^T \quad (2)$$

in which  $a_{jW}$  represents the decision makers’ preference for criterion  $j$  over the worst criterion  $W$ . In this step,  $a_{WW} = 1$ .

### 3.2.5 Step five

The last step comprises calculating the criteria’s optimal weights  $(w_1^*, w_2^*, \dots, w_n^*)$ . The optimal weight of criterion  $j$  is estimated for each pair  $\frac{w_B}{w_j}$  and  $\frac{w_j}{w_W}$  as  $\frac{w_B}{w_j} = a_{Bj}$  and  $\frac{w_j}{w_W} = a_{jW}$ . To satisfy this condition for all criteria  $j$ , the solution must be found for which the maximum absolute differences  $\left| \frac{w_B}{w_j} - a_{Bj} \right|$  and  $\left| \frac{w_j}{w_W} - a_{jW} \right|$  for all criteria  $j$  are minimized. Equation (3) represents Model 1 (Rezaei, 2015, 2016):

$$\begin{aligned}
 & \min \max_j \left\{ \left| \frac{w_B}{w_j} - a_{Bj} \right|, \left| \frac{w_j}{w_W} - a_{jW} \right| \right\} \\
 & \text{s.t.} \\
 & \sum_j w_j = 1 \\
 & w_j \geq 0, \text{ for all } j
 \end{aligned} \tag{3}$$

The above model can be transformed using Eq. (4) to produce Model 2:

$$\begin{aligned}
 & \min \xi \\
 & \text{s.t.} \\
 & \left| \frac{w_B}{w_j} - a_{Bj} \right| \leq \xi, \text{ for all } j \\
 & \left| \frac{w_j}{w_W} - a_{jW} \right| \leq \xi, \text{ for all } j \\
 & \sum_j w_j = 1 \\
 & w_j \geq 0, \text{ for all } j
 \end{aligned} \tag{4}$$

Solving Eq. (4) provides the optimal weights  $(w_1^*, w_2^*, \dots, w_n^*)$  and an indicator of the comparisons’ level of consistency or  $\xi^*$ . Equation (5) is then used to check the comparisons’ consistency:

$$\text{Consistency ratio} = \frac{\xi^*}{\text{Consistency index}} \text{ and } \text{consistency ratio} \in [0,1] \tag{5}$$

in which  $\xi^*$  is the second model’s optimal objective value. The consistency index comprises a specific consistency value for each  $a_{BW}$ , which is presented in Table 2. The closer to zero the consistency ratio is, the more consistent the comparison is.

Two characteristics distinguish the BWM from other multicriteria methods. This technique requires less information and comparative data and enables decision makers to conduct more consistent comparisons, thereby providing more reliable results (Rezaei, 2015). In addition, by using a scale of 1–9 with only integers allowed, this method avoids the problem of complexity commonly associated with comparisons and facilitates more concise,

**Table 2** Consistency index table

$a_{BW}$	1	2	3	4	5	6	7	8	9
Consistency index ( $\max \xi$ )	0.00	0.44	1.00	1.63	2.30	3.00	3.73	4.47	5.23

Source: Rezaei (2015)

accurate analyses (Fei et al., 2020). The BWM is also easy to understand, as well as letting decision makers revise their value judgments if necessary and increasing comparisons' consistency levels (Salimi & Rezaei, 2016; Rezaei et al., 2018).

The BWM is thus flexible, easy to understand and apply, and effective. However, as with all methods, the BWM has limitations including the difficulties decision makers experience while choosing only one best criterion and one worst criterion, especially when the number of decision criteria is quite high (Guo & Zhao, 2017). A second limitation is the uncertainty and ambiguity associated with subjective human judgments (Mi et al., 2019; Fei et al., 2020). Regardless of these limitations, the method's advantages seem clear, making the BWM an appropriate choice for the current research.

## 4 Application and results

The empirical component of this study involved developing a multicriteria decision-support system to evaluate the potential impact of digital technologies on SME firm performance. This phase relied on the aforementioned combination of cognitive mapping and the BWM and an expert panel. The members were successfully recruited, but the group work sessions could not be held in person as planned due to the coronavirus disease-19 pandemic. The sessions thus took place online using the Zoom platform. As mentioned previously, the approach adopted (i.e., MCDA) suggests structuring the decision-making process into three phases, which are presented in the next subsections.

### 4.1 Structuring phase: participants and procedures

In multicriteria analysis, decision making begins with a structuring phase, which is a crucial step during which the problem's basic structure is defined by a panel of decision makers and a cognitive group map is generated. The present study applied the strategic options development and analysis (SODA) approach (Ackermann & Eden, 2001) based on cognitive mapping to identify the evaluation criteria to be incorporated into the decision-support system. To this end, an expert panel was recruited from among the available professionals with know-how in the areas of digital technologies and SMEs, who served in this research as decision makers.

Creating this panel proved to be one of the most challenging tasks in the entire process. Eventually, eight decision makers with the necessary experience and knowledge agreed to participate, which met the requirement of 6 to 10 decision makers stipulated in the literature (cf. Eden & Ackermann, 2004; Rosário et al., 2021). The panel comprised chief executive officers (CEOs), managers and SME administrators from various sectors of activity, who had extensive experience with and knowledge about digital technologies.

The constructivist and process orientation of the proposed metacognitive framework meant that the group sessions were not geared toward achieving representativeness or making generalizations but rather toward maintaining a strong focus on the process (Belton & Stewart, 2002; Rodrigues et al., 2022). This approach ensured an enriched discussion of digital technologies and SMEs. The group sessions were also led by two facilitators (i.e., researchers) responsible for guiding the negotiation process and recording the results.

As mentioned previously, the pandemic restrictions meant that the sessions had to be conducted through the Zoom platform. In addition, the Miro platform (<https://miro.com/>) was used to structure the decision problem and apply the “post-its technique” (Ackermann & Eden, 2001) in the first session. This meeting lasted approximately three hours, beginning with a presentation of the panel members and facilitators, which allowed everyone to find out a little about everyone’s experience and professional path. Next, the facilitators gave a brief overview of the topic under study and the methodologies to be used throughout the study. The remainder of the first session was structured into three parts: (1) identifying the evaluation criteria to be input into the model; (2) grouping the criteria into clusters or areas of interest; and (3) analyzing each cluster’s criteria to organize them into a hierarchy.

The decision makers’ discussion and the application of the post-its technique began with the following trigger question: “*Based on your values and professional experience, what factors and/or determinants of digital technology can influence SME business performance?*”. The panel members shared their experiences and values and registered the decision criteria that, from these experts’ point of view, influence SME performance. The post-its technique consisted of writing each criterion on a post-it note and adding a positive (+) or negative (–) sign depending on that criterion’s impact on the problem under study. After a consensus was reached on the identified criteria’s number and meaning, the first part of the first session was considered complete.

In the second part, the 173 evaluation criteria identified during the discussion of ideas and experiences were grouped into six clusters. These were labeled as follows: (1) *Social and Human Factors*; (2) *Technological Factors*; (3) *Economic and Financial Factors*; (4) *Processes*; (5) *Markets*; and (6) *Governance*.

The last part consisted of an internal analysis of each cluster in which the panel reorganized each cluster’s evaluation criteria so that they formed a hierarchy according to their importance. The most significant items were placed at the top of the cluster and the least important at the bottom. This first session thus generated all the necessary information to build the group cognitive map. The *Decision Explorer* software ([www.banxia.com](http://www.banxia.com)) generated the map’s final version as presented in Fig. 1, which was then validated by the panel members at the beginning of the second group session.

The cognitive map provided the participants with a more holistic perspective on the decision problem. The map’s construction was the product of an extremely rich exchange of values, opinions and experiences that enabled the decision makers to formulate their thoughts in a more structured way. The panel members’ insights, therefore, contributed to expanding the existing knowledge about digital technology adoption in SMEs. The next phase involved applying the BWM.

## 4.2 Evaluation phase

The evaluation phase of the multicriteria decision process required a second session with the decision-maker panel. This session lasted about 2 h and 15 min and began with a brief presentation of how to apply the BWM, as well as its relevance to the decision problem. After the introduction, the key criteria were identified via the nominal group technique (NGT) and multi-voting, in which the decision makers identified the determinants they considered to be the most important in each cluster. The result was a list of 32 criteria to be analyzed further (see Table 3).

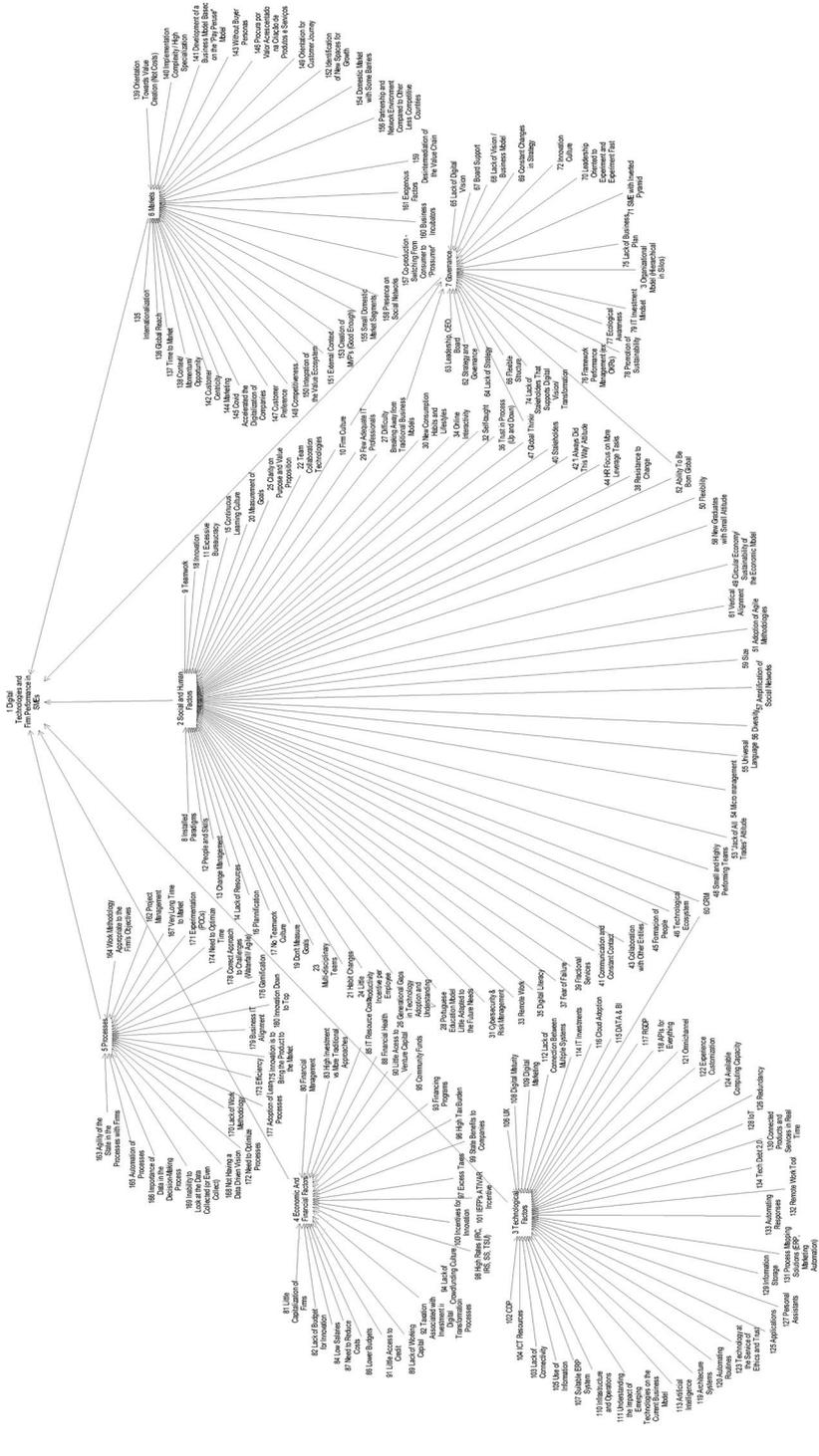


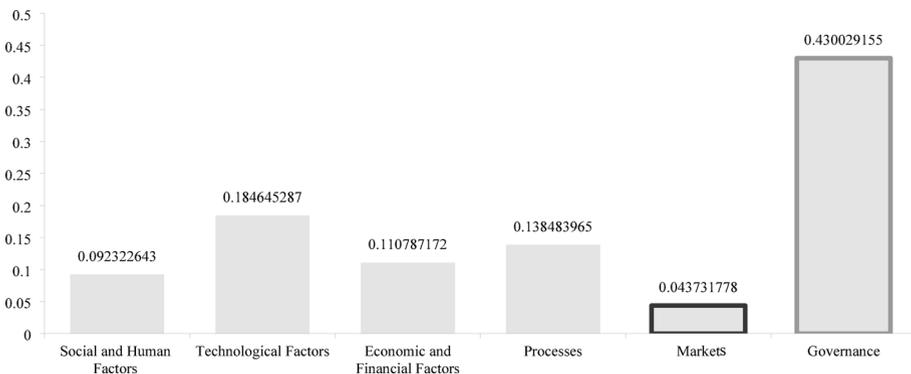
Fig. 1 Group cognitive map

**Table 3** Criteria selected for further analysis

Social and human factors	Technological factors	Economic and financial factors	Processes	Markets	Governance
Teamwork	Information and communications technology (ICT) resources	Financial management	Government’s agility in processes involving firms	Internationalization	Strategy and governance
Firm culture	Use of information	Undercapitalization of firms (-)	Work methods appropriate to firms’ objectives	Orientation toward value creation rather than costs	Leadership, CEO, and board
People and skills	User experience (UX)	Lack of budget for innovation (-)	Automation of processes	Customer centricity	Lack of vision and/or business model (-)
Change management	Digital maturity	Intensive investment vs. more traditional approaches (-)	Importance of data in decision-making processes	Search for added value in product and service creation	Innovation culture
Lack of resources (-)	Understanding of emerging technologies’ impact on current business model	Taxation associated with investment in digital transformation processes (-)	Business-IT alignment	Disintermediation of value chain	Lack of stakeholders who support digital vision and/or transformation (-)

Innovation  
Digital literacy

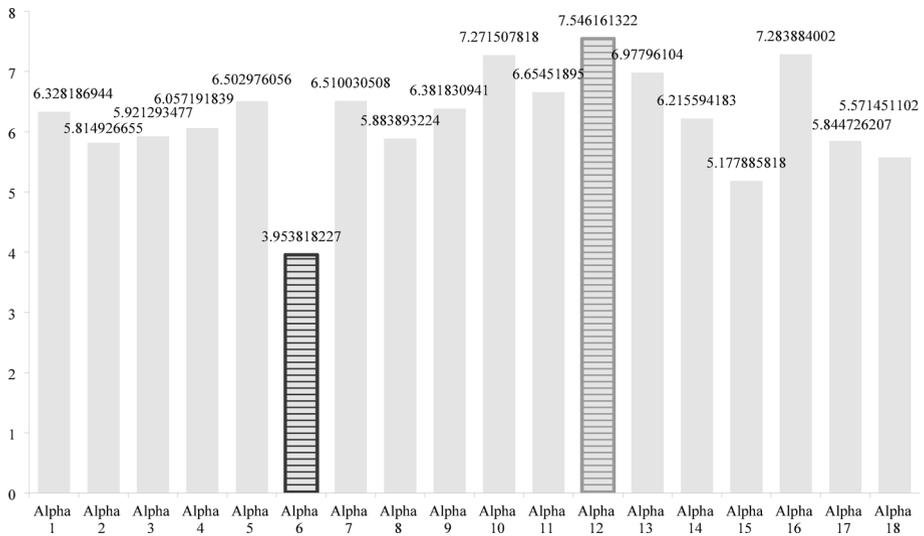
After the key criteria were identified, the BWB could be applied. The decision makers were asked to select the best (or most significant or most relevant) cluster and the worst (or least significant or least relevant) cluster. *Governance* was considered the best cluster and *Markets* the worst. The panel then assessed their preference for the best cluster over all the other clusters and their preference for all the other clusters over the worst cluster. As mentioned previously, the evaluation was based on a scale from 1 to 9 (1 = equally impor-



**Fig. 2** Clusters’ weight

**Table 4** BWM application to clusters

Number of Clusters = 6	C1	C2	C3	C4	C5	C6
Names of Clusters	Social and Human Factors	Technological Factors	Economic and Financial Factors	Processes	Markets	Governance
Best Cluster	Governance					
Worst Cluster	Markets					
Best to Others	Social and Human Factors	Technological Factors	Economic and Financial Factors	Processes	Markets	Governance
Governance	6	3	5	4	7	1
Others to the Worst	Markets					
Social and Human Factors	3					
Technological Factors	7					
Economic and Financial Factors	4					
Processes	6					
Markets	1					
Governance	8					
Weights	Social and Human Factors	Technological Factors	Economic and Financial Factors	Processes	Markets	Governance
	0.09232264	0.18464528	0.11078717	0.13848396	0.04373177	0.43002915
K <sub>si</sub> *	0.12390670					



**Fig. 3** Alphas ranking

**Table 5** Most and least important criteria selected

Cluster	Most important criteria	Least important criteria
Social and Human Factors	People and skills	Lack of resources
Technological Factors	Understanding of emerging technologies' impact on current business model	UX
Economic and Financial Factors	Undercapitalization of firms	Taxation associated with investment in digital transformation processes
Processes	Automation of processes	Business-IT alignment
Markets	Orientation toward value creation rather than costs	Disintermediation of value chain
Governance	Leadership, CEO, and board	Lack of stakeholders who support digital vision and/or transformation

tant; 2 = between equally and moderately important; 3 = moderately more important than ...; 4 = between moderately and quite important; 5 = more important than ...; 6 = between quite and very important; 7 = much more important than ...; 8 = between extremely and absolutely important; 9 = absolutely more important than ...). Table 4 and Fig. 2 show the BWM application and results obtained using the equations presented in subsections 3.2.1 through 3.2.5.

The procedure followed with the clusters was repeated for all the criteria selected in each cluster. The best (or most important) and worst (or least important) criteria within each cluster are listed in Table 5.

After applying the BWM and estimating the criteria' weights, the panel was asked to evaluate 18 real SMEs (hereafter referred to as "Alphas" to maintain confidentiality) using each of the 32 criteria selected for analysis and a scale of 1 to 9. This assessment resulted in the ranking presented in Fig. 3, which identifies the SMEs with a greater propensity to adopt digital technologies that have a stronger impact on these firms' performance.

An analysis of Fig. 3 reveals that Alpha 12 is the SME with the greatest propensity to adopt digital technologies with the highest impact on firm performance. In contrast, Alpha 6 was evaluated as having the lowest propensity to adopt digital technologies that could enhance this firm's performance. Figure 4 further illustrates the partial and final assessments of three Alphas: (1) the best performer (i.e., Alpha 12); (2) the worst performer (i.e., Alpha 6); and (3) a third coming in a close second (i.e., Alpha 10).

Table 6 shows that Alphas 10 and 12 received similar assessments for the *Social and Human Factors*, *Technological Factors* and *Processes* clusters, which partly explains their proximity in the ranking (see Fig. 4). However, Alpha 12 received a higher score for the *Governance* cluster, which is the cluster with the greatest weight in the model, so these criteria give Alpha 12 a significant advantage in the ranking (see Fig. 4). Notably, this alpha also received an extremely low score for the *Markets* cluster (see Table 6), whereas Alpha 10 was given an extremely positive evaluation for *Markets* criteria. However, because this cluster is of little importance (i.e., a low weight in the model), this advantage is not enough to put Alpha 10 at the top. Therefore, Alpha 10 could achieve more favorable global results with just a partial improvement in the *Governance* determinants.

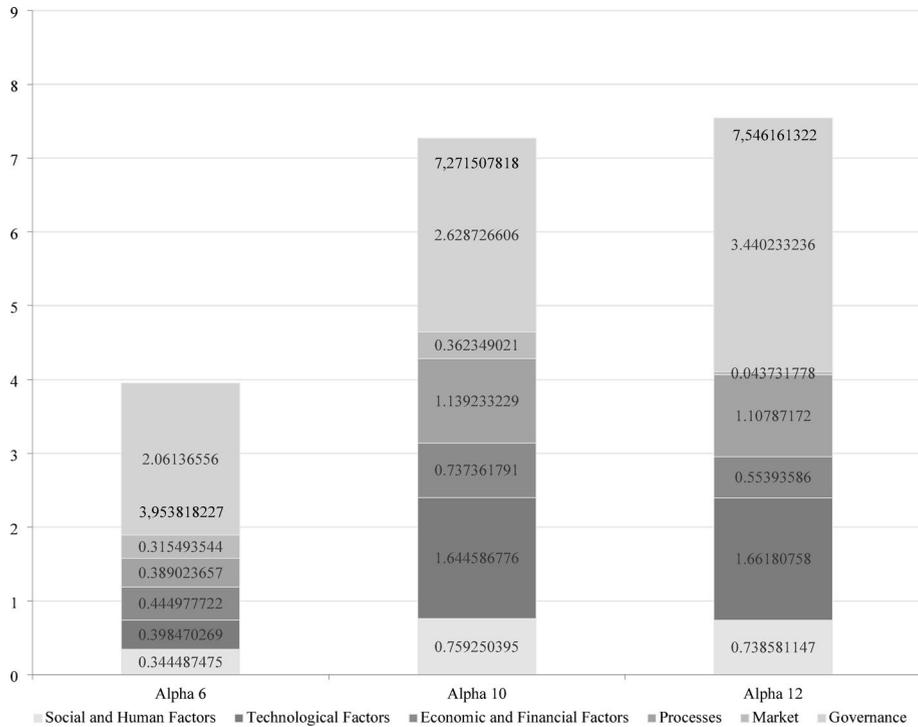


Fig. 4 Alphas’ partial evaluation

The results also highlight the case of Alpha 6, which was given the lowest position in the ranking. According to Table 6, this SME received low scores for nearly all the clusters, except for the *Markets* cluster. Since the latter has the lowest weight in the model, this positive evaluation was not enough to put Alpha 6 in a more favorable position (see Fig. 4). In addition, Alpha 6 was not given a high score for the *Governance* cluster and, since this cluster carries great weight in the model, this evaluation is quite important for Alpha 6. Overall, this SME thus received a more negative evaluation than the others (see Fig. 4).

An analysis of these two sets of results (i.e., Fig. 4; Table 6) supports the conclusion that the *Governance* cluster is extremely significant in the assessments of real SMEs, so greater effort needs to be made to improve in this area. In contrast, the *Markets* cluster appears to be unimportant in the decision makers’ analyses because positive evaluations in this area do not change the Alphas’ positions. After completing the Alphas’ ranking, the second phase (i.e., evaluation) of the decision-making process was complete, and the last phase (i.e., recommendations) could be begin.

### 4.3 Consolidation, discussion, limitations and recommendations

To consolidate the results and validate the decision-support model developed, a final session was held with an external expert neutral to the above process (i.e., a specialist who was not present in the previous sessions). COTEC Portugal agreed to send someone to participate in the third phase of the study. This organization is a business association that seeks to pro-

**Table 6** Evaluation of SMEs for each criterion on a scale of 1–9

Clusters	Criteria	Alphas																		
		1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	
Social and human factors	Teamwork	6	2	2	3	8	4	7	5	7	8	7	8	3	5	8	8	6	5	
	Firm culture	5	2	2	4	7	7	8	4	6	8	7	8	5	8	8	7	6	5	
	People and skills	8	3	3	6	8	6	6	6	6	9	7	8	6	8	6	7	6	6	
	Change management	4	3	3	9	8	2	6	4	5	9	7	8	7	5	7	8	7	6	
	Lack of resources	8	3	2	1	5	2	5	8	6	5	7	8	9	3	3	3	5	3	
	Innovation	9	5	7	7	7	2	7	7	9	7	7	8	9	8	2	8	5	5	
	Digital literacy	8	8	9	9	9	1	6	6	8	9	7	8	7	7	8	9	7	6	
	Total for cluster	7.224	4.015	4.507	6.164	7.746	3.731	6.493	5.731	6.925	8.224	7.000	8.000	6.463	6.970	6.075	7.567	6.045	5.448	
	Technological factors	ICT resources	5	5	6	7	3	1	8	5	8	9	7	9	9	8	7	9	8	8
		Use of information	3	4	7	6	9	2	8	4	7	9	7	9	9	9	4	8	7	6
UX		6	4	7	8	3	1	5	4	6	7	7	9	9	5	3	8	7	6	
Digital maturity		8	8	7	9	7	2	6	5	7	9	7	9	8	7	5	9	7	6	
Understanding of emerging technologies' impact on current business model		8	8	8	8	9	3	7	6	7	9	7	9	9	8	5	7	6	5	
Total for cluster		6.717	6.756	7.205	7.824	7.135	2.158	6.951	5.202	7.13	8.907	7.000	9.000	8.738	7.728	5.127	8.06	6.795	5.971	

**Table 6** (continued)

Clusters	Criteria	Alphas																	
		1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18
Economic and financial factors	Financial management	8	4	7	8	9	7	5	5	5	8	5	5	8	8	6	6	7	7
	Undercapitalization of firms	8	8	8	2	4	2	5	7	6	7	5	5	2	6	7	5	3	3
	Lack of budget for innovation	6	7	7	2	8	3	3	8	4	7	5	5	2	6	8	5	6	7
	Intensive investment vs. more traditional approaches	2	7	3	7	5	5	4	7	4	5	5	5	2	3	8	8	6	6
Processes	Taxation associated with investment in digital transformation processes	7	8	7	2	8	2	4	4	5	1	5	5	3	7	7	8	6	6
	Total for cluster	6.613	6.611	6.658	4.509	6.231	4.017	4.509	6.469	5.061	6.656	5.000	5.000	3.656	6.042	7.045	5.934	5.144	5.278
	Government's agility in processes involving firms	2	6	8	8	9	1	6	5	5	9	8	8	9	7	3	8	7	6
	Work methods appropriate to firm's objectives	4	5	4	6	8	2	5	6	5	9	8	8	8	6	7	9	7	6
Processes	Automation of processes	3	3	4	4	7	4	8	7	7	7	8	8	4	6	4	9	7	6
	Importance of data in decision-making processes	6	5	6	8	6	3	5	6	7	9	8	8	8	9	4	6	6	6
	Business-IT alignment	6	5	4	8	6	1	6	7	6	9	8	8	8	9	4	7	6	6
	Total for cluster	3.888	4.399	5.211	6.193	7.165	2.809	6.384	6.264	6.344	8.226	8.000	8.000	6.626	7.104	4.216	7.947	6.69	6.000

**Table 6** (continued)

Clusters	Criteria	Alphas																	
		1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18
Markets	Internationalization	1	3	7	9	6	7	8	4	4	4	1	1	6	2	9	7	8	8
	Orientation toward value creation rather than costs	4	4	6	6	8	8	7	6	5	9	1	1	7	3	3	7	6	6
	Customer centricity	5	6	5	6	8	6	6	5	6	9	1	1	8	6	8	8	6	6
	Search for added value in product and service creation	8	2	7	8	5	8	7	6	8	9	1	1	9	7	3	8	6	5
Governance	Disintermediation of value chain	3	2	7	7	7	5	6	7	5	9	1	1	9	3	3	3	5	6
	Total for cluster	3.858	3.716	6.268	6.929	7.000	7.214	6.857	5.571	5.714	8.286	1.000	1.000	7.643	4.357	4.929	7.143	6.214	6.071
	Strategy and governance	6	6	6	7	7	3	8	7	7	7	7	8	9	7	5	8	6	6
	Leadership, CEO, and board	7	7	7	6	7	4	8	6	7	7	7	8	9	5	4	8	6	6
	Lack of vision and/or business model	7	3	2	2	1	7	4	5	5	2	7	8	2	3	7	4	3	3
	Innovation culture	8	8	7	8	8	6	6	6	6	8	7	8	8	6	3	8	6	5
	Lack of stakeholders who support digital vision and/or transformation	8	8	3	1	1	9	4	4	4	4	7	8	1	6	8	3	2	5
	Total for cluster	6.932	6.261	5.677	5.541	5.770	4.794	6.845	5.968	6.365	6.113	7.000	8.000	7.235	5.351	4.861	7.039	5.265	5.313

mote business innovation and technological cooperation, especially in SME contexts. The consolidation session was thus attended by a project manager from this association who was directly linked to SME innovation.

The session was also conducted via Zoom. The meeting lasted approximately one hour and covered four aspects. The first was a brief contextualization of the decision problem and explanation of the methodologies used, while the second comprised a presentation and discussion of the results. The third aspect was the practical applicability of the evaluation system developed, and the fourth was a discussion of the project manager's suggestions and recommendations.

After the expert analyzed the results, he expressed agreement with the evaluation criteria identified and the clusters defined. The findings were, based on his experience in the field, *"very much in line with what happens in practice"* (in his words). He suggested, however, that additional interesting results might be obtained by incorporating available models for evaluating SME digital maturity.

Regarding the methodologies adopted, the specialist noted that, since this model is dependent on specific decision makers' experience and values, the results could be different if other experts were to contribute to the evaluation process. As explained previously, this issue is a product of the subjectivity associated with the selected methodologies, which is why, overall, he had *"nothing [negative] to point out"* about the methods. This expert also suggested that *"there may be some discrepancies in the evaluation of the [real] SMEs"* because some decision makers can be stricter than others. Regardless, he found cognitive mapping to be a relevant tool and the final model well structured. In addition, he considered the way that the study brought together a set of experienced individuals to assist in the map construction quite appropriate.

When asked about how the model could be implemented in practice, the project manager recommended a three-pillar strategy for disseminating tools, which COTEC Portugal uses when applying models. The first pillar is to develop *"close contacts with business associations of a sectoral or regional nature"* (in his words) in order to raise awareness about the topic in question and offer training to these associations' specialists in how to apply the tool. The second pillar consists of working with universities either through master's degree programs or doctoral candidates working on their thesis as they can use the tool and apply this knowledge later in the job market. Finally, he explained that the third pillar comprises identifying the companies that want to use the tool. According to the COTEC expert, this pillar is the most complicated because firms already immersed in specific realities are usually uninterested in applying new techniques. This resistance is especially likely to develop if a trained specialist who can help managers understand the tool and start the implementation process is unavailable. To overcome this final constraint, the interviewee said that a facilitator needs to be allocated to interested companies in order to accelerate the implementation of the evaluation model.

In his final reflection on the proposed model, this expert stated that it is *"very important awareness-raising work, capable of mobilizing companies to engage in digital transformation and innovation"* (in his words). He also asserted that the model *"serves a function that is sorely missed"* (also in his words) since many firms do not know where they are or where they want to go in terms of digital technologies, being largely ignorant of *"the real value of digitalization"* (citing the expert). He thus stressed the importance of this type of tool as an *"initiative that should be promoted"* (again in his words).

The alignment of our findings with existing literature on SME adaptability to new technologies and performance evaluation underscores the robustness and consistency of the identified patterns. For example, some of the findings resonate with the work of Santos et al. (2024), Ramos et al. (2025) and Tariq et al. (2025), which, albeit employing a different methodological combination, arrived at similar determining factors in the context of SME digitalization, encompassing technological, economic and financial dimensions. Furthermore, the congruence observed between our findings and those of Gonçalves et al. (2024) suggests a consistent and recurring trend in the factors influencing SME adaptability to new technologies. The convergence of results, despite methodological variances, enhances the reliability and validity of the identified determinants. It indicates that these factors transcend specific contexts, demonstrating their universality and applicability across diverse settings. This alignment not only corroborates the robustness of our research but also contributes to the cumulative knowledge in the field. The replication of key determinants in different studies strengthens the generalizability of these findings. It implies that the identified factors are integral and influential in shaping SME responses to technological advancements, irrespective of the specific methodological lens through which they are examined.

Nevertheless, it is important to emphasize that the present study is designed to present a methodological framework, where its application may result in different findings when applied in different contexts. The inherently process-oriented nature of the applied methodologies implies that results are generally not transferable from one context to another. As Bell and Morse (2013, p. 962) explain, “*there is less emphasis on outputs per se and more focus on process*” in this type of approach (see also Ormerod, 2013). While methodological in nature, our study remains grounded in realism, recognizing that each context possesses unique characteristics demanding tailored solutions to address the propensity for digital technology adoption in various SMEs.

## 5 Conclusion

The growing need for adaptation and innovation is increasingly recognized in the business world and society at large. SMEs must keep up with the markets’ on-going evolution if these companies want to develop competitive advantages. Thus, the adoption of digital technologies is, with each passing day, becoming more urgent. However, SMEs need to do more than just gain access to digital tools, which is already complicated to achieve. These firms must also adopt the right mindset needed to understand what digital transformation is, how it should be implemented in SMEs and what consequences it has for management and company structure. Managers thus have to understand the determinants of digital technology adoption and the ways this process can influence their firm’s performance, including acknowledging that this issue is a complex decision problem.

To address this problem, a holistic, transparent model was developed by applying a combination of two methodologies: cognitive mapping and the BWM. Based on constructivist principles, these methodologies required the participation of a group of decision makers with experience in and knowledge about digital technologies and SMEs. This panel’s expertise ensured that the two pre-defined research questions could be answered (i.e., What key determinants influence the adoption of digital technologies in SME contexts? How are these factors interrelated, and how do they affect these companies’ performance? ).

Methodologically, leveraging OR/MS methodologies—i.e., cognitive mapping and the BWM—as integral components of our framework, the present study offers a structured and systematic approach to analyze the complex decision-making processes associated with the adoption of digital technologies in SMEs. Through the use of cognitive mapping, a visual representation of the interconnected determinants influencing digital technology adoption is provided, while the BWM serves as a quantitative method to assess and prioritize these factors. Consequently, by employing these OR/MS methodologies, the investigation not only enhances the methodological depth but also contributes to the broader field of OR/MS, underscoring its applicability in addressing real-world challenges within the SME context.

The present study, therefore, makes significant contributions to both theoretical understanding and practical implications in the context of digital technology adoption in SMEs. The theoretical contributions are related to the development of a holistic and transparent evaluation system based on the combined use of cognitive mapping and the BWM to explore and elucidate the intricate determinants influencing the adoption of digital technologies in SMEs. By applying constructivist principles and engaging a panel of decision makers with expertise in digital technologies and SMEs, the study not only addresses the two key research questions presented, but also establishes a comprehensive cognitive map of 173 evaluation criteria, revealing their interconnections. The practical contributions are manifold, including a transparent evaluation system for enhanced decision-making, integration of objective and subjective elements and a shared cognitive structure derived from the collective expertise of decision makers. These practical outcomes empower managers and related entities to navigate the complexities of digital transformation and make informed decisions, fostering a more transparent evaluation process. Moreover, the societal contribution seems evident in the system's potential to raise awareness globally regarding the imperative role of digitalization in the competitiveness of SMEs.

The main limitation identified in the proposed model is related to its context dependence in that the findings are based on specific decision makers' experience, opinions and values. As previously mentioned, the goal was not to create an optimal model but instead one that could incorporate subjective determinants that are inherent to any decision problem. As a result, this study's procedures contributed to developing a better understanding of the digital technology determinants that can influence SME performance. The proposed decision-support model also helps raise managers and related entities' awareness of the importance of digitalization in increasingly competitive markets.

In the future, researchers may obtain interesting results by, first, applying the same techniques with a different panel of decision makers to allow a comparison of results and consolidate the proposed model. Additional studies could use other multicriteria assessment techniques to address the same decision problem. Finally, this study's approach needs to be applied internationally in order to generate parallel results in different contexts and locations and raise SME managers' awareness worldwide. The proposed evaluation model does much to expand the existing literature about digital technologies in SME contexts. However, any further contributions that can improve and support SME decision-making processes will certainly be treated as important and valuable.

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