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Exploring the determinants of digital entrepreneurship using fuzzy cognitive maps

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Abstract

In an increasingly digital world, almost anything can now be done through a computer or smartphone. Digital entrepreneurship is capitalizing on this trend, which brings numerous advantages to firms and society at large. However, the determinants of digital entrepreneurship's success are still unclear, as well as how they relate to each other. This study sought to develop a fuzzy cognitive map (FCM) to identify and analyze the determinants of digital entrepreneurship. Two group sessions were held with a panel of decision makers who deal with the digital entrepreneurship phenomenon every day. Based on their shared experience and knowledge, an FCM was developed and validated for this research context. Static and dynamic analyses facilitated a deeper understanding of the cause-and-effect relationships between the determinants of digital entrepreneurship, resulting in a well-informed framework that was validated by the panel members. This methodological procedure enabled an objective analysis of the dynamics behind digital entrepreneurship. The advantages and limitations of our constructivist framework are also discussed.

Keywords Cause-and-effect relationships · Digital entrepreneurship · Entrepreneurship · Fuzzy cognitive map (FCM) · Technology

Introduction

The most recent developments in research on entrepreneurship show an increasing use of digital technologies and appreciation of their advantages. This trend has contributed to entrepreneurs' growing awareness of the importance of designing a baseline strategy for digital development (Zhao and Collier 2016). The fast growth of and rapid innovation in digital technologies have radically changed competitive landscapes,

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reformulating traditional strategies, processes, and structures (cf. Bharadwaj et al. 2013; Palacios-Marques et al. 2017; Lee and Trimi 2018).

According to Zhao and Collier (2016: 2173), *"digital entrepreneurship has been viewed as a critical pillar for economic growth, job creation and innovation by many countries"*. This strategic importance is one reason why growing numbers of entrepreneurs are interested in adopting digital entrepreneurship, especially as its adoption can bring various advantages to firms. These include, among others: (1) access to a wider market and better positioning, since digital technologies have a great reach; (2) lower costs, as infrastructure is no longer needed to store products; and (3) better involvement with stakeholders.

Despite these advantages, many firms do not know how to adopt and/or develop digital entrepreneurship initiatives (Ferreira et al. 2016c). This inexperience highlights the need for a fuller understanding of the determinants of digital entrepreneurship and their cause-and-effect relationships. Even though the general interest in digital entrepreneurship has increased significantly in recent years, this is a young field of research, and the existing studies are still few in number and limited in scope (Ferreira et al. 2016c; Zhao and Collier 2016).

Given this context, the present study sought to develop a holistic cognitive structure that would facilitate the identification and analysis of the determinants of digital entrepreneurship and their cause-and-effect relationships. A review of the literature revealed no prior work reporting the use of the fuzzy cognitive mapping approach in this field of research. Thus, the proposed methodology is a significant contribution to the extant literature on digital entrepreneurship and operational research/management science (OR/MS).

Developing a fuzzy cognitive map (FCM) in this research context involved several stages, including face-to-face meetings with a panel of specialists in digital entrepreneurship and static and dynamic analyses of the determinants included in the FCM. The results show that the construction of an FCM not only reduced the number of omitted evaluation criteria but also enabled a greater understanding of the cause-and-effect relationships between the determinants identified. The final outcome was a well-informed framework validated by the expert panel members, which facilitated an objective analysis of the dynamics behind digital entrepreneurship.

The remainder of this paper is organized as follows. The second section offers an overview of the literature on digital entrepreneurship. Section three introduces the methodology. Section four describes the processes followed in the construction and testing of the FCM-based framework. Finally, section five presents conclusions and lays out a roadmap for further research.

Related literature and research gap

Sahin and Asunakutlu (2014) and Memon (2016) define entrepreneurship as the motivation to start and run a business while assuming risks to obtain profits. The cited authors emphasize that entrepreneurship manifests itself most clearly at the start of any new business. Jelonek (2015), in turn, observes that entrepreneurship is a phenomenon that articulates ideas, financial skills, and technological innovations, allowing novel organizational processes to be developed to launch new businesses and grow existing ones.

According to Halicka (2017), technological innovation is a key determinant that increasingly differentiates firms and produces competitive advantages. This innovation is also responsible for meeting societal needs since technological innovation is at the basis of production processes (Mas-Verdu et al. 2010; Höflinger et al. 2018). Giones and Brem (2017) argue that new dimensions emerge when entrepreneurship and technology are put together, resulting in digital entrepreneurship. The European Commission (2014: 8) reports that digital entrepreneurship creates *"new business opportunities and accelerate*[s] *the transformation of the* […] *business landscape, through the development and smart use of novel digital technologies, in order to increase growth and create employment"*.

Sambamurthy et al. (2003) highlight three reasons why entrepreneurship should be fostered in digital environments. The first motive is agility, which can be defined as the harmony between a company's strategy and its structures and resources. The second is digital options, which are the set of skills related to information technologies. These skills can be expressed in terms of wealth (i.e., the quality and transparency of the information that passes from one process to another) and reach (i.e., the comprehensiveness of knowledge that can enable the exchange of information between individuals). The last reason is companies' heightened state of alert since digital tools allow firms to detect new opportunities in the market.

Hull et al. (2007) suggest that digital entrepreneurship can be divided into three categories. The first is light digital entrepreneurship, in which the digital economy is only involved as a complement to more traditional processes. The second category is moderate digital entrepreneurship, which cannot exist without digital infrastructure and which requires the business in question to focus on digital products or other digital components. The last is extreme digital entrepreneurship, which implies that all business processes, that is, production, services, advertisement, and distribution, have to be digital.

In addition, Hair et al. (2013) argue that a few factors differentiate digital entrepreneurship from the so-called "traditional" entrepreneurship. First, digital entrepreneurship requires technological know-how, and, as the degree of scanning increases (i.e., the more digital the business is), the more technological know-how will be required. Second, the more digital a business is, the greater access it will have to information about costumers, competitors, and other stakeholders. That is, digital environments provide more information than the "physical" world does. Last, digital entrepreneurs have access to much wider and more varied markets than traditional entrepreneurs do due to the Internet's dimensions. Hafezieh et al. (2011) point out that another difference is the way products are marketed.

According to Ziyae et al. (2014), digital entrepreneurship has revolutionized firms worldwide, so businesses see that exploiting this strategy is increasingly important. Nevertheless, Zhao and Collier (2016) report a lack of discussion about the concept of digital entrepreneurship. Most studies related to introducing digital technology in entrepreneurship have only focused on superficial matters – many of them already related to the core concept of entrepreneurship. Table 1 presents a summary of some studies conducted in the field of digital entrepreneurship.

Although progress has been made in research on digital entrepreneurship, two general limitations are reported in the literature. These are how the determinants of digital entrepreneurship and their cause-and-effect relationships are identified, and how

Table 1 Contributions and limitations of studies on digital entrepreneurship

Authors	Methods	Contributions/Originality	Limitations
Davidson and Vaast (2010)	Theoretical discussion of an analytical model	Considers the materiality of digital entrepreneurs' practices and the multi-dimensionality of business opportunities	Fails to consider how digital entrepreneurship interrelates with other forms of entrepreneurship
Dutot and Horne (2015)	Semi-structured Interviews	Facilitates a deeper understanding of the background of digital entrepreneurship intentions	Neglects to clarify the way the determinants of digital entrepreneurship were selected; Uses a reduced number of firms and results cannot be generalized
Zhao and Collier (2016)	Conceptual framework based on a literature review	Contributes to a fuller understanding of the role of social networks, including their interactions' impacts on the progress and results of digital entrepreneurship	Fails to clarify the way the determinants of digital entrepreneurship were selected; Needs to test the process empirically
Ngoasong (2017)	Semi-structured interviews with 16 digital entrepreneurs	Develops a theoretical framework that allows an analysis of the context and background of companies' digital competencies that lead to digital entrepreneurship	Neglects to analyze cause-and-effect relationships between the determinants of digital entrepreneurship

the intensity of these determinants and relationships are evaluated and measured (cf. Ferreira et al. 2016c). In order to overcome these broad limitations, new approaches and methodologies must be explored that can more effectively identify and analyze the determinants of digital entrepreneurship and their cause-and-effect interactions. The present study, therefore, chose to use fuzzy cognitive mapping.

Methodology

Cognitive mapping

Warren (1995: 11) defines "simple" cognitive maps as networks of cause-effect relationships between the components of the situations in question. Abramova (2016: 587), in turn, writes that *"the term 'cognitive map' refers to models* […] *representing the structure of causal* […] *or* […] *cause-effect* […] *influences of mapped situations, objects or systems"*. The basis of these models is usually a graphic representation in which nodes are associated with concepts, the cause-and-effect relationships between the concepts are analyzed, and signs of influence (i.e., + or –) can be added (Abramova 2016; Ferreira et al. 2016b; Santos et al. 2018).

Ackermann and Eden (2001) further define cognitive maps as a mental representation of a concrete subject matter, which reflects not only individuals' knowledge but also their beliefs about the topic. Carlucci et al. (2013: 212) further explain that these maps are qualitative models of defined variables and the cause-and-effect connections between them. Fig. 1 provides an example of a cognitive map.

The concept of causality is central to analyzing cognitive maps, so Schneider et al. (1998: 166) see them as *"a very important descriptor of relations between variables, or concepts, which indicates whether change in one variable (concept) is a result of*

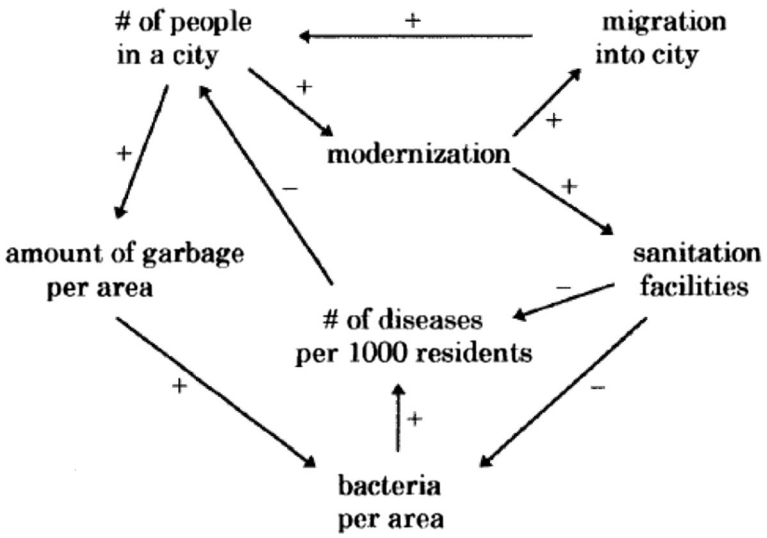

Fig. 1 Example of a cognitive map. Source: Lee and Kim (1997: 42)

change in another (is caused by change in another)". Thus, causality is determined by the perceptions of the individuals involved in constructing the cognitive map.

Although cognitive maps seek to represent reality through cause-and-effect relationships, Carvalho (2013) argues that these maps are incapable of embodying the real dynamics of problems because they cannot quantify the intensity of relationships. Kosko (1986), therefore, developed the fuzzy cognitive mapping approach, which incorporates elements from fuzzy logic and artificial neural networks into cognitive mapping. Following the same *modi operandi* as (simple) cognitive maps, FCMs represent decision criteria by nodes and their cause-and-effect relationships by arrows. However, alongside the arrows, real numbers w_{ij} are introduced to represent the degree of influence that a tail decision criteria i has on a head decision criteria j (cf. Ferreira and Jalali 2015; Carlucci et al. 2018; Branco et al. 2019).

Fuzzy cognitive maps

FCMs were introduced by Kosko (1986) as graphs that allow fuzzy causal reasoning to be represented as a diagram with a graph structure that facilitates the systematic reproduction of causal links, especially bi-directional connections (Kosko 1986: 65). According to Stula et al. (2017: 35), *"FCMs are a powerful modelling, simulation, and representation technique that can be used for decision support, strategic planning, and prediction"*. Solana-Gutiérrez et al. (2017) further report that these maps are a tool that facilitates the modeling of systems and functions in which concepts are connected through cause-and-effect relationships.

In addition, FCMs facilitate the integration of different perceptions of various individuals. As Ferreira et al. (2016b), Mls et al. (2017), and Ribeiro et al. (2017) note, FCMs are dynamic models that are easy to represent and execute, allowing human knowledge to be incorporated into specific contexts. Thus, Azevedo and Ferreira (2017), Malek (2017), and Pires et al. (2018), among others, refer to fuzzy logic cognitive mapping as a knowledge-based methodology. The relevant concepts are first identified, and the relationships between them are then depicted in the form of a graph, thereby helping researchers to collect data from experts, in particular, because this methodology is participative, clear, and transparent.

According to Kim and Lee (1998), building FCMs takes place in three fundamental stages. First, the reason for creating the FCM needs to be clarified since, if the goal of the mapping exercise is unclear, the search for the most important factors may lack direction and the map might reach a size that makes analysis difficult. Second, the most important concepts and/or determinants have to be identified, namely, which concepts may or may not influence the decision problem. Last, the cause-and-effect relationships between these concepts need to be identified and analyzed. Solana-Gutiérrez et al. (2017: 261) observe that, overall, *"the construction of a*[n] *FCM requires the input of human experience and knowledge of the system under consideration"*.

Kim and Lee (1998), Papageorgiou et al. (2002), Mazlack (2009), Salmeron (2009), Yaman and Polat (2009), Carlucci et al. (2013), Ferreira and Jalali (2015), Nápoles et al. (2016), and Misthos et al. (2017), among many others, emphasize that the concepts included in FCMs can have three types of cause-and-effect relationships. These allow the degree of influence w that one concept has over another to be

understood and analyzed. The first type of relationship is positive causality ($w_{ij} > 0$), which means that an increase in the value of a concept C_i translates into an increase of the value of another concept C_j and, conversely, a decrease in the value of C_i leads to a decrease in the value of C_j. The second type of connection is negative causality ($w_{ij} < 0$), which occurs when an increase in the value of C_i leads to a decrease in the value of C_j and vice-versa. The last type of link is null causality ($w_{ij} = 0$), in which no relationship is observed between concepts C_i and C_j. Fig. 2 presents a conventional diagram of an FCM's structure.

According to Carlucci et al. (2013), a state vector $n \times 1$ exists that includes the values of n concepts, as well as an intensity matrix n x n that gathers the intensities of the connections between the n concepts (cf. Kok 2009; Ferreira et al. 2016a). The main diagonal of the resulting matrix is usually equal to 0 since it presupposes that none of the concepts has a cause-and-effect relationship with itself (Carlucci et al. 2013). The intensity matrix W – also known as the adjacent matrix – of the previously described FCM can be represented as Formula (1):

$$W = \begin{array}{c|c|} & \begin{array}{ccccc} C_1 & C_2 & C_3 & C_4 & C_5 \end{array} \\ \hline \begin{array}{c} C_1 \\ C_2 \\ C_3 \\ C_4 \\ C_5 \end{array} & \begin{array}{ccccc} 0 & w_{12} & 0 & 0 & w_{15} \\ 0 & 0 & 0 & 0 & 0 \\ 0 & w_{32} & 0 & w_{34} & 0 \\ w_{41} & 0 & 0 & 0 & w_{45} \\ w_{51} & 0 & 0 & 0 & 0 \end{array} \\ \hline \end{array} \quad \text{in which} -1 \leq w_{ji} \leq 1 \tag{1}$$

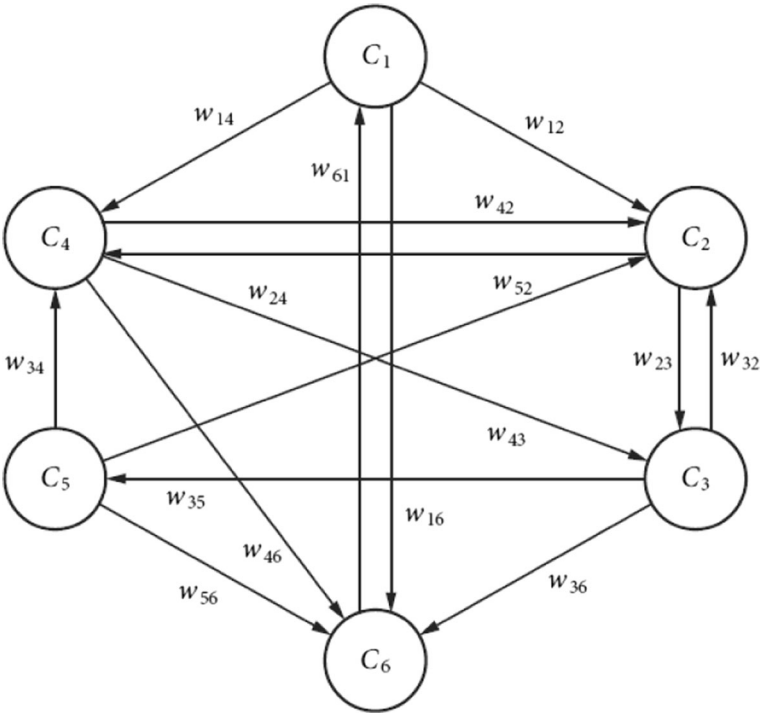

Fig. 2 Typical structure of an FCM. Source: Kang et al. (2012: 78)

As Mazlack (2009) and Carlucci et al. (2013) note, the value of each concept is influenced by the values of any connected concepts, as well as the first concept's original value. Thus, an *"FCM is free to interact and* […], *at every step of interaction, every criterion has a new value"* (Ferreira and Jalali 2015: 237), which can be obtained through Formula (2):

$$A_i^{(t+1)} = f\left(A_i^{(t)} + \sum_{\substack{j=i \\ j \neq i}}^{n} A_j^{(t)}.w_{ji}\right) \quad (2)$$

Mathematically, $A_i^{(t+1)}$ represents the activation level of concept C_i in the moment $t+1$, $A_j^{(t)}$ denotes the activation level of concept C_j in the moment t, and w_{ji} represents the fuzzy intensity between two concepts. In addition, A_i^t stands for the activation level of concept C_i in the moment t, and f represents the activation function, which can assume different forms. These are: (1) binary (i.e., $f(x)$= 0 or 1); (2) trivalent (i.e., $f(x)$= -1, 0 or 1); (3) sigmoid (i.e., $f(x) \in [0; 1]$); or (4) hyperbolic tangent (i.e., $f(x) \in [-1; 1]$) (Azevedo and Ferreira 2017).

Mazlack (2009) states that the new state vector A_{new} is calculated by multiplying the weight matrix W by the state vector A_{old}, given that this new state vector represents the impact of changing one concept on all concepts in an FCM. Thus, the new vector is repeatedly multiplied by the adjacent matrix until the system can converge to a fixed point. Fig. 3 gives an example of this type of simulation exercise.

According to Carlucci et al. (2013: 213), *"*[t]*ypically,* [the system] *converges in less than 30 simulation time steps"* since, by the end of the simulation, the criteria hierarchy (i.e., the strength of the impact of a criterion over the other criteria) becomes clearer.

Although it is widely recognized in the literature that each problem structuring method has strengths and weaknesses (cf. Belton and Stewart 2002; Woodside et al. 2018)), three major factors impacted our methodological option. First, fuzzy cognitive mapping is a well-established method, recognized for being simple and facilitating decision making across several organizational contexts. Second, the authors of this paper have previous experience in its practical application, and familiarity with the method is an important factor to ensure its proper implementation. Last, we have found no prior documented evidence reporting the use of fuzzy cognitive mapping to analyze the determinants of digital entrepreneurship,

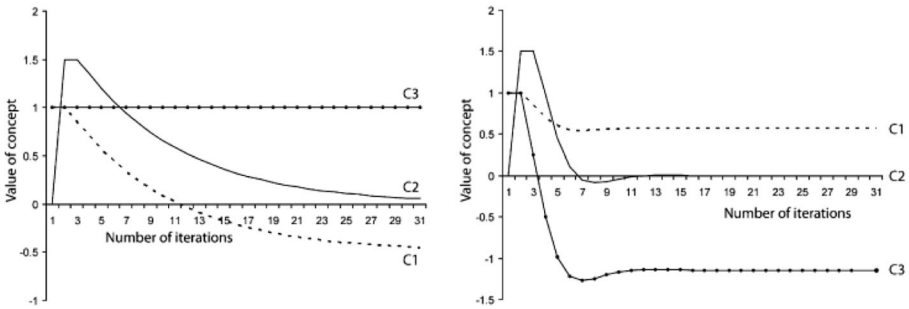

Fig. 3 Stabilization points of an FCM. Source: Yaman and Polat (2009: 386)

allowing our study to add to the extant literature on the study topic and OR/MS. Following this, FCMs have limitations, such as the time required to carry out the methodological procedures, but using these maps has various noteworthy advantages. The benefits range from facilitating decision-making processes to substituting other methodologies when time and data are limited (Lee and Kim 1997; Ferreira et al. 2017).

Application and results

Definition of decision problem

As mentioned previously, the present study sought to develop an FCM to identify and analyze the determinants of digital entrepreneurship and their cause-and-effect relationships. The primary objective was to overcome some limitations of previous studies.

Two group sessions were held, lasting around 4 h each (i.e., a total of 8 h), attended by two facilitators (i.e., researchers) and a panel of decision makers with specialized know-how on digital entrepreneurship's determinants. More specifically, the panel comprised six experts with a high level of responsibility in their respective firms (i.e., chief executive officers (CEOs), managers, and directors from different industries).

Notably, recruiting the panel was a challenging exercise. More than two months were taken up by making contact with potential participants and forming the group since many of those contacted were unavailable for so much time in face-to-face sessions. In the more extreme cases, these individuals did not respond. However, after consulting the relevant literature, the conclusion was reached that no ideal number of decision makers has been established for this type of study, although some guidelines exist. For instance, Bana e Costa et al. (2002: 227) suggest that decision-making groups need 5 to 7 experts and/or other key stakeholders. Given that the current research's final panel was made up of six decision makers who were able to collaborate fully, the suggested interval was respected.

In addition, representativeness was not – but did not need to be – a concern during the recruitment process. The type of methodologies used is process-oriented, so the procedures followed to construct the FCM, when correctly adjusted, can be replicated in other contexts and/or with different panels (see Belton and Stewart 2002; Bell and Morse 2013; Ferreira 2016; Branco et al. 2019). Indeed, the aim was to bring together a knowledgeable and experienced group of experts to formulate new insights and reflect, in our case, on the determinants of digital entrepreneurship.

Development of basic cognitive structure

The first session started with an explanation of the research framework and a brief introduction to the methodology and principles on which it was based. This briefing gave the group a clearer idea of what their role would be, thereby avoiding possible

procedural errors. In practical terms, this first session's goal was to gather the necessary elements to develop a cognitive map, so the following trigger question was presented: *"Based on your personal values and professional experience, which factors influence digital entrepreneurship?"*. This question stimulated a discussion between the participants, which was facilitated by applying the "post-its technique" (Ackermann and Eden 2001).

This technique required the panel members to write on post-it notes the factors and/or determinants that, in their opinion, influence digital entrepreneurship. Only one criterion was written on each post-it note, and, when a factor has a negative impact as a determinant, that note was marked with a negative sign (−) in the top right corner of the same post-it note. These criteria thus represented the perceptions each decision maker had of digital entrepreneurship determinants based on their professional and personal experiences. By the end of this phase, 186 determinants had been identified.

In the second phase of the first session, the different determinants were grouped into "areas of concern" (i.e., clusters), with the group's negotiations resulting in seven clusters. These were labeled: (1) "Innovation"; (2) "Human Resources (Team)"; (3) "Financial Resources"; (4) "Strategy, Business Model, and Planning"; (5) "Technology and Equipment"; (6) "Entrepreneur Profile"; and (7) "External Factors".

The third and last phase of the first session covered the internal organization of the clusters. The panel was asked to organize the post-its following a means-ends logic in which the most important a criterion was the closer it was put to the top of its respective cluster. The session was concluded when the panel members agreed with the cognitive structure developed – after everyone in the group had had the opportunity to analyze all the clusters and make any changes the members found necessary. Next, the *Decision Explorer* software (www.banxia.com) was used to develop a group cognitive map encompassing the panel's perceptions of the determinants of digital entrepreneurship and their respective cause-and-effect relationships. Fig. 4 shows the final version of the cognitive map obtained, which was subsequently analyzed and validated by the panel as a group.

An analysis of Fig. 4 confirms that this map includes all the criteria the panel considered important in terms of determinants that influence digital entrepreneurship. Even though this process was in part subjective, the final cognitive map clearly enables for a better understanding of which criteria influence this kind of entrepreneurship the most strongly.

Causal dynamics

In the second group session, the panel members were given the opportunity to analyze the map and, if necessary, rewrite concepts, add and/or eliminate concepts, restructure the clusters, and change connections between criteria and clusters. The participants were then asked to assign degrees of intensity to the relationships between the concepts. Due to each decision maker's different experiences and perceptions, this process involved intensive periods of discussion and negotiation. The interval [−1, 1] was used to express intensity as per the theoretical guidelines of the FCM methodology.

At this stage, *FCMapper* (http://www.fcmappers.net) and *Panjek* (http://pajek.imfm.si/doku.php) software packages were used to produce an FCM to facilitate a further analysis of the determinants of digital entrepreneurship. Fig. 5 shows the basic structure of

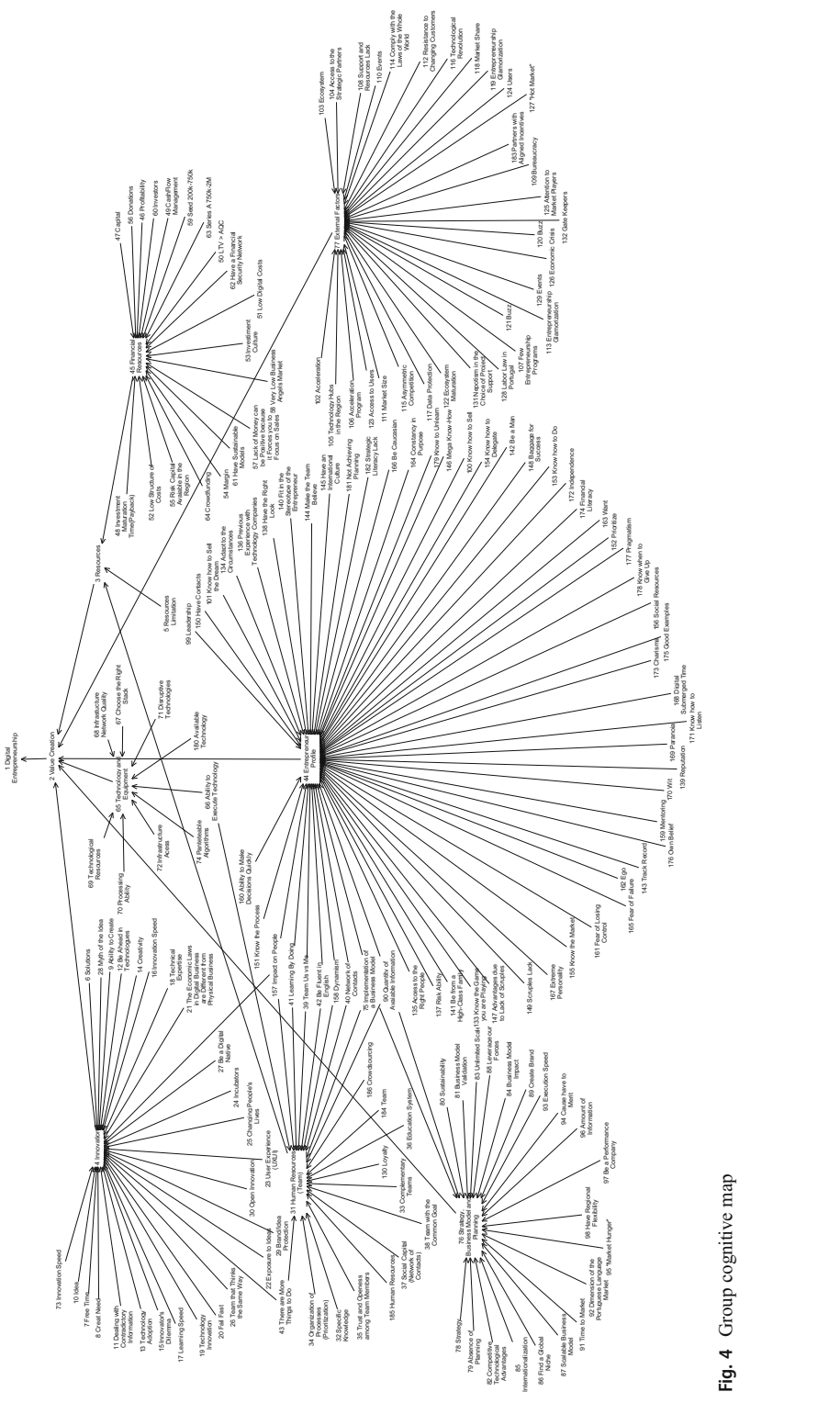

Fig. 4 Group cognitive map

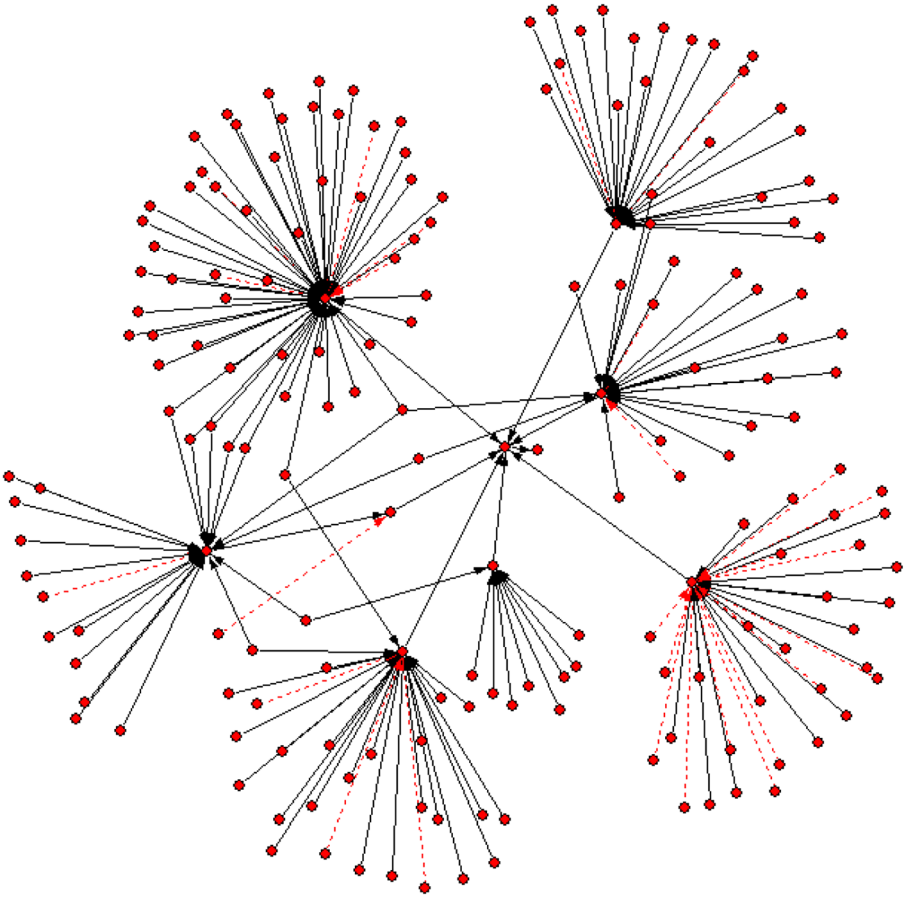

Fig. 5 Base structure of the FCM

the FCM created, which is similar to a neural network. All labels were removed to simplify this figure. The complete version of this structure, containing all the panel's specifications, is available upon request.

In Fig. 5, the connections in black represent positive cause-and-effect relationships (i.e., with intensity levels between 0 and 1), while the connections in red represent negative cause-and-effect relationships (i.e., with intensity levels between −1 and 0). Notably, the degree of intensity of the connections between the criteria was attributed by the decision makers only after intense discussion and negotiation. Fig. 6 provides an example, in this case of the values given by these experts to the "External Factors" cluster.

Thus, during this modeling phase, the participating experts assigned a fuzzy linguistic variable that was quantified to show the causal relationships' direction and intensity (Nápoles et al. 2016: 1). This process facilitated a fuller understanding of the cause-and-effect links between determinants of digital entrepreneurship, allowing them to be analyzed and discussed more thoroughly.

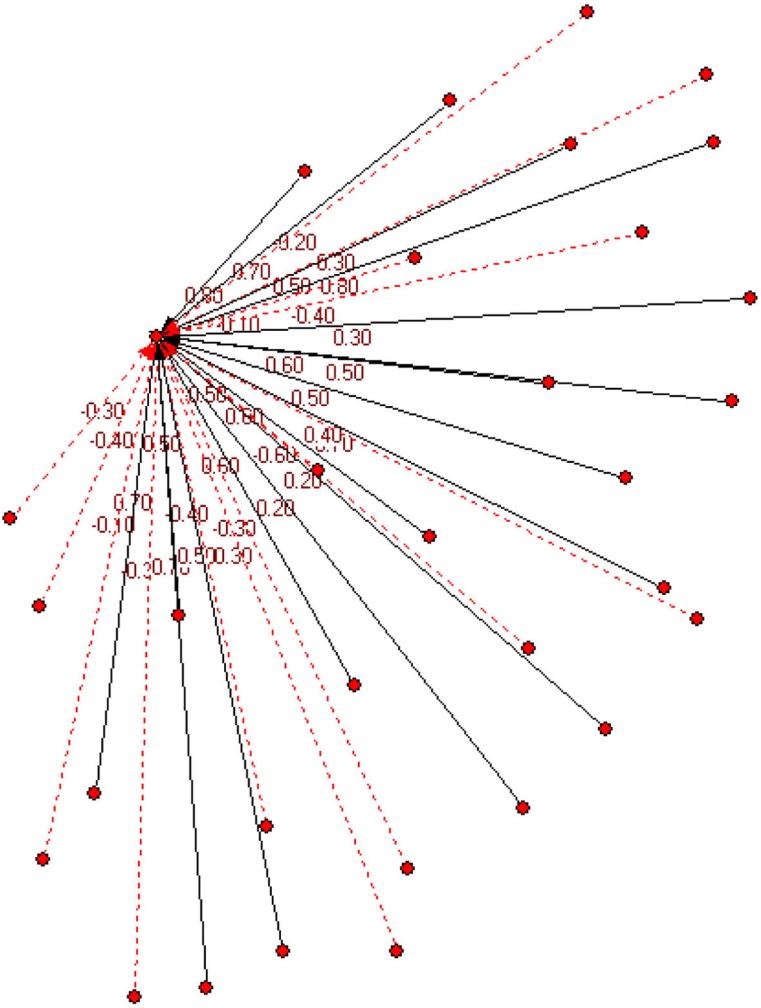

Fig. 6 Intensity degrees of External Factors cluster

Centrality of determinants of digital entrepreneurship

Based on the collective perceptions of the decision makers, degrees of centrality were then calculated for the determinants in the FCM. Centrality, according to Solana-Gutiérrez et al. (2017), is the most important measure to consider when dealing with complex FCMs. Table 2 shows the degrees of centrality of the seven most significant determinants of digital entrepreneurship. The complete list is available upon request.

According to Özesmi and Özesmi (2003) and Malek (2017), the centrality of a concept and/or criterion represents the effect it has on an FCM as a whole (i.e., how that component contributes to the FCM structure). This centrality results from the sum of a concept's outdegree with its indegree. The former *"indicates*

Table 2 Degrees of the most central determinants

Determinant	Outdegree	Indegree	Centrality
Entrepreneur Profile	0.80	32.00	32.80
Strategy, Business Model, and Planning	0.90	15.40	16.30
Financial Resources	0.80	13.90	14.70
External Factors	0.70	14.00	14.70
Innovation	0.40	14.20	14.60
Human Resources (Team)	0.70	13.60	14.30
Technology and Equipment	0.50	5.70	6.20

the effect of the variable on other variables and is the sum of all vectors exiting the variable", while the latter *"is the sum of all vectors entering the variable, and provides information on how the variable is affected by other variables"* (Malek 2017: 129). As shown in Table 2, the determinants in order of the most to least important within digital entrepreneurship are: (1) "Entrepreneur Profile"; (2) "Strategy, Business Model, and Planning"; (3) "Financial Resources"; (4) "External Factors"; (5) "Innovation"; (6) "Human Resources (Team)"; and (7) "Technology and Equipment".

Dynamic analyses of determinants of digital entrepreneurship

Dynamic analyses of the determinants included in the FCM were carried out using the *Mental Modeler* software (http://www.mentalmodeler.org/). According to Gray et al. (2013: 965), this kind of analysis *"makes the mental models of stakeholders explicit and provides an opportunity to incorporate different types of knowledge into* […] *decision-making, define hypotheses to be tested, and run scenarios to determine perceived outcomes of proposed policies"*.

Dynamic analysis at cluster level

Dynamic analysis at the cluster level is important because it facilitates the visualization of a determinant's possible impact on all clusters and other determinants. To this end, three artificial scenarios were created with variations of −0.50, 0.75, and 1.00.

Given the large number of determinants in the cognitive structure developed in the present study (i.e., 186), the dynamic analysis focused only on some concepts. Notably, none of the selected criteria functions as a cause of the seven clusters, but, nonetheless, these criteria have the strongest impact on the FCM structure when variations take place.

The degrees of intensity assigned by the decision makers indicate that the "quantity of available information" determinant has a direct link to three clusters. These include "Entrepreneur Profile", with an intensity of 0.50; "Strategy, Business Model, and Planning", with 0.80; and "Human Resources (Team)", with 0.70. This determinant also has an indirect link to three other determinants. The first is to

"resources" via the "Human Resources (Team)" cluster, with an intensity of 0.70. The second link is to "value creation" via the "Entrepreneur Profile" and "Strategy, Business Model, and Planning" clusters, as well as via the "resources" determinant, with intensities of 0.80, 0.90, and 0.80, respectively. The last link is to the general concept of "digital entrepreneurship" via the "value creation" determinant, with a degree of intensity of 1.00.

As shown in Fig. 7, the determinant most strongly affected by the "quantity of available information" is "value creation", which, according to the expert panel, is a basic determinant of digital entrepreneurship. As for the clusters, "Strategy, Business Model, and Planning" shows the most significant change. According to the panel members, this is easy to explain because a range of information is necessary to help align strategies with company values and plan ahead based on the needs the firm in question intends to meet.

The "implementation of a business model" determinant has a direct link to three clusters, namely, "Entrepreneur Profile", with an intensity of 0.90; "Strategy, Business Model, and Planning", with 0.90; and "Human Resources (Team)", with 0.90. This concept further has an indirect link to three determinants. The first is to "resources" by means of the "Human Resources (Team)" cluster, with an intensity

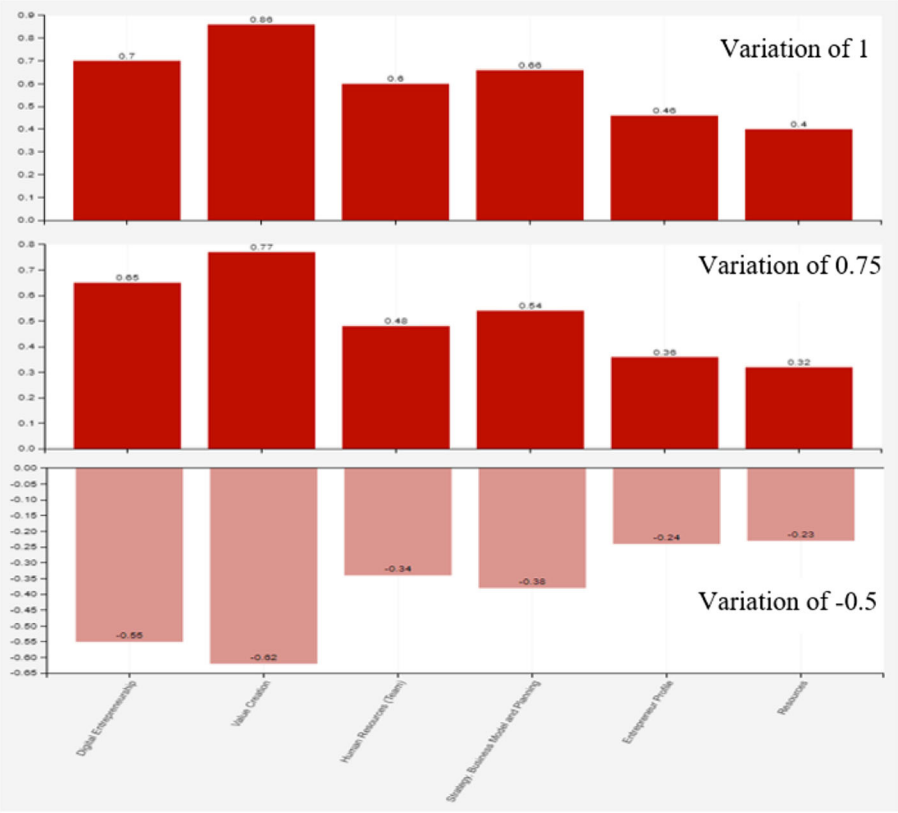

Fig. 7 Variation in impacts caused by the "quantity of available information" determinant

of 0.70. The second link is to "value creation" by means of the "Strategy, Business Model, and Planning" and "Entrepreneur Profile" clusters, as well as via the "resources" determinant, with degrees of intensity of 0.90, 0.80, and 0.80, respectively. The last link is to "digital entrepreneurship" by means of the "value creation" determinant, with an intensity of 1.00.

Interestingly, Fig. 8 shows that the three variations of the business model determinant have exactly the same effect. According to the panel, this means the three clusters (i.e., "Entrepreneur Profile"; "Human Resources (Team)"; and "Strategy, Business Model, and Planning") need to be closely attuned.

The "impact on people" determinant has a direct link to three clusters: "Innovation"; "Human Resources (Team)", and "Entrepreneur Profile", with degrees of intensity of 0.90, 0.20, and 0.80, respectively. This determinant also has an indirect link to three other concepts. The first is to "resources" through the "Human Resources (Team)" cluster, with an intensity of 0.70. The second link is to "value creation" through the "Innovation" (0.40) and "Entrepreneur Profile" (0.80) clusters, as well as the "resources" determinant (0.80). The last link is to "digital entrepreneurship" through the "value creation" determinant, with a degree of intensity of 1.00.

As Fig. 9 reveals, two of the clusters and two of the determinants have a nearly identical impact, and one cluster and one determinant's variations are practically

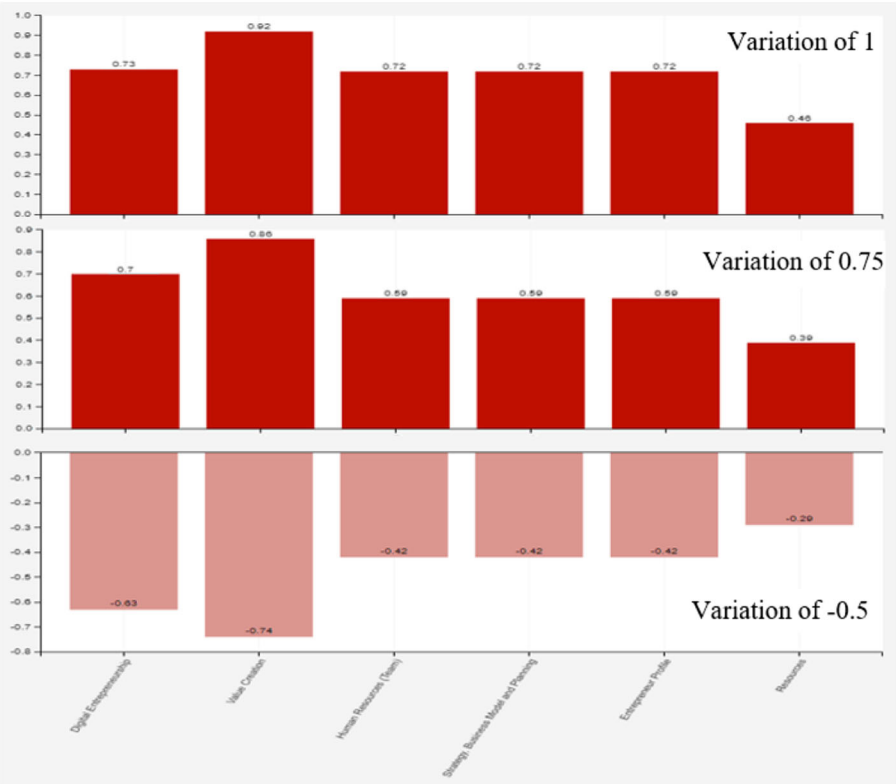

Fig. 8 Variation in impacts caused by the "implementation of a business model" determinant

Fig. 9 Variation in impacts caused by the "impact on people" determinant

non-existent. A bigger discrepancy is visible in the scenarios of 1 and 0.75, while the variation of −0.50 shows a less accentuated difference.

Finally, the "ability to execute technology" determinant has a direct link to the "Human Resources (Team)" cluster, with a degree of intensity of 0.80, and to the "Technology and Equipment" cluster, with 0.90. This concept also has an indirect link to three determinants. The first is to "resources" through the "Human Resources (Team)" cluster, with an intensity of 0.70. The second link is to "value creation" through the "Technology and Equipment" cluster (0.50) and the "resources" determinant (0.80). The last link is to "digital entrepreneurship" through the "value creation" determinant, with a degree of intensity of 1.00.

An analysis of Fig. 10 in terms of the "ability to execute technology" determinant shows that the most important impact is on the "Technology and Equipment" cluster. Thus, companies need to have not only the necessary skills but also adequate infrastructure and advanced technological resources in order to "execute" technology in the best way.

After conducting a dynamic analysis of clusters, intra-cluster analysis was also carried out. This involved examining the behavior of some determinants relative to the clusters to which they belong.

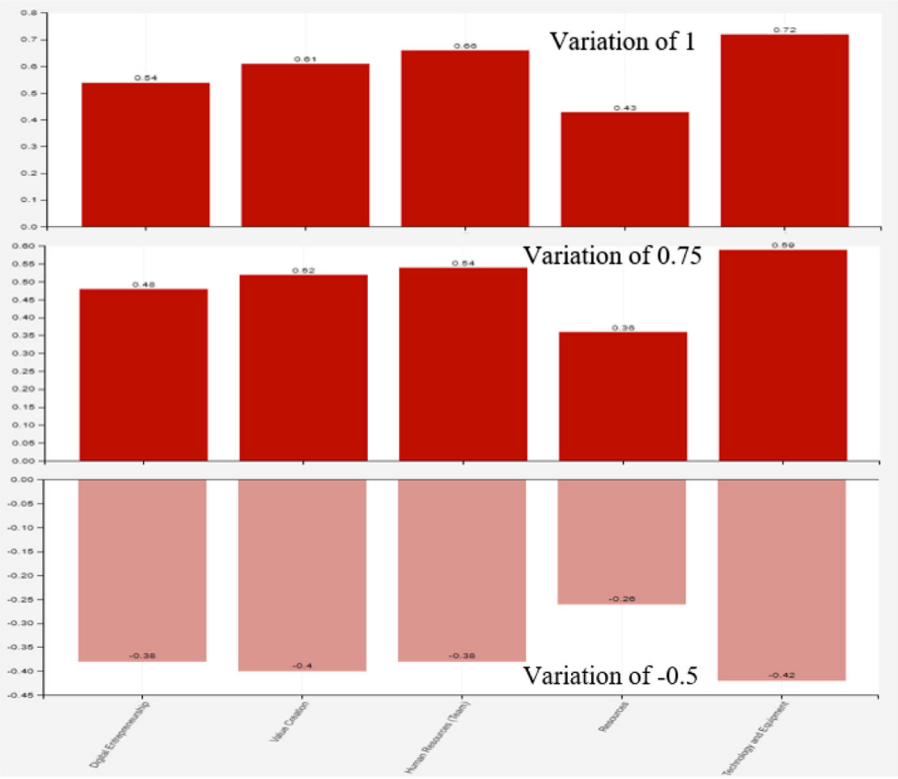

Fig. 10 Variation in impacts caused by the "ability to execute technology" determinant

Dynamic analysis at intra-cluster level

Dynamic analysis at the intra-cluster level facilitated a better understanding of the impact of determinants on the cluster in which they are inserted. This analysis considered the same three scenarios used in the previous analyses (i.e., variations of −0.50, 0.75, and 1.00) and the degrees of intensity attributed by the panel members.

Regarding the most central cluster (i.e., "Entrepreneur Profile"), the "leadership" determinant stands out from the other concepts in this cluster. If entrepreneurs do not have good leadership skills, they can jeopardize their entire business. In addition, "poor planning" has a strong negative degree of intensity within this cluster (see Table 3).

Table 3 Intra-cluster dynamic analysis of "Entrepreneur Profile" cluster

Determinant	Value Assigned	Δ − 0.5	Δ 0.75	Δ 1.00
Poor Planning	−0.60	0.29	−0.42	−0.54
Fear of Failure	−0.40	0.20	−0.29	−0.38
Ability to Make Decisions Quickly	0.50	−0.24	0.36	0.46
Leadership	0.90	−0.42	0.59	0.72

Table 4 Intra-cluster dynamic analysis of "Strategy, Business Model, and Planning" cluster

Determinant	Value Assigned	Δ − 0.5	Δ 0.75	Δ 1.00
Dimensions of Language Market	−0.90	0.42	−0.59	−0.72
Absence of Planning	−0.80	0.38	−0.54	−0.66
Execution Speed	0.60	−0.29	0.42	0.54
Internationalization	1.00	−0.46	0.64	0.76

According to Table 4, the "language market" determinant could be a serious hindrance to the second cluster (i.e., "Strategy, Business Model, and Planning"). Some markets are quite small from an international perspective, which is why the decision makers assigned the maximum degree of intensity to the internationalization determinant.

Table 5 reveals that the "capital" determinant is obviously important in the analysis of the third most significant cluster (i.e., "Financial Resources"). However, contrary to what many researchers think, a "low-cost structure" is even more important because it allows for long-term saving.

As presented in Table 6, "bureaucracy" is one of the determinants of the "External Factors" cluster that has a more negative impact. In a purely digital context, the "access to users" determinant also becomes critical because these same users are key stakeholders.

As for the fifth most significant cluster (i.e., "Innovation"), the "team that thinks in similar ways" determinant does not have an impact as negative as the "myth of the idea" determinant, but the former concept still produces small variations (see Table 7). While forming a team with the same way of thinking is comfortable, digital entrepreneurs must recognize that progress and innovation start, most often, from disagreement with and opposition to other team members' ideas. The "transformation of people's lives" determinant presents the most marked variations according to the expert panel members.

Regarding the "Human Resources (Team)" cluster, Table 8 shows that the panel saw the "education system" determinant as something structured in specific ways. This makes people follow a line of thinking that results in advancing individuals and not their team, which has a negative impact on this specific cluster. In addition, the "trust and openness among team members" and "social capital (network of contacts)" determinants have identical impacts since the degrees of intensity attributed by the decision makers only differ by one tenth of a point.

Table 5 Intra-cluster dynamic analysis of "Financial Resources" cluster

Determinant	Value Assigned	Δ − 0.5	Δ 0.75	Δ 1.00
Minimal Business Angels Market	−0.40	0.10	−0.29	−0.38
750 k-2 M Series A Funding	−0.10	0.05	−0.07	−0.10
Capital	0.60	−0.29	0.42	0.54
Low-Cost Structure	0.80	−0.38	0.54	0.66

Table 6 Intra-cluster dynamic analysis of "External Factors" cluster

Determinant	Value Assigned	Δ − 0.5	Δ 0.75	Δ 1.00
Bureaucracy	−0.70	0.34	−0.48	−0.60
Nepotism in Project Support Choices	−0.50	0.24	−0.36	−0.46
Attention to Market Players	0.20	−0.10	0.15	0.20
Access to Users	0.80	−0.38	0.54	0.66

Table 9 presents the results of the intra-cluster analysis carried out for the last cluster (i.e., "Technology and Equipment"). Both the "processing skills" and "technological resources" concepts have similar behavior due to the degrees of intensity the panel members gave them. These determinants are also the most dominant concepts in this cluster.

Once the dynamic analysis of each cluster was completed, the conclusion could be drawn that several factors positively or negatively influence the concept of digital entrepreneurship.

Validation, limitations, and recommendations

The methodology applied produced an FCM that identifies the determinants of digital entrepreneurship and the ways they relate to each other. Having the help of six decision makers with specific know-how on the subject facilitated the creation of an FCM that is closer to the reality of digital environments since all the panel members presented and shared their personal and professional experiences.

Even without any familiarity with fuzzy cognitive mapping, all the decision makers recognized the benefits of this method. The panel emphasized that the greatest advantages are how easy the FCM is to understand and how extensively it can consequently be developed. As Vliet et al. (2010: 6) note: *"*[The FCM] *is not too difficult (as all stakeholders should be able to understand the basics), is easy to teach (as it need*[s] *to be taught to all partners), has a high level of integration, can be performed in a short time (as funds and time allocated to the workshops are limited), and gives a system*[atic] *description".*

Because this methodology considers the business experience of each expert panel member, their involvement in the process contributes to more informed decisions, which makes the results more credible (Vliet et al. 2010: 2). The present study's participants also mentioned that previous efforts to identify and analyze the determinants of digital entrepreneurship have been inadequate and unreliable. The

Table 7 Intra-cluster dynamic analysis for "Innovation" cluster

Determinant	Value Assigned	Δ − 0.5	Δ 0.75	Δ 1.00
Myth of the Idea	−0.70	0.34	−0.48	−0.60
Team That Thinks in Similar Ways	−0.40	0.20	−0.29	−0.38
Ideas	0.30	−0.15	0.22	0.29
Transformation of Peoples' Lives	0.90	−0.42	0.59	0.72

Table 8 Intra-cluster dynamic analysis for "Human Resources (Team)" cluster

Determinant	Value Assigned	Δ − 0.5	Δ 0.75	Δ 1.00
Education System	−0.70	0.34	−0.48	−0.60
Crowdsourcing	0.30	−0.15	0.22	0.29
Trust and Openness Among Team Members	0.70	−0.34	0.48	0.20
Social Capital (Network of Contacts)	0.80	−0.38	0.54	0.66

panel thus confirmed that the proposed methodology contributes significantly to the existing literature on this topic.

Regardless of this positive feedback from the panel of decision makers, the methodology used in this study has some limitations. These include the difficulty with which the results can be generalized to other fields of study and other realities, requiring any extrapolation of the findings to be conducted with due caution. However, as discussed previously, the constructivist stance of the methods applied puts the focus on the process, which can be replicated if the necessary adjustments are made (Bell and Morse 2013).

In addition, the context and participants directly influenced the content of the FCM developed. For instance, if the panel had been composed of other experts or constituted in a different context or if the facilitators had been other researchers and both sessions had proceeded differently, the results and conclusions would have been different. The participants were aware of these limitations, yet the panel was enthusiastic about how the construction of the FCM in question facilitated a more holistic perspective on what the determinants of digital entrepreneurship are and how they relate to each other.

Conclusion

Certain determinants have a greater influence on digital entrepreneurship, so these should be the main areas of concern for entrepreneurs who wish to be successful in the "digital world" in which people currently live. As mentioned previously, digital entrepreneurship is seen by many countries as a fundamental pillar of economic growth, especially since this form of entrepreneurship helps create jobs. Therefore, identifying the determinants of digital entrepreneurship is extremely important, as is understanding the cause-and-effect relationships between them.

Table 9 Intra-cluster dynamic analysis for "Technology and Equipment" cluster

Determinant	Value Assigned	Δ − 0.5	Δ 0.75	Δ 1.00
Choice of Right Software Stack	0.30	−0.15	0.22	0.29
Disruptive Technologies	0.50	−0.24	0.36	0.46
Processing Skills	0.70	−0.34	0.48	0.60
Technological Resources	0.80	−0.38	0.54	0.66

In the present study, an FCM was developed based on the outcomes of face-to-face sessions with a panel of decision makers (i.e., CEOs, managers, and directors). Their participation enabled the structuring and validation of this model since their perceptions correspond to the reality they experience in digital environments. Even though the panel members were all unfamiliar with the adopted approach (i.e., fuzzy cognitive mapping), they recognized advantages in its applicability and in the way that it can integrate each decision maker's experience. This increased the results' credibility. Thus, FCMs can be said to have a high potential for applications in the field of digital entrepreneurship. Using FCMs allowed the present research to incorporate versatility, transparency, and feedback into the analysis of the determinants of digital entrepreneurship, which are of great importance to entrepreneurs, investors, government authorities, and society at large.

Due to the limitations related to the proposed methodology's context-specific and process-oriented nature, future studies may want to consider using different methods and/or replicating the processes followed in this study with a different group of decision makers in order to elicit other types of feedback. Although direct comparisons with other methods fell outside the scope of the present research, we recognize the importance of doing this and encourage comparisons in further research. The methodological approach adopted in this study could also be extended to other contexts. Any progress along these lines would be welcome as another step forward toward an accurate analysis of the determinants of digital entrepreneurship.

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