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Detecting and developing new business opportunities in society 5.0 contexts: A sociotechnical approach

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A R T I C L E I N F O

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Society 5.0
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A B S T R A C T

Rapid technological evolution has become a great challenge for businesses and societies due to the openness provided by new digital technologies, platforms, and infrastructure and to the impacts of these innovations on how people work and live. The concept of a super-smart society (*i.e.*, Society 5.0) comprises a fresh way to apply these innovations, in which human beings contribute to adapting technologies to daily activities in their society and making Society 5.0 ideas applicable to different areas of each individual's life. Digital transformation and technological innovation are basic components of this paradigm. This study sought to develop a decision-support model that can help companies structure and prioritize new business opportunities within Society 5.0 contexts. The analysis system relies on a constructivist approach that promotes debates between specialists and combinations of methodologies such as cognitive mapping and interpretive structural modeling. The results highlight the most important areas in which new business opportunities can arise, thereby demonstrating that the proposed model is a valuable tool for incorporating a future orientation into business technological innovation initiatives.

1. Introduction

Since the 1990s, the world's economy has rapidly globalized due to the development of information and communication technologies, especially with the rise of cell phones and the Internet, which has made innovation a significant component of economic growth [1,2]. However, businesses must constantly adapt to unpredictability due to exponential technological innovation.

Diverse digital technologies have emerged over the past 10 years and changed how people live and work [3–5]. As a result, companies and industries need to incorporate new technology into their operations, which requires modifications of critical business functions and affects essential operations, processes, products, and services. Vial [6] defines digital transformation as a process that combines information, computers, communication, and connection technologies to modify organizations' features and improve them significantly. Appio et al. [7] further note that "*digital transformation describes the deep-seated changes occurring at multiple levels and shape the ways agents innovate by sensing, seizing, and transforming opportunities engendered by the new digital paradigm*"(p. 4). These alterations thus harness the transformative and disruptive effects of digital technologies on society and business [3]. Companies' success has consequently become increasingly dependent on achieving technology-related competitive advantages [8,9].

The concept of Society 5.0—also known as a super-smart society—first appeared in Japan in 2016 (cf. [1]). The goal of this paradigm is to build a human-centered society in which goods and services are

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readily available to meet a variety of needs and close socioeconomic gaps so that everyone can live a comfortable yet active life [1]. Various studies of Society 5.0 have focused on the applicability of smart technologies in different domains (*e.g.*, health, education, industry, logistics, supply chain, and disaster management) (cf. [10,11]). Society 5.0 initiatives also include institutional and individual reforms that facilitate the adoption of business models and socioeconomic concepts that promote innovation and globalization. This paradigm further requires the creation of sustainable development and social equity programs [10]. The present research thus sought to address the following questions:

- How can new business opportunities in Society 5.0 settings be identified?
- What are the most influential relationships between them?
- Which new business opportunities should be given priority in decision-making processes?

Methodologically, businesses can deal with globalization, speedy innovation, complexity, and conceptual multiplicity by using a combination of constructivist techniques. As such, our study is process-oriented. This means that a major part of its contribution is precisely bound with the methodology used, and the added flexibility and comprehensiveness offered by the combined use of cognitive mapping and interpretive structural modeling (ISM) to identify and detect new business opportunities in Society 5.0 contexts. Despite the relative popularity of cognitive mapping and ISM, their integrated use is far more scarce; and we have found no prior evidence of their application in this study context. These methods promote debate and knowledge and experience exchange among decision makers, and thus include subjectivity in their procedures to provide a more comprehensive view of new business opportunities in different social environments. By applying these techniques, decision makers can identify fresh opportunities in Society 5.0 contexts, group these prospects into areas of interest, and prioritize them by importance. The modeling process helps managers structure the decision problem under consideration, supports decision making in Society 5.0 settings, and identifies the social impacts of the latest opportunities.

This paper is divided into five sections. The following section presents a literature review focused on Society 5.0 and new business opportunities. The third section covers the methodologies applied, while the fourth section presents the results and proposed model. The last section discusses the study's main conclusions and limitations, as well as suggestions for future research.

2. Related literature and research gaps

According to Correani et al. [12], *"digital transformation favors the interconnection among diverse industries by guiding firms to new opportunities for creating and appropriating value through digitization and connectivity"*(p. 38). Ardito et al. [13] further note that the adoption of certain enabling technologies—*e.g.*, information systems or improved Big Data analytics techniques—is necessary to accomplish digital transformation. However, it is worth noting that digital transformation is posing new challenges that seem to differ from those going along with previous technological shifts (cf. [14,15]). There are many reasons why digital transformation fails, including the failure to consider relevant aspects of change management in relation to individuals and societies [16]. Thus, digital transformation is not always straightforward.

Several important conceptualizations have been put forward in this context over the past few years. "Industry 4.0", "Industry 5.0" and "Society 5.0" are just examples of the diversity of definitions within the digital transformation field. Although intrinsically related, these concepts differ significantly. Ardito et al. [13] observe that *"the main idea underlying Industry 4.0 is running businesses by adopting digital technologies that can help firms to create connections between their machinery, supply systems, production facilities, final products, and customers in order to gather and share real-time market and operational information"*(p. 326). While Industry 4.0 takes on a technology-centered approach and places emphasis on digitalization and artificial intelligence (AI)-driven technologies for enhancing production efficiency and flexibility than it does on the original principles of social justice and sustainability (cf. [11]), Industry 5.0 triangulates resilience, sustainability, and human-centricity as key components of the value-creation systems supported by advanced technology [17]. Industry 5.0 thus reveals the power of industry to achieve societal goals beyond jobs/growth, and becomes a resilient provider of prosperity [11,18].

Because industry is an integral part of society, the coexistence of Industry 5.0 and Society 5.0 can be confusing. However, Deguchi et al. [19] and Huang et al. [11] explain that instead of having each system operating within a limited scope, Society 5.0 requires systems to operate integrated throughout society, and this involves *"comfort in all aspects of life, including in energy, transport, medical care, shopping, education, work, and leisure"* ([19], p. 2). Therefore, Society 5.0 focuses heavily on the public impact of technology and on the need to create a better society [11].

Following this, Society 5.0 requires to balance what is best for society with what is best for the individual, and this leads to two kinds of relationships: (1) the relationship between technology and society; and (2) the technology-mediated relationship between individuals and society. These relationships usually involve three baseline elements that drive social innovation, namely: data, information, and knowledge, requiring individuals to be literate in personal data and information. Society 5.0 is thus a data-driven and people-centric conceptualization that features an iterative cycle between cyberspace and physical space *"in which data are gathered, analyzed, and then converted into meaningful information, which is then applied in the real world"* ([19], p. 3).

As mentioned previously, the idea of Society 5.0 first appeared in Japan in April 2016. As also noted, this paradigm seeks to create a human-centered society in which products and services are readily provided to satisfy varied current and potential needs and reduce social and economic disparities. A super-smart society allows everyone to enjoy a secure yet invigorating life [1]. Society 5.0 is based on digital platforms, infrastructure, and services created by smart technologies such as AI, robotics, Internet of things (IoT), and blockchain systems, as well as augmented and virtual reality or robotic process automation. These tools have now reached a stage in their development that they can facilitate significant socioeconomic change [20]. The increased use of smart technologies in Society 5.0 directly affects each person due to the disappearance of traditional jobs and, conversely, a need for training and retraining. This paradigm also requires organizations to implement adequate security measures due to the large quantities of personal data collected and shared across systems ([19–21]). Following this, the present research concentrates on Society 5.0 and the associated fresh opportunities for companies. The importance of this paradigm is due to its reliance on digital transformation and new technologies. In recent decades, different digital technologies have radically modified how individuals live and work. However, Arthur [22] observes that *"technologies somehow must come into being as fresh combinations of what already exists"*(p. 18–19). Companies need to explore and harness the available new technologies, but these innovations often present significant challenges to both businesses and societies due to the multiple possibilities these tools offer.

Coccia and Watts [9] argue that technology enables people to accomplish their goals and/or resolve issues inherent to its implementation. Thus, digital innovations must adapt to the surrounding environment and consider societies' existing technological, social, and economic components. According to Vial [6], 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"*(p. 18). This type of change comprises the transformational, disruptive effects of digital technologies on business and society [3], and this process is essential to achieving competitive

Table 1
Recent studies: New business opportunities in society 5.0.

AUTHORS	METHODOLOGy	CONTRIBUTIONS	LIMITATIONS
Carayannis et al. [27]	Qualitative analysis	- Literature review. - Description of human adaptations required for new industries.	- Limitations related to qualitative studies. -Lack of analyses of causal relationships between variables.
Demir et al. [26]	Qualitative analysis	- Capabilities that human beings should acquire to adapt to Society 5.0.	- Limitations related to qualitative studies.
Fukuda [1]	Qualitative analysis	- Identification of science, technology, and innovation activities in Society 5.0 in three different countries: Japan, Germany, and United States of America.	- Limitations related to qualitative studies. - Specific geographical contexts with factors that may differ in each location.
Foresti et al. [28]	Qualitative analysis	- Application of smart systems that support human activities. - Examination of advantages provided by systems that integrate human and machines.	- Application of one specific method. - Preliminary evaluation that needs additional research. - Empirical research findings that cannot be generalized.
Nagy and Hajrizi [10]; Nagy et al. [29]	Qualitative analysis	- Clarification of necessary conditions for adaptation within Society 5.0 contexts. - Main condition focused around responsible innovation.	- Limitations related to qualitative studies (*e.g.*, limited generalization). - Need to create methodologies, rules, and procedures to guarantee main condition.
Broo et al. [30]	Qualitative analysis	- Analysis of historical perspective and changes inherent to digital transformation. - Influence of digital transformation on political, economic, and social issues. - Identification of four strategies to apply to inherent challenges.	- Limitations related to qualitative studies. - Specific geographical area with particular cultural, political, and economic factors.
Doyle-Kent and Kopacek [31]	Qualitative analysis and informational interviews	- Creation of a conceptual model considering *cobots*' contributions.	- Limitations related to qualitative studies. - Limited geographical area that limits generalization. - Specific area of *cobot* operations.
Maddikunta et al. [18]	Survey	- Definition of key Industry 5.0 concepts. - Survey of Industry 5.0 applications (that can also be adopted in Society 5.0 contexts). - Benefits of these applications.	- Limitations related to qualitative studies (*e.g.*, restricted generalization).

advantages [8,9]. Emergent innovations including AI, IoT, and machine learning have had an impact on digital transformation [4,23,24]. In addition, Fukuda [1] notes that innovative business models and new technologies affect this process.

Nagy and Hajrizi [10] suggest that Society 5.0 programs can initially focus on two goals. The first is to improve companies by encouraging the digitization and restructuring of businesses around new values that will improve productivity in economies and societies revitalized by innovation and globalization. The second goal is to help people restructure their lives and thus increase their individual self-worth since every person can live a secure, pleasant, and healthy life and achieve their desired lifestyle. The main added value of Society 5.0 is the management of socioeconomic problems by focusing on individuals' best interests, including sustainable programs that ensure social equity [10].

A super-smart society is characterized by three features: (1) smart manufacturing using IoT and network technologies; (2) connected and fused cyber and physical spaces (*i.e.*, cyber-physical systems); and (3) systematized services and business practices integrating a variety of systems' elements [25]. According to Nagy and Hajrizi [10], Huang et al. [11] and Demir et al. [26], Society 5.0's new business opportunities include, among others, digital drugs, smart factories, green ecology, smart fashion, intelligent traffic, innovation ecosystems, personalized coronavirus disease therapy, and fusion energy. The main challenges of this paradigm comprise data security, human-robot coworking, scalability, skilled workforces, and regulatory compliance. Many recent studies have analyzed the new business opportunities available in Society 5.0. Table 1 summarizes some of the research that has addressed this topic, including the respective contributions and limitations.

The limitations listed in Table 1 can be summarized into three basic shortcomings. The first is the predominance of qualitative studies based on literature reviews, without empirical research results. The second is the unclear process by which new business opportunities are identified. Another general limitation is the absence of empirically robust methods that compare and prioritize these opportunities in order to help companies meet the constant challenges inherent to Society 5.0. To address these gaps, the present study applied a methodology based on a combined use of value-focused thinking (VFT) and ISM to clarify the causal relationships between fresh business opportunities, and thus develop a structured process companies can easily apply.

3. Methodological background

3.1. Multiple-criteria decision analysis and problem-structuring methods

New complex problems constantly emerge in the business world, and difficult decisions should be made to achieve and maintain competitive advantages. However, the formulation of each problem varies from individual to individual, and proposed solutions may involve taking divergent paths. Decision makers should first understand complex challenges and the factors involved and incorporate their personal intrinsic values in the search for solutions [32,33].

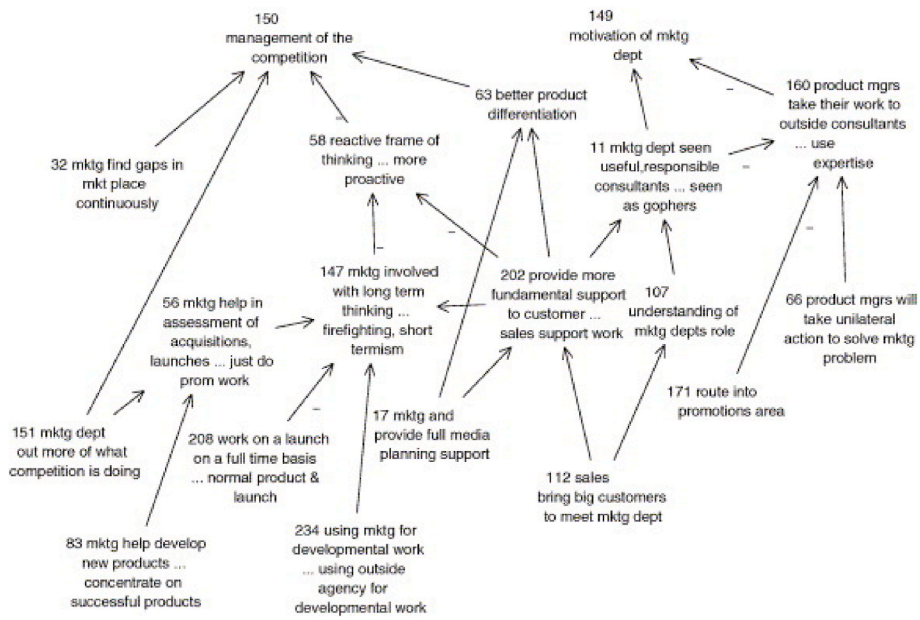

Fig. 1. Example of cognitive map.
Source: Eden [40] (p. 675)

Multiple-criteria decision analysis (MCDA) uses a constructivist approach that integrates the objective and subjective variables essential to successful cognitive processes that produce value judgments able to guide actors' behaviors. Decision making in MCDA consists of three stages: (1) structuring; (2) evaluation; and (3) making recommendations [34]. Effective problem structuring is especially crucial as the subsequent phases are strongly dependent on the results of the first stage [35]. The problem-structuring methods (PSMs) developed to help decision makers dissect challenges are often referred to as soft operational research (*i.e.*, "soft OR") methods (cf. [35]), which were introduced by Rosenhead (cf. [36]). These methods provide a comprehensive overview of the general decision problem. According to Mingers and Rosenhead [36], PSMs should integrate different perspectives, offer cognitive accessibility to actors from different backgrounds, and operate iteratively to change the representation of the decision problem to reflect the decision makers' discussion. These methods also need to permit partial or local improvements if significant changes are identified and approved.

3.2. Value-focused thinking and cognitive mapping

Diverse PSMs have been created including cognitive mapping, scenario planning, soft systems methodology, stakeholder analysis, and strategic assumption surfacing and testing (cf. [32,37]). As a holistic approach and systematic procedure that facilitates the identification and structuring of decision makers' values and objectives and the generation and evaluation of alternatives, value-focused thinking (VFT) is another significant approach that has had a significant impact on this field [35, 38].

In the present study, VFT was supported by cognitive mapping techniques that produced a graphical representation of the decision problem. This output helps participants organize their ideas, experiences, and values by visualizing how each individual perceives the most critical aspects of the decision problem and their causal relationships, thereby improving the decision makers' understanding and decisions [39]. The resulting group map integrates various individual perspectives [40]. Fig. 1 provides an example of a cognitive map, which consists of a chain of concepts connected by arrows that represent cause-and-effect relationships. These maps also include plus (+) or minus (−) signs depending on the positive or negative relationship between concepts

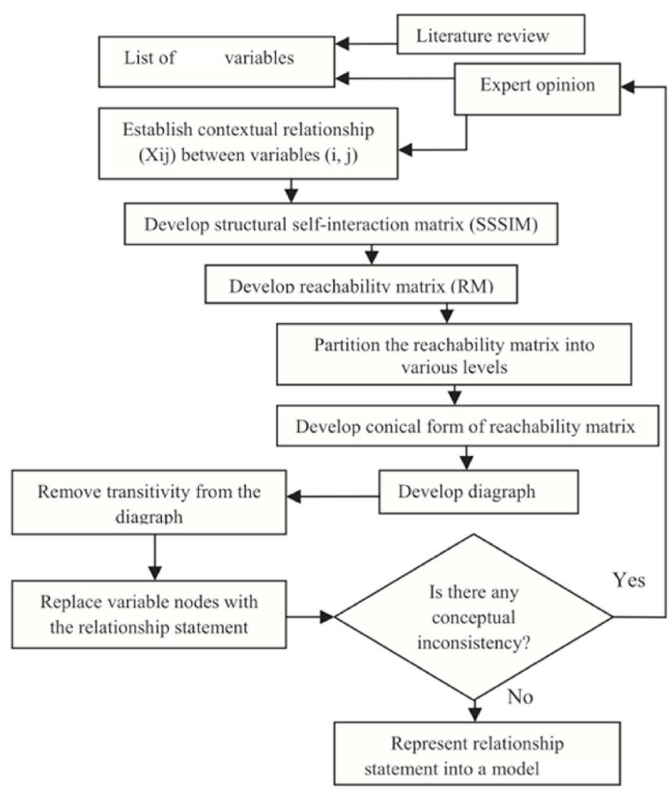

Fig. 2. Interpretive structural modeling steps.
Source: Khan and Rahman [44] (p. 63)

[41]. Vaz *et al.* [42] note that plus signs are frequently omitted to avoid visual density and confusion, but both signs are used to identify if a specific criterion/concept inhibits or favors the other concepts under analysis.

3.3. Interpretive structural modeling (ISM)

The evaluation stage in the current research included applying the ISM technique developed by Warfield [43], which identifies and clarifies cause-and-effect relationships between multiple variables [44,45]. ISM is characterized by scholars as helping decision makers analyze cause-and-effect links (*i.e.*, interpretative), representing the structure of complex connections between variables (*i.e.*, structural), and modeling schematics into a systematic whole [46]. This technique thus provides a fuller understanding of complex decision situations involving different factors and their interrelationships.

ISM's benefits include, first, the identification of causal links between variables. Second, this technique is a systematic, dynamic way to formulate judgments, ideas, and opinions related to decision problems, which allows decision makers to review their input when necessary. Last, the ISM graph-theoretic approach produces visual models that facilitate a clearer understanding of complex relationships between variables [47]. Fig. 2 presents the ISM processual steps, which are discussed in greater detail in the following subsections.

3.3.1. Step one

The first step is to identify and list the variables that influence a complex decision problem. The results can be based on literature reviews or experts' opinions.

3.3.2. Step two

The second step requires establishing the cause-and-effect relationships between the listed factors by constructing a structural self-interaction matrix (SSIM). First, the group of experts discusses and debates the existing links between each pair of variables. The relationships are classified by assigning codes: (1) *V* if variable *x* influences variable *y*; (2) *A* if variable *y* influences variable *x*; (3) *X* if variable *x* and *y* influence each other; and (4) *O* if variable *x* and *y* have no effect on each other [44,48].

3.3.3. Step three

The third step comprises developing a reachability matrix (RM) based on the SSIM. In this step, qualitative classifications are changed into binary classifications, namely replacing the codes *V*, *A*, *X*, and *O* with "1" and "0" according to the following rules:

- For any two variables, if the relationship is classified as *V*, then the coordinates (*x*, *y*) are replaced by "1" and the coordinates (*y*, *x*) are substituted by "0".
- For any two variables, if the link is classified as *A*, then the coordinates (*x*, *y*) are rewritten as "0" and the coordinates (*y*, *x*) are replaced by "1".
- For any two variables, if the connection is classified as *X*, then the coordinates (*x*, *y*) are replaced by "1" and the coordinates (*y*, *x*) are rewritten as "1".
- For any two variables, if the relationship is classified as *O*, then the coordinates (*x*, *y*) are substituted by "0" and the coordinates (*y*, *x*) are replaced by "0" [44,48].

3.3.4. Step four

The fourth step is to construct a final RM (FRM) that includes transitive relationships. This step focuses on identifying indirect relationships between pairs of variables. For example, in a group of three variables *A*, *B*, and *C*, if the first element *A* affects *B* and *B* affects *C*, then *A* affects *C* transitively. Variables with no direct links in the RM are analyzed. When a transitive relationship is detected, "0" is replaced by "1*" [44,48].

3.3.5. Step five

The fifth step comprises determining the reachability and antecedent sets for each variable based on the FRM. The reachability set comprises the variable in question and all the factors it affects. The antecedent set, in turn, embraces the variable itself and all the factors that affect that variable. The intersection set of each factor corresponds to the variables shared by the reachability and antecedent sets. After extracting the intersection set, the variables are placed hierarchically. The top positions include the variables for which the intersecting factors of the reachability and antecedent sets equal the reachability set itself. By repeating this analysis, the partition levels based on the FRM are iteratively defined [44,48].

3.3.6. Step six

The sixth step consists of generating a *matrice d'impacts croises multiplication appliqué à un classement* (MICMAC) (*i.e.*, cross-impact matrix multiplication applied to classification), which categorizes the variables into four quadrants [44,48]:

- *Autonomous* quadrant that includes variables with weak drive and dependence power.
- *Dependent* quadrant that includes variables with weak drive power but strong dependence power.
- *Linkage* quadrant that includes variables with strong drive and dependence power.
- *Driver* quadrant that includes variables with strong drive power but weak dependence power.

3.3.7. Step seven

The last step is to develop the ISM model without the transitive links based on the relationships revealed by the FRM (*i.e.*, using a canonical matrix) [44,48].

Although the present study follows the same processual steps presented in Fig. 2, it is worth noting that Khan and Rahman [44] make no use of cognitive mapping. Thus, our study adopts a different and unique combination of methods. Because VFT and ISM rely on decision makers' experience, expertise, and values, which are harnessed to generate new knowledge and approaches, both seem to be relevant to analyze new business opportunities in Society 5.0.

4. Applications and results

4.1. Structuring phase: group cognitive map

The first phase of the decision-support process needs to focus on problem structuring with the help of an expert panel. Ackermann and Eden [41] recommend that the panel include 5 to 10 specialists recruited for their diverse professional experience, age, and relevant know-how, which, in the present study, had to be in technology-related areas. Specifically, the expert panel included professionals with experience in innovation and technology in varied social contexts (*i.e.*, health, human resource management, organizational transformation, information security, and pharmaceuticals). The selection criteria ensured coverage of the most crucial areas of the surrounding society in order to structure the decision problem accurately.

The first group work session was held remotely with the assistance of three online platforms. The first was Miro (https://miro.com/), which facilitated the use of the "post-its technique" [41] to promote brainstorming. The second was Zoom (https://zoom.us/), which enabled multiple decision makers to participate simultaneously. The last was Google Drive (https://drive.google.com/drive/), which allowed the participants to simultaneously share documents and edit them.

This session lasted approximately four hours, and it was attended by seven decision makers and two facilitators who led the meeting and helped the panel reach a consensus by encouraging the experts' discussions and negotiations. The group work was preceded by a short presentation of the Society 5.0 concept, after which the following trigger question was posed: *"Based on your knowledge and professional experience, what new business opportunities can arise in Society 5.0 contexts?"*.

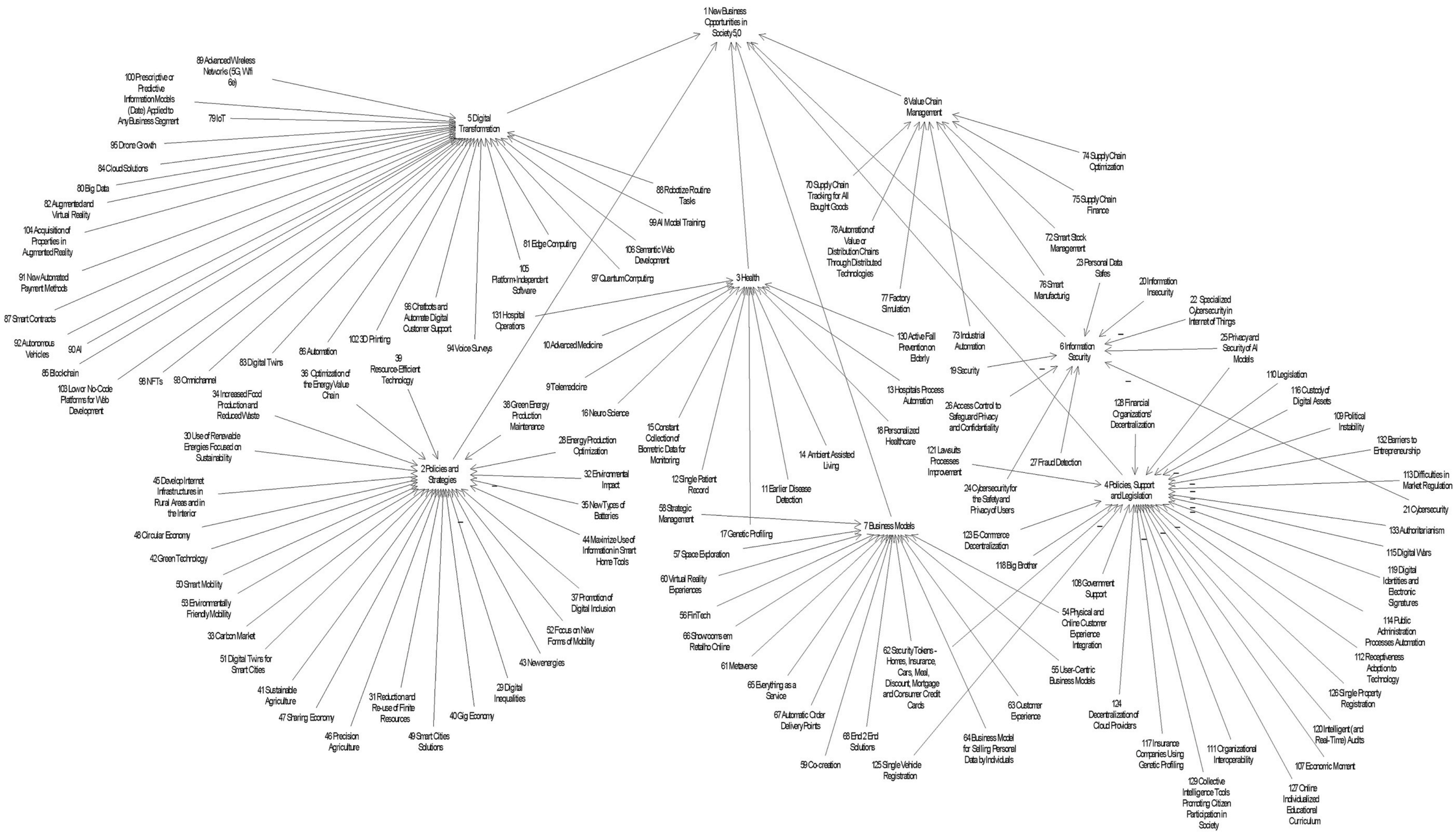

Fig. 3. Group cognitive map.

Table 2
New business opportunities by cluster.

CLUSTER	#	NEW BUSINESS OPPORTUNITIES
Policies and Strategies (C1)	SC30	Use of renewable energies focused on sustainability
	SC31	Reduction and re-use of finite resources
	SC34	Increased food production and reduced waste
	SC37	Promotion of digital inclusion
	SC41	Sustainable agriculture
	SC47	Sharing economy
	SC50	Smart mobility
Health (C2)	SC11	Earlier disease detection
	SC14	Ambient assisted living
	SC15	Constant collection of biometric data for monitoring
	SC18	Personalized healthcare
	SC131	Hospital operations
Policies, Support, and Legislation (C3)	SC109	Political instability
	SC111	Organizational interoperability
	SC113	Difficulties in market regulation
	SC119	Digital identities and electronic signatures
	SC128	Financial organizations' decentralization
	SC129	Collective intelligence tools promoting citizen participation in society
	SC132	Barriers to entrepreneurship
Digital Transformation (C4)	SC80	Big data
	SC82	Augmented and virtual reality
	SC83	Digital twins
	SC87	Smart contracts
	SC89	Advanced wireless networks (*i.e.*, 5G, Wi-Fi, and 6e)
	SC90	Artificial intelligence
	SC103	Low or no code platforms for Web development
Information Security (C5)	SC21	Cybersecurity
	SC22	Specialized cybersecurity in Internet of things
	SC23	Personal data safes
	SC26	Access control to safeguard privacy and confidentiality
	SC27	Fraud detection
Business Models (C6)	SC55	User-centric business models
	SC59	Co-creation
	SC61	Metaverse
	SC64	Business model for selling personal data by individuals
	SC65	Everything as a service
Value Chain Management (C7)	SC70	Supply chain tracking for all bought goods
	SC72	Smart stock management
	SC73	Industrial automation
	SC74	Supply chain optimization
	SC76	Smart manufacturing

Note. SC = specific criterion or subcriterion (*i.e.*, specific business opportunity).

The "post-its technique" was applied to identify the decision-making variables. In this procedure, the panel members had to add a plus sign (+) if they considered the new business opportunity an advantage or a minus sign (−) if they considered the opportunity a limitation on the use of innovative technologies in key areas (cf. Fig. 1). During this process, the facilitators encouraged discussion and opinion sharing in order to identify as many variables as possible. The results included 126 criteria (*i.e.*, new business opportunities).

In the second part of the first session, the specialists grouped these variables into clusters. They were asked to: (1) define the clusters; (2) ensure that each post-it contained only one new business opportunity and that the criterion was allocated to the appropriate cluster; and (3) indicate whether each opportunity could be present in more than one cluster. All the steps were completed via discussion until a consensus was reached by the experts. Seven clusters were identified and labeled as follows: (1) *Policies and Strategies* (C1); *Health* (C2); *Policies, Support, and Legislation* (C3); *Digital Transformation* (C4); *Information Security* (C5); *Business Models* (C6); and *Value Chain Management* (C7).

Table 3
Structural self-interaction matrices for inter-cluster and intra-cluster analyses.

Structural Self-Interaction Matrix (SSIM) – Clusters

	C1	C2	C3	C4	C5	C6	C7
C1		X	X	X	X	X	X
C2			X	A	A	A	A
C3				X	X	X	V
C4					X	X	X
C5						X	V
C6							X
C7							

SSIM – C1

	SC30	SC31	SC34	SC37	SC41	SC47	SC50
SC30		X	O	O	V	V	V
SC31			X	O	X	A	A
SC34				O	X	A	O
SC37					V	V	V
SC41						X	O
SC47							X
SC50							

SSIM – C2

	SC11	SC14	SC15	SC18	SC131
SC11		O	A	A	A
SC14			X	X	V
SC15				X	X
SC18					X
SC131					

SSIM – C3

	SC109	SC111	SC113	SC119	SC128	SC129	SC132
SC109		V	X	V	V	V	V
SC111			X	X	X	V	V
SC113				O	X	O	O
SC119					X	V	V
SC128						O	V
SC129							O
SC132							

SSIM – C4

	SC80	SC82	SC83	SC87	SC89	SC90	SC103
SC80		O	V	O	A	V	O
SC82			V	O	A	A	O
SC83				O	O	O	O
SC87					O	O	O
SC89						O	O
SC90							O
SC103							

SSIM – C5

	SC21	SC22	SC23	SC26	SC27
SC21		X	X	X	X
SC22			X	X	X
SC23				X	X
SC26					X
SC27					

SSIM – C6

	SC55	SC59	SC61	SC64	SC65
SC55		O	X	X	O
SC59			O	O	O
SC61				O	O
SC64					O
SC65					

SSIM – C7

	SC70	SC72	SC73	SC74	SC76
SC70		A	O	X	X
SC72			O	X	A
SC73				V	X
SC74					A
SC76					

Table 4
Inter-cluster structural self-interaction matrix.

	C1	C2	C3	C4	C5	C6	C7
C1		X	X	X	X	X	X
C2			X	A	A	A	A
C3				X	X	X	V
C4					X	X	X
C5						X	V
C6							X
C7							

Table 5
Inter-cluster reachability matrix.

	C1	C2	C3	C4	C5	C6	C7
C1	1	1	1	1	1	1	1
C2	1	1	1	0	0	0	0
C3	1	1	1	1	1	1	1
C4	1	1	1	1	1	1	1
C5	1	1	1	1	1	1	1
C6	1	1	1	1	1	1	1
C7	1	1	0	1	0	1	1

Table 6
Inter-cluster final reachability matrix.

	C1	C2	C3	C4	C5	C6	C7	Dr Pw
C1	1	1	1	1	1	1	1	7
C2	1	1	1	1*	1*	1*	1*	7
C3	1	1	1	1	1	1	1	7
C4	1	1	1	1	1	1	1	7
C5	1	1	1	1	1	1	1	7
C6	1	1	1	1	1	1	1	7
C7	1	1	1*	1	1*	1	1	7
Dp Pw	7	7	7	7	7	7	7	

Note. Dr Pw = drive power; Dp Pw = dependence power.

The last procedure consisted of ranking the criteria within each cluster according to their importance so that each cluster was divided into three levels. The top level comprised the most important variables. The intermediate and lower levels contained the criteria of intermediate and least importance, respectively. The expert panel also checked all the criteria for any duplicates. The necessary adaptations were made to make the variables more noticeable and distinct from each other. The results were used to generate a cognitive map with the *Decision Explorer* software (http://www.banxia.com). This map thus outlined the group's vision of new business opportunities in Society 5.0. Fig. 3 shows the final version of the cognitive map, which was validated by the decision makers (size restrictions prevent a better visualization, but an editable version of the entire group causal map can be obtained from the corresponding author upon request).

The cognitive mapping procedures proved to be extremely useful as this process generated a rich exchange of information and experience. The final map provided the expert panel with a more holistic view of the decision problem and a better understanding of the cause-and-effect relationships among new business opportunities in Society 5.0 contexts. Once the group's knowledge had been harnessed and the structuring phase completed, the second session could focus on applying ISM.

4.2. Evaluation phase: ISM and MICMAC

The second session comprised evaluation procedures, which focused on selecting the most significant criteria in each cluster and identifying inter- and intra-cluster cause-and-effect relationships. The session lasted four hours, and it was attended by five of the seven initial experts and one facilitator. The meeting began with the presentation of the cognitive map from the first session so that the panel could approve its contents and structure. The decision makers were next asked to select the most crucial criteria in each cluster using nominal group technique (NGT) and multi-voting. Each round focused on ensuring that only the most significant variables would be selected. Table 2 shows the results of this first procedure, namely the seven clusters' key criteria (*i.e.*, new business opportunities).

The next procedure of the second session consisted of evaluating the causal relationships between the clusters (*i.e.*, inter-cluster analysis) and between the criteria in each cluster (*i.e.*, intra-cluster analyses). Table 3 shows the SSIM matrices generated by establishing the following type of causal relationships: (1) *V* for a direct link; (2) *A* for an inverse connection; (3) *X* for a bidirectional relationship; and (4) *O* for the absence of a causal link. Four 7 × 7 matrices (*i.e.*, one inter-cluster and three intra-cluster) and four 5 × 5 matrices (*i.e.*, all intra-cluster) were produced. An Excel file was shared during the Zoom session, and the relationship codes were filled in after the expert panel reached a consensus on each link.

4.2.1. Inter-cluster assessment

The comparative analysis of the relationships between the seven clusters provided a deeper understanding of the types of connections between them and the role of each cluster in the detection and development of new business opportunities in Society 5.0. Table 4 presents the SSIM matrix of the existing causal links between the clusters.

Table 4 reveals the bidirectional influence flowing between C1, C2, and C3. C2 does not affect the remaining four clusters (*i.e.*, C4, C5, C6, and C7), but it is influenced by them. In addition, C7 shares bidirectional effects with C1, C4, and C6. Although C7 influences C2, C7 is not influenced by C2. In addition, C7 is affected by C3 and C5, but C7 does not influence them. After the causal relationships shown in Table 4 were identified, the codes were converted into binary relationships (*i.e.*, "0" or "1") to form the RM (see Table 5).

The next step was to find any transitive relationships between the clusters using Warshall's [49] algorithm. This analysis focused on the pairs that do not have a direct relationship (*i.e.*, $(C_y, C_x) = 0$) in the RM and the links that change the degree of influence of each cluster (cf. [50]). The result was the FRM presented in Table 6.

The influence of each cluster was determined based on the number of clusters it can affect, and its degree of dependence was estimated based on the number of clusters that influence it. This step thus assessed the capacity of each cluster to condition the ability of the decision-support model to help experts detect and develop new business opportunities. The results infer that all seven clusters have equal influence and dependence on each other. Table 7 shows that all these areas are crucial to finding and exploiting fresh business prospects since the clusters all share the same reachability, antecedent, and intersection sets and appear at the same partition level.

Finally, MICMAC analysis was conducted for all seven clusters with reference to their drive and dependence power. All clusters fall within quadrant III (*i.e.*, linkage), which means that decision makers need to include—and treat as equally important—all seven clusters. Fig. 4 presents the MICMAC results and final inter-cluster ISM diagram.

4.2.2. Intra-cluster assessment

The next step was to analyze the relationships between the most significant new business opportunities in each cluster and their potential to influence companies' performance within the respective cluster by linking diverse opportunities. The cause-and-effect links revealed by the SSIM matrix in C1 were defined and used to construct an initial RM. Unrelated pairs of variables and their possible transitive relationships were then analyzed to generate the FRM. Notably, no new opportunity directly influences SC37. Finally, the reachability, antecedent, and intersection sets were defined, and the corresponding partition levels were identified. C1's ISM diagram appears in Fig. 5.

The results show that the opportunities are distributed across two partition levels. Level 2 contains SC37, and the remaining criteria

Table 7
Inter-cluster partition matrix.

	Reachability Set	Antecedent Set	Intersection Set	Level
C1	C1–C2–C3–C4–C5–C6–C7	C1–C2–C3–C4–C5–C6–C7	C1–C2–C3–C4–C5–C6–C7	1
C2	C1–C2–C3–C4–C5–C6–C7	C1–C2–C3–C4–C5–C6–C7	C1–C2–C3–C4–C5–C6–C7	1
C3	C1–C2–C3–C4–C5–C6–C7	C1–C2–C3–C4–C5–C6–C7	C1–C2–C3–C4–C5–C6–C7	1
C4	C1–C2–C3–C4–C5–C6–C7	C1–C2–C3–C4–C5–C6–C7	C1–C2–C3–C4–C5–C6–C7	1
C5	C1–C2–C3–C4–C5–C6–C7	C1–C2–C3–C4–C5–C6–C7	C1–C2–C3–C4–C5–C6–C7	1
C6	C1–C2–C3–C4–C5–C6–C7	C1–C2–C3–C4–C5–C6–C7	C1–C2–C3–C4–C5–C6–C7	1
C7	C1–C2–C3–C4–C5–C6–C7	C1–C2–C3–C4–C5–C6–C7	C1–C2–C3–C4–C5–C6–C7	1

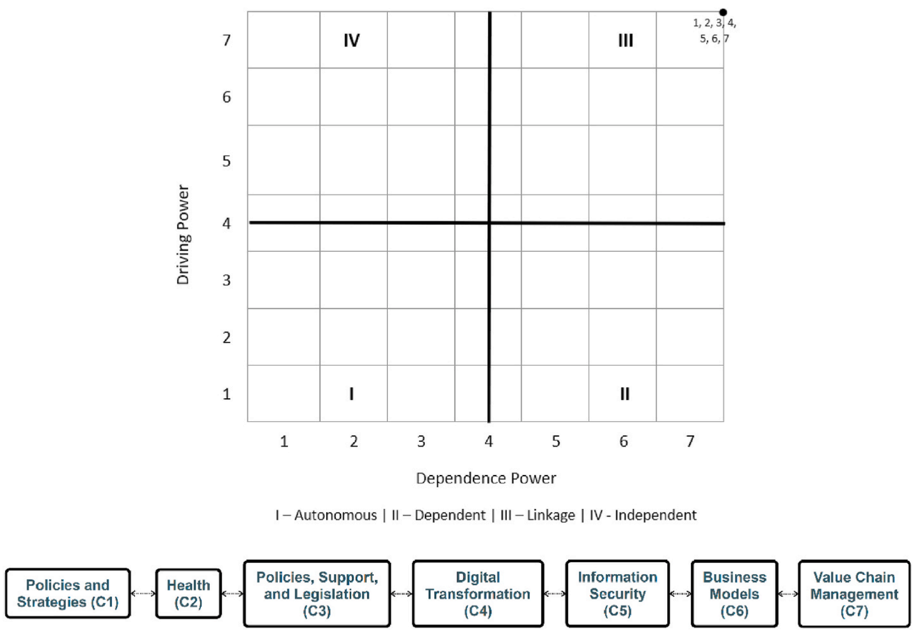

Fig. 4. Micmac and inter-cluster ISM diagram.

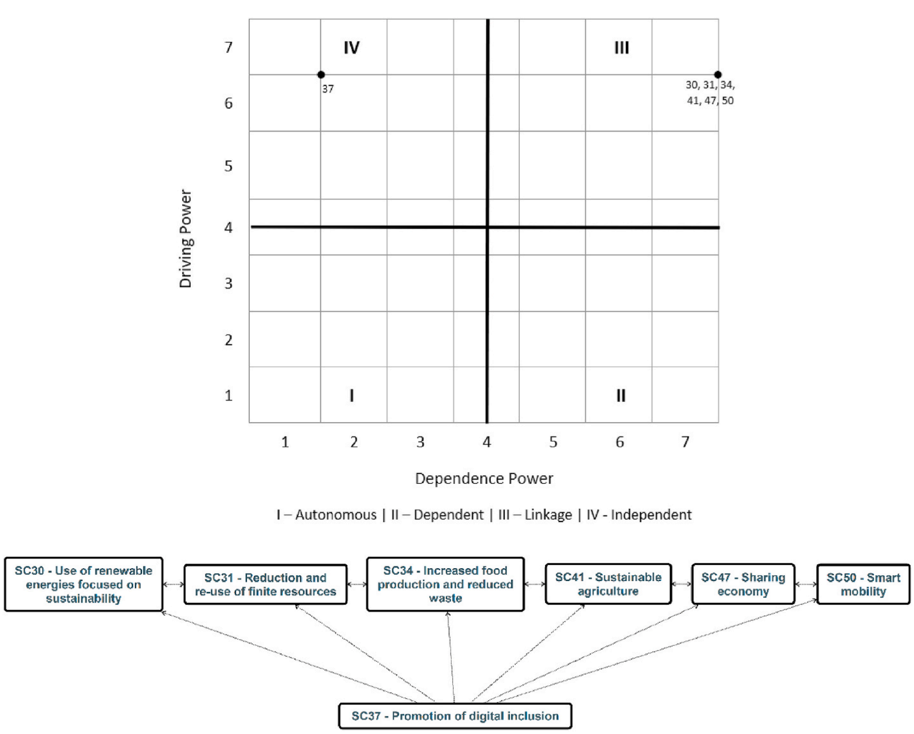

Fig. 5. C1 MICMAC and ISM diagram.

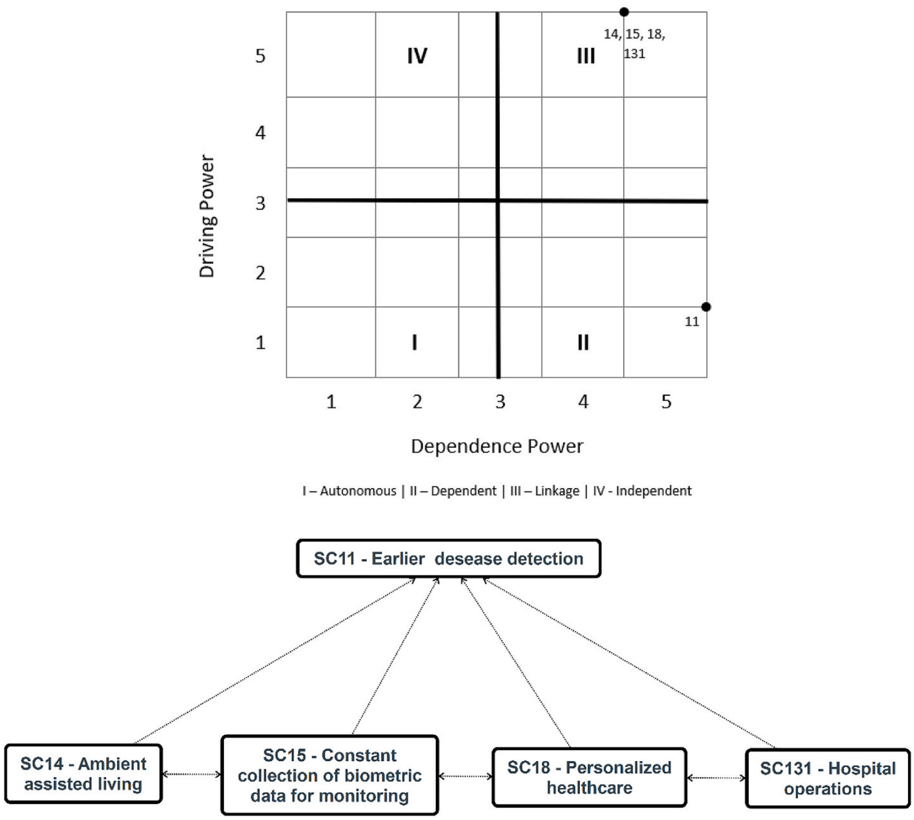

Fig. 6. C2 MICMAC and ISM diagram.

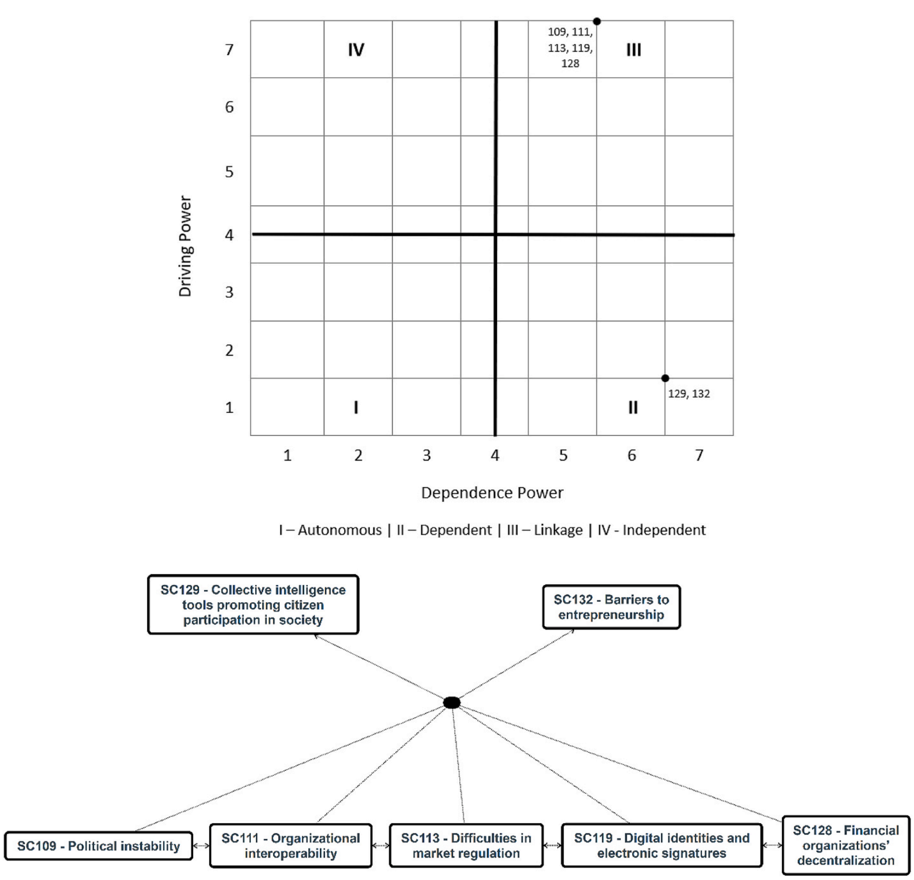

Fig. 7. C3 MICMAC and ISM diagram.

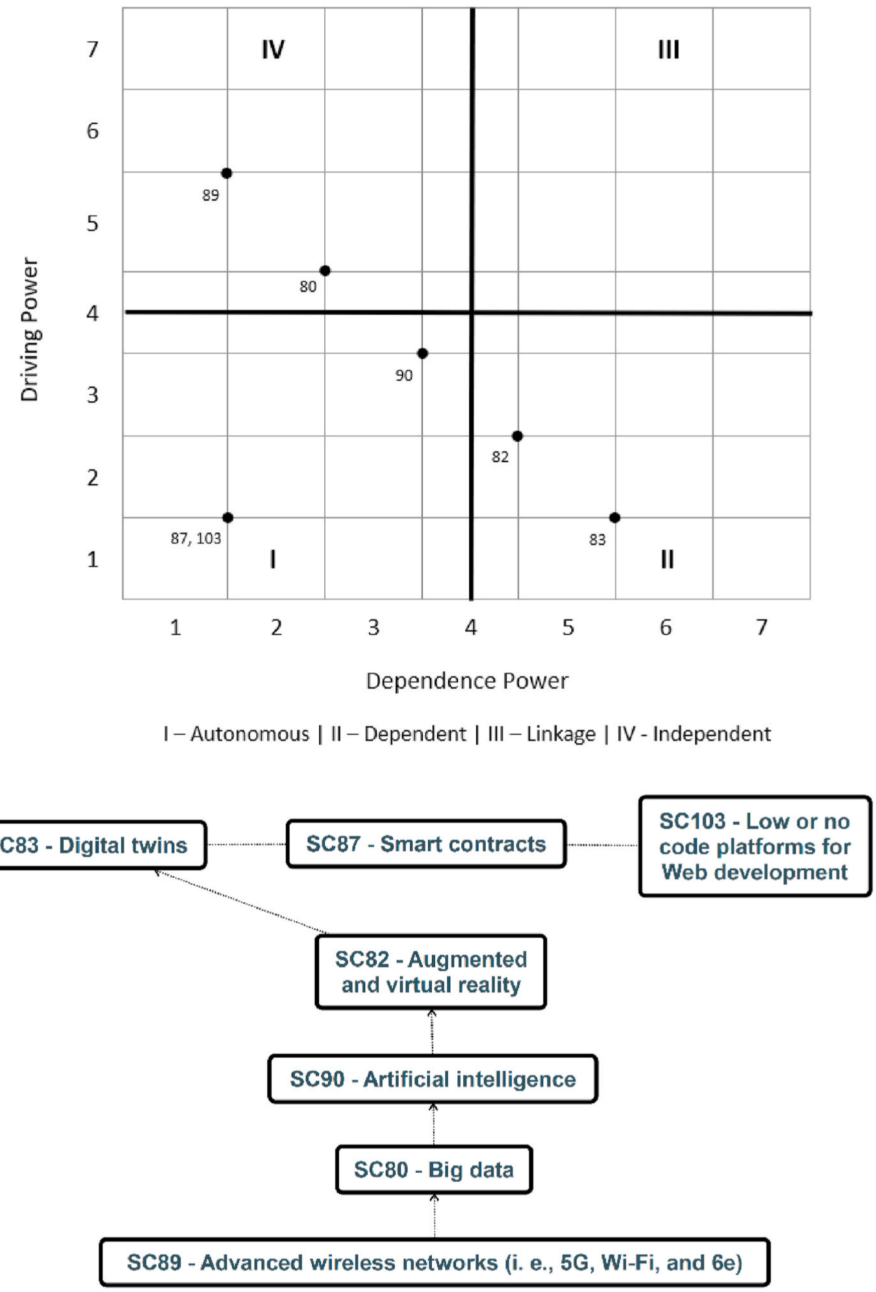

Fig. 8. C4 MICMAC and ISM diagram.

appear in Level 1. To complete the cluster analysis, the MICMAC technique was applied, revealing that one new business opportunity (*i.e.*, SC37) is characterized by independence (*i.e.*, quadrant IV) and has a greater influence on the other C1 variables. The remaining new prospects (*i.e.*, SC30, SC31, SC34, SC41, SC47, and SC50) fall into quadrant III, so their interrelationships are quite influential and these criteria are strongly dependent on each other. Fig. 5 includes the ISM and MICMAC results.

Next, the cause-and-effect relationships between key factors in C2 were defined, and the RM was created. Then, the transitive relationships were examined for the pairs of variables only indirectly related to each other. The FRM was based on the results of this step. The partition levels were subsequently determined. Fig. 6 shows the ISM diagram obtained for C2, which shows that most opportunities are in Level 2 (*i.e.*, SC14, SC15, SC18, and SC131), except for SC11 in Level 1. The MICMAC results for this cluster indicate that only SC11 appears in quadrant II, revealing a high degree of dependence on the remaining opportunities. These other criteria fit into quadrant III (*i.e.*, linkage), thereby demonstrating a strong degree of bidirectional dependence and influence. In addition, the results confirm the importance of each opportunity to the cluster and its overall significance in the decision-support model.

The causal relationships in C3 were examined and its RM constructed. The analysis of transitive relationships using Warshall's [49] algorithm then produced a FRM that clarified the following partition levels: SC129 and SC132 in Level 1; and the remaining opportunities (*i.e.*, SC109, SC111, SC113, SC119, and SC128) in Level 2. Fig. 7 presents the ISM results for this cluster.

The MICMAC technique revealed that C3 contains two opportunities (*i.e.*, SC129 and SC132) in quadrant II (*i.e.*, dependence), which indicates weak influence and strong dependence on the other C3 criteria. In contrast, the remaining new business opportunities have a strong impact, and they are quite interdependent because they are located in

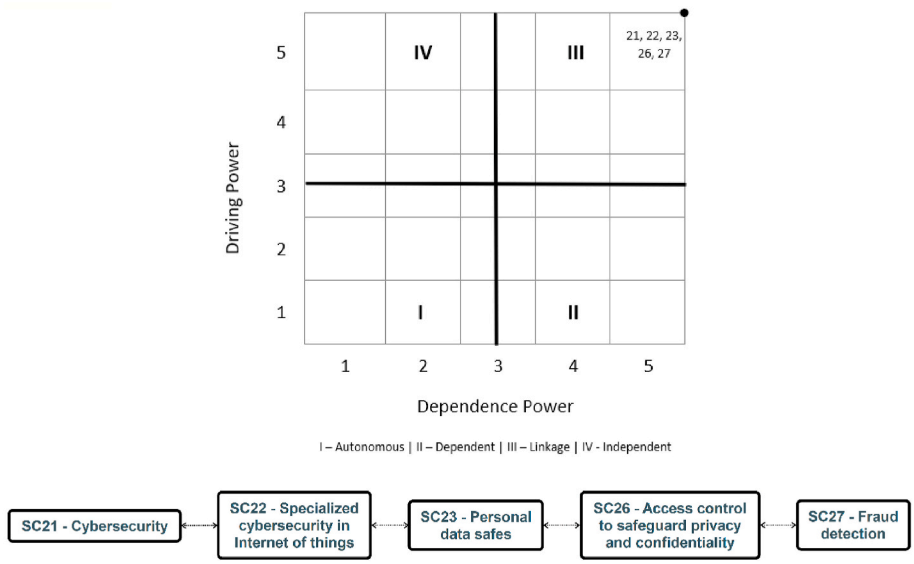

Fig. 9. C5 MICMAC and ISM diagram.

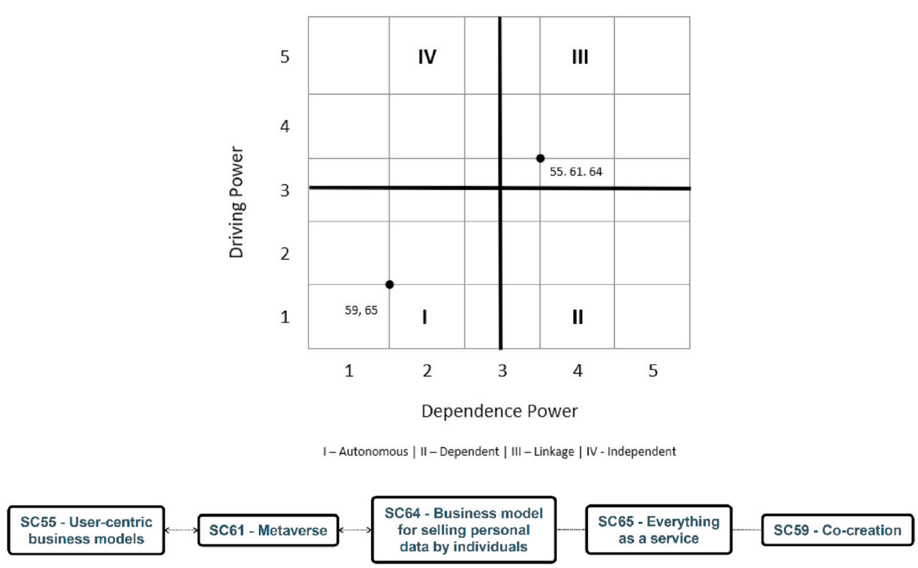

Fig. 10. C6 MICMAC and ISM diagram.

quadrant III (*i.e.*, linkage).

The RM for C4 was created based on the causal relationships detected. The pairs of opportunities unrelated to each other were next identified so that the transitive relationships could be analyzed and the FRM generated. The MICMAC technique was then applied, verifying that SC80 and SC89 are independent (*i.e.*, quadrant IV) and strongly influence the remaining opportunities. In quadrant I (*i.e.*, autonomy), SC87, SC90, and SC103 reveal a low degree of both influence and dependence. The remaining criteria (*i.e.*, SC82 and SC83) are quite dependent since they appear in quadrant II (*i.e.*, dependence). Five partition levels were identified for these criteria, and the C4 ISM diagram was created. Fig. 8 shows that the opportunities are present in the following levels: SC83, SC87, and SC103 in Level 1; SC82 in Level 2; SC90 in Level 3; SC80 in Level 4; and SC89 in Level 5.

When C5 was analyzed, both the RM and FRM revealed bidirectional causal relationships between all the new business opportunities. Thus, the degree of influence and dependence is equal for all criteria, which fall within the same level. Fig. 9 presents the ISM diagram for C5. The MICMAC analysis verified that all these new business opportunities appear in the same place in the diagram (*i.e.*, quadrant III), revealing strong dependence and influence between C5 opportunities. The results also show that, if a change occurs in a given criterion, it will trigger a bidirectional reaction in the other variables.

In C6, the panel members first identified the causal relationships in order to construct the RM. The transitivity analysis conducted next identified the pairs of variables without a direct link, and the results were incorporated into the FRM. Similarly to C5, all the C6 opportunities are in Level 1, indicating identical importance within this cluster. Fig. 10 contains the ISM diagram and the MICMAC results, which show that SC59 and SC65 appear in quadrant I (*i.e.*, autonomy) and have weak links within C6 as these variables present little influence and dependence. The remaining new business opportunities (*i.e.*, SC55, SC61, and SC64) fall into quadrant III and have substantial bidirectional influence.

Finally, the causal relationships were defined in the C7 RM. The expert panel identified the pairs of variables with indirect connections with each other in order to analyze the transitive relationships in this cluster and construct the FRM. The ISM diagram was then created, revealing all criteria (*i.e.*, SC70, SC72, SC73, SC74, and SC76) in the

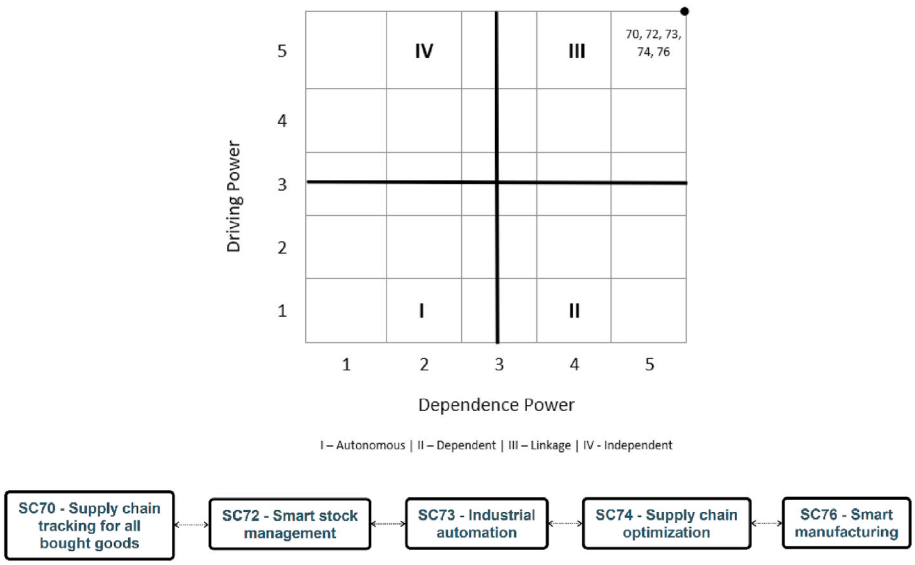

Fig. 11. C7 MICMAC and ISM diagram.

same partition level (see Fig. 11). The MICMAC results (see Fig. 11) verify that all C7 opportunities are located in quadrant III (*i.e.*, have strong influence and a bidirectional dependence on each other).

This study thus identified seven areas of business activities offering new opportunities related to Society 5.0: (1) policies and strategies; (2) health; (3) policies, support, and legislation; (4) digital transformation; (5) information security; (6) business models; and (7) value chain management. It is worth recalling that the business opportunities identified in our study, associated cause-and-effect relationships and respective interpretations were all directly provided and approved by the panel members according to Eden and Ackermann's [51] guidelines for cognitive mapping and after intense collective discussion and negotiation. Specifically, the decision-maker panel reached a consensus on both the clusters obtained and type of relationship(s) they deemed to exist between each pair of business opportunities. In this regard, we highlight the importance of group dynamics, since this allows individuals to confront different opinions and to reach more consensual solutions. Fig. 12 shows the final model generated by the *SimpleMind* software (https://simplemind.eu), including all seven clusters and their most important criteria (again, size restrictions prevent a better visualization, but an editable version of the ISM model can be obtained from the corresponding author upon request). This empirically robust model is clearly structured and adaptable as it presents the new business opportunities by priority and respective area of activity—ready to be used by the business community.

4.3. Discussion, consolidation and recommendations

Two additional consolidation sessions of around 40 minutes each were conducted to strengthen the above results and validate the model. These meetings were also held online via Zoom. The two experts interviewed have experience in innovation and application of innovative models in business contexts. One specialist is a startup co-founder and product director, and the other is a startup advisor and mentor who works with various organizations such as COTEC Portugal and the European Commission. These experts were not present at the previous model-building sessions. Thus, they were considered neutral and exempt from any bias in favor of the results.

The sessions' agenda included: (1) a brief contextualization of the research topic and methodology; (2) presentation and discussion of the results; (3) analysis of the practical applicability of the proposed model; and (4) discussion of suggestions and recommendations. After hearing about the methodology, one expert said: *"it is a good strategy because it involves a phase of individual brainstorming and then more collective thinking or collective prioritization.* […] *Logically and conceptually, the methodology applied appears to make good sense"* (in his words). The other expert considered the methodology *"appropriate"* (his expression), but he suggested businesses should use the techniques in association with system dynamics and scenario planning.

Regarding the findings, the interviewees in general agreed with the model. One specialist specified that *"the clusters that were formed make sense. I cannot remember anything else that would make sense to include here"* (also in his words). However, the other expert stated that the inter-cluster results needed to add education and training and the integration of the most recent technologies to C4.

When asked about the proposed model's applicability and possible users, one interviewee asserted that entrepreneurs could apply this analysis system to improve both current and future business models. The other specialist recommended that important members of political parties with high profiles at the national level should be included because the research topic is *"a social problem,* [so applications …] *have to deeply involve the government itself and the country's leaders"* (again in his words). To implement the model, the specialists said defining a work team was essential to ensure general and specific leadership. In other words, to *"encourage ownership,* [the team …] *would have to be in charge of the general coordination of the implementation process, but then, for each area, there would have to be key people experienced in that type of business"* (citing the decision makers). According to one interviewee, the implementation strategy also must include specifying the processual phases for each new business opportunity.

Overall, the experts found the model to be a good *"diagnostic tool for evaluating new opportunities"* (using their words), and useful as a reference point for a preliminary assessment of new business opportunities in Society 5.0. The interviewees also noted that, for entrepreneurs, the proposed model is an *"interesting tool with which to confirm ideas and identify blind spots in analyses"* (also in their words), thereby promoting brainstorming and exploring unidentified opportunities.

Although the findings of our study are to some extent context-specific, it is worth reminding that our analysis system is process-oriented, and that the framework proposed should be seen as a learning mechanism and not as an end in itself or a tool to prescribe optimal solutions. Methodologically, this means that, with the necessary adjustments, the proposed procedures can be replicated in other contexts, countries and/or with different expert panels (cf. [52]).

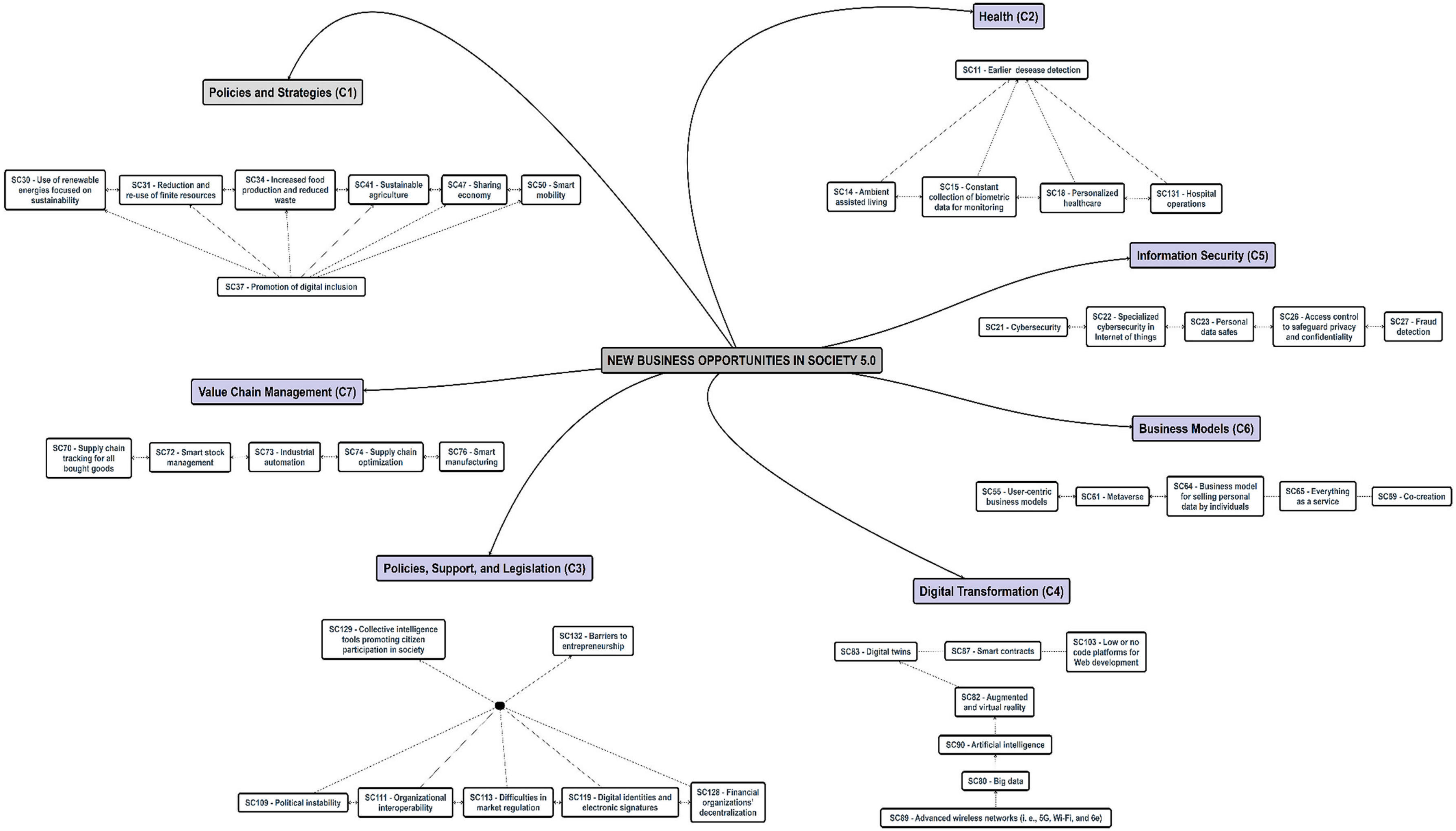

Fig. 12. ISM final model.

5. Conclusion

In the last decade, complex infrastructure and multiple digital technologies and platforms have emerged that have affected the way people live and work. This has increased the volatility created by social and economic changes. Humans' future survival depends on creating a society that can coexist with ecosystems based on advanced technologies in many areas. Thus, the Society 5.0 paradigm focuses on human beings and technology benefits in terms of individuals' welfare.

Given this challenge, the present study sought to build a simple, transparent model for detecting and developing new business opportunities in Society 5.0 contexts to enable companies to respond effectively to the changing technological and digital world in which people live. The proposed model can both empower societies and influence future innovation models that organizations may choose to implement. Technological evolution has had a strong impact on how individuals live and work, which has resulted in increased volatility due to rapid socioeconomic change. Thus, a symbiotic relationship must be fostered between societies and current high-tech ecosystems.

The Society 5.0 concept appeared in response to people's emerging empowerment and drive to use technologies to meet humanity's needs. However, the literature review conducted for this research confirmed the scarcity and methodological limitations of studies focused on this paradigm as these are exploratory or based on literature reviews. The current research sought to fill the gaps by developing a model based on experts' opinions to help companies detect and prioritize new business opportunities and to support future decision making regarding the best innovation strategies.

While addressing the three research questions initially presented (*i.e.*, *How can new business opportunities in Society 5.0 settings be identified? What are the most influential relationships between them?* and *Which new business opportunities should be given priority in decision-making processes?*), our study makes important theoretical and practical contributions to the field of technology management in general and Society 5.0 in particular. With regard to the findings, although they are idiosyncratic, they can be an important starting point for other researchers and/or practitioners hoping to identify and develop new business opportunities in Society 5.0 contexts. They can also be used as a springboard for additional studies, complementing previous contributions in the field. From a methodological perspective, our contribution is two-fold: one coming from the combination of the methods used, which we believe to be novel in Society 5.0 contexts; and, second, from the description of the process followed, which allows for replications in other contexts and/or with different expert panels, due to the process-oriented nature of the framework.

The results of the present study also make other contributions. The expert panel's cognitive map brings together 126 criteria and their respective relationships, and the model developed is simple and clearly structured. The selected methodologies integrated subjective and objective elements into the decision-making process, which helped the participants identify new business opportunities in Society 5.0, including the relevant areas of business activity. The techniques applied facilitated the construction of causality matrices between the variables and the development of a structured, hierarchical model that reflects the degree of importance of the opportunities identified based on their causal relationships. Notably, we are cognizant of other decision makers who may wish to apply cognitive mapping and ISM to their specific situation. Even though they may not understand the "process", they may desire to know our final recommendation(s). In this case, we recommend that these decision makers study both the group cognitive map and ISM diagrams (Figs. 4–12), and select the business opportunities that best fit their unique situation. We could prioritize business opportunities that may have the greatest impact for each particular context and/or suggest specific actions and initiatives. However, this would need to be done on a casuistic basis due to specific characteristics of each situation. Furthermore, although our study is process-oriented, we note that it also is realistic, particularly if we consider that it can accommodate new information at any time and that each context has specific characteristics and that will require different solutions to different situations.

The methodological limitations of the present study also need to be considered. First, subjectivity is an inherent part of the methodology applied, which was based on sharing and discussing experiences and values. Second, the expert panel defined the causal relationships, which may have introduced bias because the causal links are based on individuals' observations. Last, the final model lacks a firm definition of the most influential factors and other criteria in each cluster. Nonetheless, this research was based on a combined use of methodologies that produced a simple, practical model that can guide the formulation of new business models focused on meeting social needs.

The limitations of our study provide opportunities for future studies. Researchers can apply the same methodologies with a different group of specialists or carry out investigations concentrating on the same topic but using different multi-criteria techniques. In addition, the present results can be complemented by applying other methodologies to encourage the implementation of the proposed decision-support model. In conclusion, our evaluation system addresses social and economic needs, and thus enriches the literature due to its applicability in business environments and significant contribution to decision-making processes in Society 5.0 contexts.

Credit author statement

The authors of this paper have directly participated in the planning and execution of the study and have read and approved the final version submitted. The contents of this manuscript have not been previously published.

Data availability

Data will be made available on request.

Acknowledgments

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References

[1] K. Fukuda, Science, technology and innovation ecosystem transformation toward Society 5.0, Int. J. Prod. Econ. 220 (2019) 1–14.

[2] A. Rocha, F. Ferreira, A. Milici, N. Banaitienė, A. Banaitis, Enhancing innovation culture: the case of multinational advertising agency VMLY&R Lisboa, Technol. Econ. Dev. Econ. 28 (5) (2022) 1476–1501.

[3] V. Jafari-Sadeghi, A. Garcia-Perez, E. Candelo, J. Couturier, Exploring the impact of digital transformation on technology entrepreneurship and technological market expansion: the role of technology readiness, exploration and exploitation, J. Bus. Res. 124 (2021) 100–111.

[4] S. Lemos, F. Ferreira, C. Zopounidis, E. Galariotis, N. Ferreira, Artificial intelligence and change management in small and medium-sized enterprises: an analysis of dynamics within adaptation initiatives, Ann. Oper. Res. (2022), https://doi.org/10.1007/s10479-022-05159-4.

[5] F. Vieira, F. Ferreira, K. Govindan, N. Ferreira, A. Banaitis, Measuring urban digitalization using cognitive mapping and the best worst method (BWM), Technol. Soc. 71 (2022) 1–12.

[6] G. Vial, Understanding digital transformation: a review and a research agenda, J. Strat. Inf. Syst. 28 (2019) 118–144.

[7] F. Appio, F. Frattini, A. Petruzzelli, P. Neirotti, Digital transformation and innovation management: a synthesis of existing research and an agenda for future studies, J. Prod. Innovat. Manag. 38 (1) (2021) 4–20.
[8] J. Ferreira, C. Fernandes, F. Ferreira, To be or not to be digital, that is the question: firm innovation and performance, J. Bus. Res. 101 (2018) 583–590.
[9] M. Coccia, J. Watts, A theory of the evolution of technology: technological parasitism and the implications for innovation management, J. Eng. Technol. Manag. 55 (11) (2020) 1–18.
[10] K. Nagy, E. Hajrizi, Building pillars for adapting Society 5.0 in post-conflict countries, IFAC-PapersOnLine 52 (2019) 40–45.
[11] S. Huang, B. Wang, X. Li, P. Zheng, D. Mourtzis, L. Wang, Industry 5.0 and society 5.0: comparison, complementation and co-evolution, J. Manuf. Syst. 64 (2022) 424–428.
[12] A. Correani, A. De Massis, F. Frattini, A. Petruzzelli, A. Natalicchio, Implementing a digital strategy: learning from the experience of three digital transformation projects, Calif. Manag. Rev. 62 (4) (2020) 37–56.
[13] L. Ardito, A. Petruzzelli, U. Panniello, A. Garavelli, Towards Industry 4.0: mapping digital technologies for supply chain management-marketing integration, Bus. Process Manag. J. 25 (2) (2019) 323–346.
[14] B. D'Ippolito, A. Petruzzelli, U. Panniello, Archetypes of incumbents' strategic responses to digital innovation, J. Intellect. Cap. 20 (5) (2019) 662–679.
[15] R. Ceipek, J. Hutz, A. Petruzzelli, A. De Massis, K. Matzelr, A motivation and ability perspective on engagement in emerging digital technologies: the case of Internet of Things solutions, Long. Range Plan. 54 (5) (2021), 101991.
[16] R. Rodrigues, F. Ferreira, A. Milici, E. Carayannis, J. Ferreira, Change management and advanced wireless network implementation: detection of monetization opportunities and challenges, IEEE Trans. Eng. Manag. (2022), https://doi.org/10.1109/TEM.2022.3187650.
[17] D. Ivanov, The Industry 5.0 framework: viability-based integration of the resilience, sustainability, and human-centricity perspectives, Int. J. Prod. Res. 61 (5) (2022) 1683–1695.
[18] P. Maddikunta, Q. Pham, B. Prabadevi, N. Deepa, K. Dev, T. Gadekallu, R. Ruby, M. Liyanage, Industry 5.0: a survey on enabling technologies and potential applications, Journal of Industrial Information Integration 26 (2021) 1–19.
[19] A. Deguchi, C. Hirai, H. Matsuoka, T. Nakano, K. Oshima, M. Tai, S. Tani, What is Society 5.0? in: O. Kamimura (Ed.), Society 5.0: A People-Centric Super-smart Society Springer Open, Singapore, 2018, pp. 1–23.
[20] K. Grunwitz, The Future Is Society 5.0, vol. 8, Computer Fraud & Security, 2019, p. 20.
[21] C. Freire, F. Ferreira, E. Carayannis, J. Ferreira, Artificial intelligence and smart cities: a DEMATEL approach to adaptation challenges and initiatives, IEEE Trans. Eng. Manag. 70 (5) (2023) 1881–1899.
[22] B. Arthur, The Nature of Technology. What it Is and How it Evolves, Allen Lane–Penguin Books, London, 2009.
[23] S. Ghosh, M. Hughes, I. Hodgkinson, P. Hughes, Digital transformation of industrial businesses: a dynamic capability approach, Technovation 113 (2021) 1–18.
[24] D. Mourtzis, Design and Operation of Production Networks for Mass Personalization in the Era of Cloud Technology, Elsevier, London, 2021.
[25] T. Sawaragi, Y. Horiguchi, T. Hirose, Design of productive socio-technical systems by human-system co-creation for super-smart society, IFAC-PapersOnLine 53 (2020) 10101–10108.
[26] K. Demir, G. Döven, B. Sezen, Industry 5.0 and human-robot co-working, Proc. Comput. Sci. 158 (2019) 688–695.
[27] E. Carayannis, F. Ferreira, P. Bento, J. Ferreira, M. Jalali, B. Fernandes, Developing a socio-technical evaluation index for tourist destination competitiveness using cognitive mapping and MCDA, Technol. Forecast. Soc. Change 131 (2018) 147–158.
[28] R. Foresti, S. Rossi, M. Magnani, C. Guarino Lo Bianco, N. Delmonte, Smart society and artificial intelligence: Big Data scheduling and the global standard method applied to smart maintenance, Engineering 6 (2020) 835–846.
[29] K. Nagy, E. Hajrizi, L. Palkovics, Responsible innovation in support of Society 5.0: aspects of audit and control, IFAC-PapersOnLine 53 (2020) 17469–17474.
[30] D. Broo, O. Kaynak, S. Sait, Rethinking engineering education at the age of Industry 5.0, Journal of Industrial Information Integration 25 (2021) 1–8.
[31] M. Doyle-Kent, P. Kopacek, Adoption of collaborative robotics in Industry 5.0. An Irish industry case study, IFAC-PapersOnLine 54 (2021) 413–418.
[32] J. Rosenhead, J. Mingers, Rational Analysis for a Problematic World Revised, John Wiley Publisher, Chichester, 2001.
[33] F. Andrade, F. Ferreira, R. Correia, Ranking residential neighborhoods based on their sustainability: a CM-BWM approach, Int. J. Strat. Property Manag. 26 (6) (2022) 410–423.
[34] F. Ferreira, Multiple Criteria Evaluation of Bank Branches: Decision Analysis Models and Applications, University of Algarve Press, Faro, 2011.
[35] M. Marttunen, J. Lienert, V. Belton, Structuring problems for multi-criteria decision analysis in practice: a literature review of method combinations, Eur. J. Oper. Res. 263 (2017) 1–17.
[36] J. Mingers, J. Rosenhead, Problem structuring methods in action, Eur. J. Oper. Res. 152 (2004) 530–554.
[37] R. Soares, F. Ferreira, F. Teixeira, N. Ferreira, A multicriteria evaluation system for large real estate investments, Int. J. Strat. Property Manag. 26 (4) (2022) 305–317.
[38] R. Keeney, Value-focused thinking: identifying decision opportunities and creating alternatives, Eur. J. Oper. Res. 92 (1996) 537–549.
[39] F. Ferreira, S. Santos, P. Rodrigues, From traditional operational research to multiple criteria decision analysis: basic ideas on an evolving field, Probl. Perspect. Manag. 9 (3) (2011) 114–121.
[40] C. Eden, Analyzing cognitive maps to help structure issues or problems, Eur. J. Oper. Res. 159 (3) (2004) 673–686.
[41] F. Ackermann, C. Eden, Strategic options development and analysis, in: M. Reynolds, S. Holwell (Eds.), Systems Approaches to Managing Change: A Practical Guide, Springer London, United Kingdom, 2010, pp. 135–190.
[42] A. Vaz, F. Ferreira, L. Pereira, R. Correia, A. Banaitis, Strategic visualization: the (real) usefulness of cognitive mapping in smart city conceptualization, Manag. Decis. 60 (4) (2022) 916–939.
[43] J. Warfield, Developing interconnection matrices in structural modeling, IEEE Transactions on Systems, Man, and Cybernetics 4 (1) (1974) 81–87.
[44] I. Khan, Z. Rahman, Brand experience anatomy in retailing: an interpretive structural modeling approach, J. Retailing Consum. Serv. 24 (2015) 60–69.
[45] R. Raut, B. Gardas, M. Jha, P. Priyadarshinee, Examining the critical success factors of cloud computing adoption in the MSMEs by using ISM model, J. High Technol. Manag. Res. 28 (2017) 125–141.
[46] F. Tamtam, A. Tourabi, Interpretive structural modeling of supply chain leagility during COVID-19, IFAC-PapersOnLine 54 (2021) 12–17.
[47] M. Ghobakhloo, M. Fathi, Industry 4.0 and opportunities for energy sustainability, J. Clean. Prod. 295 (2021) 1–16.
[48] M. Fathi, M. Ghobakhloo, A. Syberfeldt, An interpretive structural modeling of teamwork training in higher education, Educ. Sci. 9 (2019) 1–18.
[49] S. Warshall, A theorem on Boolean matrices, Journal of the Association for Computing Machinery 9 (1962) 11–12.
[50] N. Ahmad, A. Qahmash, SmartISM: implementation and assessment of interpretive structural modeling, Sustainability 13 (16) (2021) 8801.
[51] C. Eden, F. Ackermann, SODA – the principles, in: J. Rosenhead, J. Mingers (Eds.), Rational Analysis for a Problematic World Revisited: Problem Structuring Methods for Complexity, Uncertainty and Conflict, John Wiley & Sons, United Kingdom, 2001, pp. 21–41.
[52] S. Bell, S. Morse, Groups and facilitators within problem structuring processes, J. Oper. Res. Soc. 64 (7) (2013) 959–972.