Digital sustainable business model innovation: applying dynamic capabilities approach (DSBMI-DC)

Nastaran Hajiheydari, Mohammad Kargar Shouraki, Hamed Vares and Ayoub Mohammadian

Abstract

Purpose – *How to respond to social and environmental concerns while pursuing economic goals remained a dilemma for today's businesses. Besides, the digital revolution has profoundly changed people's lifestyles, turning out the challenge of how to present products and services to the new generations of consumers through emerging digital channels. To overcome these challenges, a business needs to rely on its internal capabilities but must make them dynamic and modify them, when necessary, in response to or anticipation of external changes. This study aims to propose a model for business model innovation (BMI) with the goal of pursuing sustainability and adapting to the changes of the digital age pursuing dynamic capabilities principles.*

Design/methodology/approach – *This study followed a mixed-method design, using meta-synthesis in its first phase (qualitative) and interpretive structural modelling in its second phase (quantitative).*

Findings – *The proposed model consists of four layers including approach, aspect, dimension and component. Based on quantitative results, the 16 dimensions were categorised in four main levels of "sustainable computing", "sustainable execution", "sustainable engagement" and "sustainable results". Considering sustainability and digital transformation as main change drivers for contemporary businesses, this paper proposes a novel framework in the field of BMI.*

Originality/value – *The results of this study suggest that BMI requires not only proper business design based on social and environmental sustainability and digital transformation requirements but also attention to a new component called sustainable engagement, which represents the need for engaging with social and environmental issues in addition to customers.*

Keywords *Business model innovation, Sustainability, Digital transformation, Dynamic capabilities*

Paper type *Research paper*

1. Introduction

Contemporary businesses are increasingly forced to re-think their business model innovation (BMI). This trend is from three major dilemmas:

1. the challenge of achieving sustainability in business practices (Romero *et al.*, 2021; Jørgensen and Pedersen, 2018);
2. the challenge of digital transformation of business environments and the emergence of technological opportunities; and
3. changes in customer lifestyle and preferences due to the previous two challenges (Jørgensen and Pedersen, 2018).

Today's businesses are expected to have a proper response to social and environmental issues as well as the economic expectations of their shareholders (Geissdoerfer *et al.*, 2018;

Nastaran Hajiheydari is based at Sheffield University Management School, The University of Sheffield, Sheffield, UK and University of Tehran, Tehran, Iran. Mohammad Kargar Shouraki is based at Department of Business Administration, Faculty of Management, University of Tehran, Tehran, Iran and Department of IT Management, Faculty of Management, University of Tehran, Tehran, Iran. Hamed Vares is based at Department of Business Administration, Faculty of Management, University of Tehran, Tehran, Iran. Ayoub Mohammadian is based at Department of IT Management, Faculty of Management, University of Tehran, Tehran, Iran.

Received 7 August 2021
Revised 29 March 2022
Accepted 29 March 2022

The authors sincerely thank Professor Ozcan Saritas, the editor in chief; and gratefully acknowledge two anonymous reviewers for their constructive and helpful suggestions.

Aluchna and Rok, 2018). Thus, sustainable business models (BM) have become increasingly popular in the first two decades of the 21st century with the vision of realizing sustainable development strategies and endeavours (Szromek, 2021). Moreover, many international stock exchanges and even some smaller exchanges have passed regulations that force companies to publish performance reports on the sustainability of their business. For example, sustainability reports have become mandatory for companies in the Singapore Exchange since 2011, the Toronto Stock Exchange since 2014, the Hong Kong Stock Exchange since 2015 and over 6,000 European companies since 2017.

Research also supports this claim that sustainable capabilities positively influence companies' operational outcomes, lower capital costs, improve performance and increase stock value. After reviewing 190 empirical studies on sustainability, researchers reported that by paying attention to their value chains and economic practices, sustainable BMs would help companies operate in line with their promises to customers and push them to innovate to create economic, social and environmental value (Bocken *et al.*, 2014). We thus suggest that sustainability is a major requirement for any business or organization that seeks to adapt to today's ever-changing business environment. As a result, giving proper response to social, environmental and economic challenges has become a major strategic concern for business in the 21st century (Geissdoerfer *et al.*, 2018; Aluchna and Rok, 2018; Nosratabadi *et al.*, 2019).

Pioneers in sustainability have made the concern for environmental and social issues a feature of their products and services, thereby transforming this challenge into a sustainable competitive advantage (Eikelenboom and de Jong, 2019). They have attempted to create a sustainable BM by focusing less on short-term profit maximization and more on creating long-term value for all stakeholders, which of course needs fundamental changes in how they conduct business, reflecting their attention to social and environmental issues in addition to economic performance (Geissdoerfer *et al.*, 2018; Bocken *et al.*, 2019). Recently, research has also made a great effort to investigate sustainable BMs. Indeed, advocacy for sustainable BMs is increasing thanks to growing support for mitigating the adverse environmental impacts of production–consumption systems as well as their social consequences (Bergmann and Utikal, 2021).

Due to different business and regulation trends, managers are now interested in questions like how they can achieve sustainability and what would be a good BM for creating a sustainable and profitable business (Jørgensen and Pedersen, 2018; Brenner, 2018; Clinton and Whisnant, 2019). Many companies around the world have embraced this concept, successfully leveraging it for economic success and competitive advantage. While sustainability may mean differently to different people, many business leaders have realized that sustainable BMs and business sustainability practices can make their companies more competitive in the emerging global economy (Hajiheydari *et al.*, 2019).

Besides suitability, another business challenge of the 21st century is how to respond to the impact of transformative technologies and seize the resulting business opportunities. Since the turn of the century, the advancement of digital technologies has created a need to constantly review and innovate in BMs (Aagaard *et al.*, 2019). As a result, many businesses and industries are undergoing wide-ranging changes in response to global digitalization (Ukko *et al.*, 2019). Digital technologies have had a profound impact on the BM of many industries by fundamentally changing how they conduct business, a change that has led to disruptive innovation in BMs (Gupta, 2018; Johnson, 2018). We refer to the fundamental changes caused by fast technological developments of recent decades as "digital transformation" (Kotarba, 2018). Simply put, digital transformation means the use of new digital technologies to improve business by enhancing customer experience, simplifying operations or creating new BMs. It thus aims at modification (or adaptation) of BMs in response to or anticipation of changes in consumer behaviours and preferences due to fast technological advancement and innovation (Kotarba, 2018). Successful companies (like

Apple) often excel in using these technologies to find new ways to create value for their customers (Warner and Wäger, 2019).

However, the key to the successful adoption of emerging technologies is to revolutionize the BM to achieve an unprecedented increase in the depth and speed of innovation (Brenner, 2018). The use of "transformation" term rather than "change" emphasizes that an organization's digital transformation goes beyond the functional dimension, encompassing all actions that should be taken to make the most of the opportunities created or avoid the threats posed by digital technologies (Warner and Wäger, 2019). Therefore, we argue that just adding a digital component to an existing business will not revolutionize that business. New technology only makes room for innovation in the BM and must be viewed as a driving factor for a business transformation (Johnson, 2018), generating new value creation options at strategic levels (Gupta, 2018). Moreover, digital transformation has changed the lifestyle of customers, and businesses must try to present their values to new generations of consumers in novel and more attractive ways, responding to their needs through BMI (Jørgensen and Pedersen, 2018). Overall, in the digital age, the success of many traditional businesses depends on how well they adapt digital technologies, thus, it becomes a top priority to develop new BMs based on emerging disruptive technologies (Tesch, 2019).

Research has shown that the capacity to use digital technologies is one of the key determinants of success in achieving sustainable development (Aluchna and Rok, 2018). Therefore, to achieve BMI, a business needs to ensure proper alignment between its digitalization efforts and its sustainability measures (Aluchna and Rok, 2018; Eikelenboom and de Jong, 2019; Hajiheydari *et al.*, 2019 and Parida *et al.*, 2019). But how and with what kind of capabilities a company can renovate its BM so that it takes into account social and environmental issues as well as economic factors while maintaining enough dynamism to properly respond to rapid changes of the digital age (Brenner, 2018; Leleux and Van der Kaaij, 2018).

Furthermore, because a sustainable BM may lose its innovation over time, a business or organization may need to continuously make internal changes to ensure proper integration or adaptation to the external environment. Therefore, the sustainability and lifespan of BMs also depend on the dynamic capabilities of the business (Teece, 2018). Dynamic capabilities even contribute to the acceleration of BMI in businesses (Lin *et al.*, 2020). Unlike conventional capabilities, dynamic capabilities are responsible for reconfiguring and transforming static resources, knowledge and competencies into innovative products and processes in response to or anticipation of changes in the external environment (Clauss *et al.*, 2019). To create and maintain a successful BM, a business will need a set of such capabilities to help it adjust the components of the model to fit the changing environment (Inigo *et al.*, 2017). Research has shown that dynamic capabilities also help a business make the best use of digital transformation opportunities (Obaya *et al.*, 2020). Thus, we suggest that to achieve innovation in sustainable BMs in the digital age, it is necessary to examine how dynamic capabilities can also be used for this purpose (Teece, 2018). The ability of a business to implement, configure and improve its BM through innovation is a factor of its dynamic capabilities. Therefore, managers need to identify the resources and capabilities that are necessary for their line of business and rebuild or renovate their BMs when needed to gain and retain competitive advantage (Teece, 2018; Khodaei and Ortt, 2019).

This study thus aims to provide a model for sustainable BM innovation based on previous classical models for better adaptation to digital developments using the dynamic capabilities approach. Shakeel *et al.* (2020) and Cantele *et al.* (2020) have proposed a framework for sustainable BMs and we know the concepts of digital transformations BM based on Verhoef *et al.* (2021) and Parida *et al.* (2019) works. In addition, Sniukas (2020) and Teece (2018) have introduced BMI as a dynamic capability. However, the research still lacks an innovative framework for achieving sustainability through digital transformation,

following dynamic capabilities principles. We believe that such an integrated framework can propose insights needed for pursuing sustainability considering external changes such as digital revolutions while incorporating internal dynamic capabilities. Therefore, the main goal of this study is to propose a model for developing sustainable BMs in which external factors (digital technologies) and internal factors (dynamic capabilities) are considered. Accordingly, the study pursues the three following objectives:

1. identifying the key factors of "business model innovation", "sustainability", "dynamic capabilities" and "digital age";
2. determining the associations between these factors and ranking them in terms of their importance in the four aspects of "business model innovation", "sustainability", "dynamic capabilities" and "digital age"; and
3. developing an integrative framework for BMI with regard to "sustainability", "dynamic capabilities" and "digital age" factors.

2. Research background

This section first discusses the theories related to the main elements of our study and then concentrates on the theoretical background of each element. There are several theories in relation to the BM concepts. The list of dominant theories in this field is presented in Table 1.

Because all main concepts of the research conform to the resource-based theory (see Table 1), it is considered as the base theory for this study. We also build up on the dynamic capabilities' theory as the second theoretical level of the research to support dynamic capabilities approach. Network and digital transformation theories are considered as the third theoretical level of the research. Thus, in the next section, we discussed the application of these theories in the digital dimension and the application of digital transformation theory in other dimensions such as BM, sustainability, and dynamics capabilities. One of the goals of this research is to facilitate developing a sustainable digital capability for a BM, which has been mainly overlooked in previous studies despite its importance for the success and sustainability of businesses in the digital era.

According to Figure 1, the main theoretical lens that we used is rooted in the resource-based view with a focus on dynamic capabilities that is well-developed to be responsive to the changes that are introduced by the digital transformation approach.

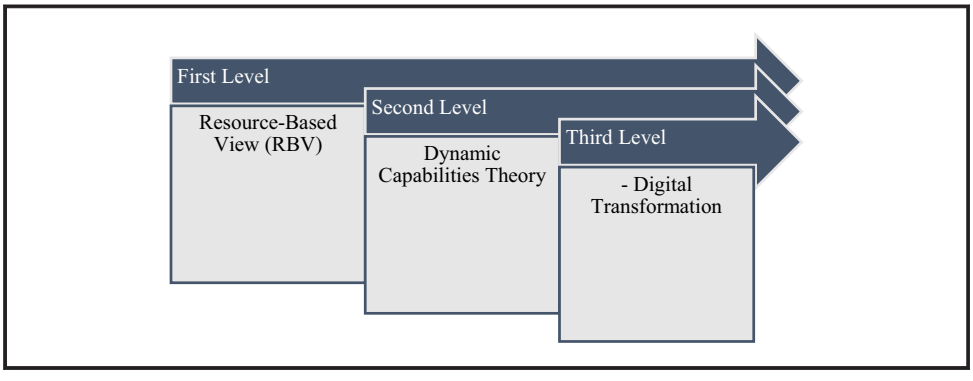
A BM describes the logic of how companies do business and their ability to create, deliver and capture value (Teece, 2018). Nowadays, the BM concept is an important foundation for business innovation and commercialization of digital technologies (Teece, 2018). Research has shown that the most important factors affecting the BMI are sustainability, digital transformation and dynamic capabilities. To the best of our knowledge, no research has focused on the links between these three factors and how they are related to BMI. The two main drivers of movement towards business sustainability are social and environmental pressures from consumers and the digitalization developments; two issues that have a fundamental impact on all businesses. Meanwhile, to successfully transform these challenges into opportunities, according to the resource-based theory, businesses need to rely on their own resources to develop their dynamic capabilities. Therefore, considering all factors of sustainability, digital transformation and dynamic capabilities are of vital importance for our understanding of the business's success in this field.

Despite the breadth of literature on BM and BMI, the theoretical foundations of sustainable business model innovation (SBMI) are still in their infancy and there is no consensus among researchers on how to conceptualize SBMI (Geldres-Weiss *et al.*,

Table 1 Prominent theories in relation to the main concepts of this study

Title	*Business model*	*Sustainability*	*Digital transformation*	*Dynamics capabilities*
Theory	Dynamic capabilities theory Resource-based view Business strategy theory Strategic network theory	Strategic choice theory Social network theory Resource-based view Social network theory	Digital transformation Resource-based view Dynamics capabilities	Resource-based view Knowledge-based view Network theory
Reference	Parida *et al.* (2019), Sniukas (2020); Čirjevskis (2019); Lüdeke-Freund (2020); Hu *et al.* (2019), VoDoVoZ and MaY (2017); Ghezzi and Cavallo (2020)	Jabłoński (2019); Lüdeke-Freund (2020); Hu *et al.* (2019)	Nwaiwu (2018), Caputo *et al.* (2021); Nadkarni and Prügl (2021)	Vicente *et al.* (2018), Andresen (2020)

Figure 1 Order of the theories used in the research



2021). However, the global-scale disaster (COVID-19 pandemic) and its consequent financial crisis and the intensification of long-anticipated environmental disasters (climate change) have pushed companies more than ever to revise their BM to generate maximum shared value for all of their stakeholders. To achieve this goal, companies have no other choice rather than to innovate their BMs (Muhic and Bengtsson, 2019). The research background of related concepts is discussed in Section 2.1.

2.1. Business model innovation

According to Foss and Saebi (2017), while there is extensive literature on BM, what drives BM into BMI is still unclear (Geldres-Weiss *et al.*, 2021). BM can be described as a tool for innovation to improve economic performance and gain a competitive advantage (Teece, 2018). Kuratko *et al.* (2011) also suggest that to maintain a competitive advantage in a turbulent business environment, BM needs to be non-static and it is necessary to modify corporate operations for continuous improvement. Hence, to compete in today's dynamic global markets, companies are constantly adapting, reorganizing and redefining their business (Geldres-Weiss *et al.*, 2021). The foundation of BMI is the need for change in company structure for value proposition, creation, delivery and capture (Geissdoerfer *et al.*, 2018). BMI enables a company to develop capabilities to adapt to a changing business environment. According to Zott *et al.* (2011), BMI offers a more specific change in the customer value proposition, and it goes beyond just changing products and processes (Geldres-Weiss *et al.*, 2021).

2.2. Sustainable business model

There are very diverse opinions on the conceptualization of "sustainable business model" (Geissdoerfer *et al.*, 2018; Muhic and Bengtsson, 2019). Goni *et al.* (2017) argue that this diversification is rooted in the fact that sustainability-related issues have been becoming more common and frequent over the past decades. Similarly, Chofreh *et al.* (2018) discuss that the pervasive problems of depletion of water resources, air pollution, low human development, slow economic growth and climate change have utterly confused and dumbfounded policymakers, academics and experts. Researchers claim that governments need to respond to such problems by imposing restrictive regulations on businesses to force them to move towards sustainability (Geldres-Weiss *et al.*, 2021). However, Schaltegger *et al.* (2012) state that creating a sustainable BM means volunteering to help solve social or environmental problems while making a profit (Velter *et al.*, 2020).

2.3. Sustainable business model innovation

The purpose of the SBMI is to develop a new BM or modify the components of an existing BM to address the sustainability-related concerns of stakeholders while creating a long-term sustainable competitive advantage (Geldres-Weiss *et al.*, 2021). Literature has previously introduced SBMI as a potent solution to gain competitive advantage while simultaneously solving a social or environmental problem. It thus develops a blueprint for change in the way of doing business by considering social and environmental concerns in the main business operations. SBMI discusses whether it is possible to improve the positive effects or alleviate the negative effects of a business on society and the environment. For such efforts to be effective, it is necessary to change the form of value proposition, value network and value capture (Bocken *et al.*, 2019).

Therefore, a company should seriously seek to create positive social and environmental values and optimize them for itself as well as a wider network of stakeholders including the society and the environment (Bocken *et al.*, 2019).

2.4. Sustainable business model innovation in the digital age

The concept of the BM in business and management literature was first used to understand the effects and changes caused by information technology (e.g. the internet) on how companies do business after 2000 (Kotarba, 2018). The impact of digital technologies on people's lifestyles is also undeniable. Pervasive technological innovations not only protect the environment and reduce pollution but also improve social equality and justice by providing equal and transparent access to limited resources (Brenner, 2018).

Since the start of this digital era, the variety of BMs and the need for developing sustainable BMs have increased more than ever. The concept of "digital transformation" has emerged in recent decades in response to the development and widespread impact of digital technologies on businesses. Digital transformation is discussed as a new paradigm in doing business, aligned with modification or innovation in business processes and models while revising the approaches to social behaviours and customer experience (Fellenstein and Umaganthan, 2019). We thus in this study reflect on the concept of digital transformation which is concerned with the changes digital technologies can bring about in a company's BM, resulting in transformative changes in company products, structure and processes (Warner and Wäger, 2019).

2.5. Sustainable business model innovation in the digital age and dynamic capabilities

In a rapidly changing world with fast technological developments, any company that seeks to gain and maintain its competitive advantage while addressing a social or environmental

issue needs to rely on its enhanced internal capabilities. Therefore, an important related notion for a competitive business is dynamic capabilities, which result from the combination of management, learning and reconfiguration processes. For this purpose, the company needs to carefully monitor and analyze its environment to identify changes and new trends and then reconfigure itself with anything that it might need to gain a competitive advantage in the new environment (Vicente *et al.*, 2018)

Teece (2007) describes dynamic capabilities as the ability to sense, recognize and measure change, seize, capture and acquire value, and ultimately make reforms and reconfigurations that are necessary for designing, implementing and innovating in the BM. According to Teece (2018), creating dynamic capabilities helps the company identify opportunities, muster resources for development, revise parts of its BM, and change its organizational structure and culture (Muhic and Bengtsson, 2019). Therefore, businesses need to focus on how to use dynamic capabilities for introducing digital transformation and innovation to their BMs (Fellenstein and Umaganthan, 2019). Current literature has considered one of the three concepts of sustainability, digital transformation or dynamic capabilities at a time without considering the effects of the other concepts or how they interact with each other. To fill this gap, our study focuses on the conceptualization of all three concepts of sustainability, digital transformation and dynamic capabilities and their interactions in the context of BMI.

3. Methodology

This study is designed based on an exploratory mixed research approach through a two-stage exploration plan for using the results of the qualitative method for driving the quantitative step. In this study, we first collected and analysed the qualitative to discover and identify the phenomenon under study (here: sustainable BMI in the digital age). Then, in the quantitative phase, we explained the relationship between the components of this phenomenon by collecting quantitative data. The reasons for choosing the combined exploratory research method for the present study are:

- Extracting the dimensions of a sustainable BM in the digital age with a dynamic capabilities approach requires a review of the latest scholarly findings (qualitative stage: meta-synthesis and content analysis).
- Lack of a comprehensive model of sustainable business considering the digital age and dynamic capabilities necessitates collaboration with experts in this field through interpretive structural modelling (ISM) approach (quantitative step).

The main purpose of this study is to propose a framework for sustainable BMI in the digital age. We thus followed the exploratory mixed research methodology to first, obtain more and better evidence from reliable sources to better understand the links between "business model innovation", "sustainability", "dynamic capabilities" and "digital age". This study tries to fill the gaps in the current literature that does not support our understanding of SBMI with attention to external factors (digital transformation) as well as internal dynamic capabilities. In the second phase, the interdisciplinary nature of the research subject calls for a discussion among experts from different fields to cover all aspects of the subject and work towards a consensus.

This study deploys the meta-synthesis method to search for relevant written sources (articles) and the content analysis method to analyse the qualitative data extracted from the texts. In the qualitative phase, we reviewed text to organize and cluster concepts, recognize themes and develop sub-themes. Meta-synthesis is considered as an integrative method for qualitative synthesis which is applied to integrate, evaluate and interpret the findings of multiple qualitative studies to transform individual findings into conceptualizations and interpretations (Peñarroya-Farell and Miralles, 2021). Therefore, in this study, qualitative

meta-synthesis is applied for systematically reviewing qualitative studies with a common focus. Scholars can re-analyse and interpret current qualitative studies through this method to produce fresh and synthesised findings (Gümüş *et al.*, 2021).

In the quantitative phase, the results of the previous step were used to make a series of interpretations and inferences. In this phase, we followed ISM to further assess the aforementioned interactions and determine the level to which each concept should belong in the model. ISM is a logical mathematically derived methodology aimed at representing a complex phenomenon comprising the interrelated variables through a systematic process. It follows structural modelling of interconnected matrices to specify relationships between variables based on the experts' judgments (Hajiheydari *et al.*, 2021). It ultimately helps researchers to transform the vague and inadequately articulated rational representation of systems (here SBMI) into a visible and well-structured model (the research findings). The ISM can explain a complicated interrelation between factors explicitly in a hierarchy (Mandal and Deshmukh, 1994; Wu *et al.*, 2015; Hajiheydari *et al.*, 2021; Kim *et al.*, 2018).

In this study, we deployed the seven-step method meta-synthesis of Sandelowski and Barroso (2006), described as follows.

3.1 Step 1: formulating the review question

For starting the meta-synthesis, we answered the questions of what, who, when and how:

Q1. The main objective of the research is to identify the activities and capabilities needed to innovate in a sustainable business model in the digital age (what?).

Q2. The population of the research comprises all experimental and theoretical studies in Science Direct, Scopus, Web of Science and ProQuest (who?).

Q3. The review intends to cover all experimental and theoretical studies published in target databases in the field of sustainable business model innovation from 2010 to 01/04/2020 (when?).

Q4. The review uses the criteria shown in Table 2 to decide which studies should be included in or excluded from the research (how?).

3.2 Step 2: systematic search

Based on the inclusion and exclusion criteria (Table 2), the keywords of interest were chosen according to the subject (Table 3). Because the purpose of the study was to investigate those aspects of sustainability, digital age and dynamic capabilities that are related to and would affect the BM, the term "business model innovation" was the main keyword.

The search for the above terms in the title, abstract and keywords of the articles published in Science Direct, Scopus, Web of Science and ProQuest revealed 254 articles, which after removing duplicates, decreased to 131 unique articles.

Table 2 Inclusion and exclusion criteria of the research

Criteria	*Inclusion*	*Exclusion*
Language	English	Non-English
Date of publication	01/01/2010–01/04/2020	Before 01/01/2010 or after 01/04/2020
Research subject	Business model innovation, sustainability, digital age, dynamic capabilities	Other
Research type	Article, dissertation, book chapter	Other (news, reports, etc.)

Table 3 Keyword selection

No.	Keyword selection
1	Business model innovation & sustainable
2	Business model innovation & digital transformation
3	Business model innovation & dynamic capabilities
4	Business model innovation & digital transformation & dynamic capabilities
5	Business model innovation & sustainable & digital transformation
6	Business model innovation & sustainable & dynamic capabilities
7	Business model innovation & sustainable & digital transformation & dynamic capabilities

3.3 Step 3: screening and selecting appropriate sources

We then performed the screening process in four stages (Figure 2). In the last stage of screening, the Critical Appraisal Skills Program (CASP) was used to evaluate the quality of sources. At this stage, the tools of CASP helped the researcher determine the accuracy, validity and significance of the sources. As shown in Figure 2, ultimately 11 of the 40 sources that had reached this stage were removed, leaving 29 articles for the final review.

3.4 Step 4: extraction of findings

In this step, the 29 selected sources underwent an in-depth thematic analysis, involving repeated reviews using the content analysis method. As shown in Figure 3, "business model innovation" and "sustainability" were more frequently discussed in these sources than other concepts. The content analysis performed at this step yielded 84 initial codes, the results of which are presented in Section 4.

3.5 Step 5: analysis and synthesis of qualitative findings

In this step, we reviewed the 84 initial codes twice and interpreted them (by two first authors) to ultimately extract 3 approaches, 4 aspects, 16 dimensions and 37 components (Table 4).

Figure 2 Source screening process

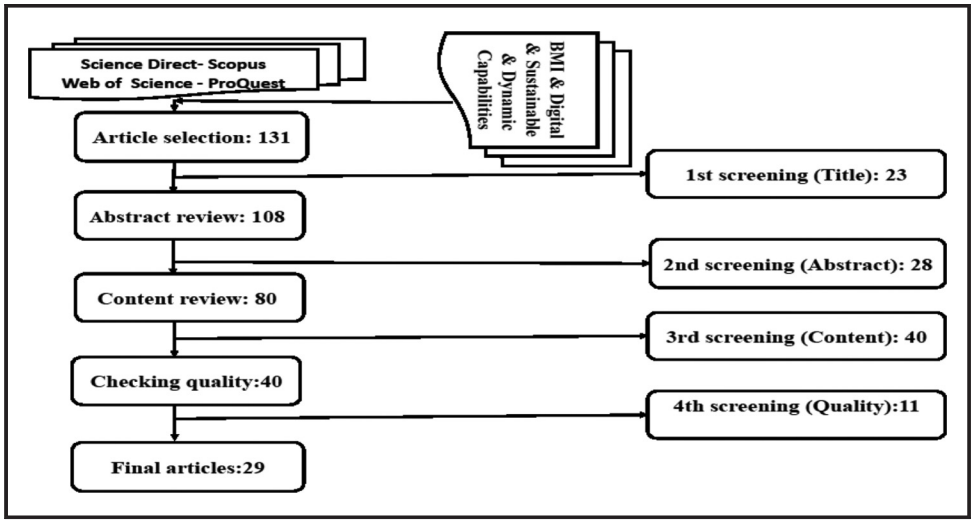
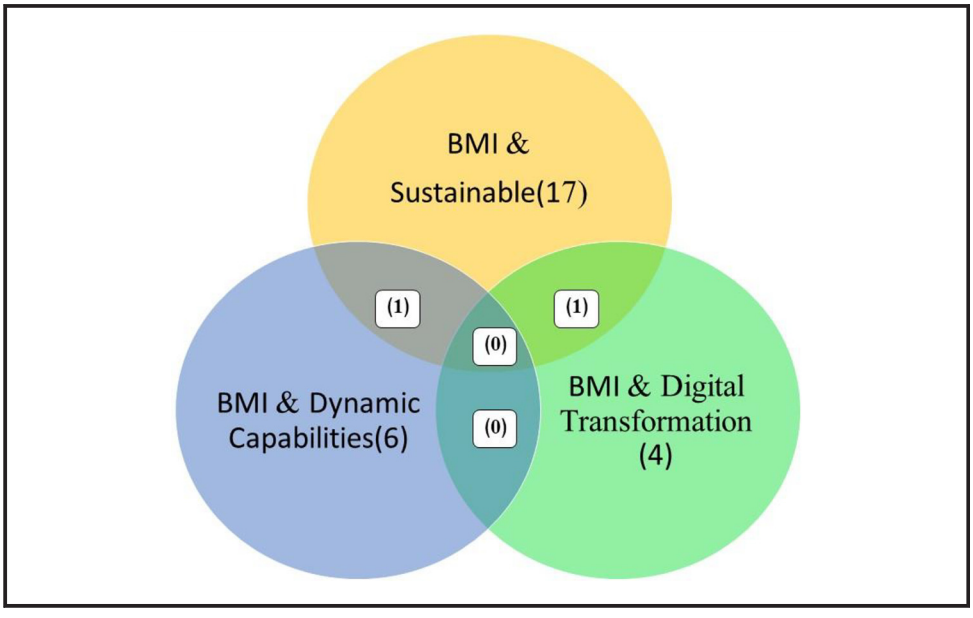


Figure 3 Number of final sources discussing each core concept of the research subject



3.6 Step 6: quality control

For reliability assessment, a business management expert with relevant academic experience (the third author) performed encoding and code categorization. We then compared the resulting aspects and dimensions with those obtained in the previous step. We calculated the kappa index based on the number of similar and dissimilar concepts (dimensions), resulting in the kappa index of 0.707, confirming the validity of these results. To establish the validity of the process, we then collected the opinions of a group of experts consisting of nine university professors with PhD qualifications. content validity ratio was used to assess the validity of dimensions. The validity of the questionnaire was assessed using the content validity index, based on which all 16 dimensions were found to be valid with a score of over 0.7.

3.7 Step 7: presentation of meta-synthesis findings

In this step, we finalized the model dimensions and classes, sequence and links of approaches, aspects, dimensions and components, and the links between them (Section 4).

4. Research findings

4.1. Findings of the qualitative study: meta-synthesis results

A summary of the results of the meta-synthesis and content analysis conducted in the first phase of the research is presented in Table 4.

4.2. Findings of the quantitative study: interpretive structural modelling

After finalizing 16 dimensions in the qualitative phase, in the second study, we determined the links between them through ISM. For this purpose, we selected 18 experts with PhD qualifications and sufficient knowledge and experience in this subject, through snowball sampling to complete the matrix questionnaires of ISM.

Table 4 Sequence of links between approaches, aspects, dimensions and components (in three parts A, B and C)

Approach	*Perspective*	*Dimension*	*Component*	*Reference*
A) Approach 1: the ability to sense and recognize changes – drivers of sustainable digital value creation				
Digital Sustainable sensing capabilities	Sustainable computing	Business computing	Understanding customer value	Gil-Gomez *et al.* (2020), Velter *et al.* (2020); Geissdoerfer *et al.* (2018), Ghezzi and Cavallo (2020); Karlsson *et al.* (2018), Yang *et al.* (2017); Frank *et al.* (2019); Čirjevskis (2019); VoDoVoZ and MaY (2017), Vicente *et al.* (2018)
			Customer relationship	Gil-Gomez *et al.* (2020), Ghezzi and Cavallo (2020); Yang *et al.* (2017), Frank *et al.* (2019); Čirjevskis (2019); VoDoVoZ and MaY (2017); França *et al.* (2017); Paiola and Gebauer (2020)
			External scan	Ghezzi and Cavallo (2020), VoDoVoZ and MaY (2017); Paiola and Gebauer (2020), Shakeel *et al.* (2020); Rachinger *et al.* (2019), Best *et al.* (2021); Inigo *et al.* (2017)
			Internal scan	Ghezzi and Cavallo (2020), VoDoVoZ and MaY (2017); Paiola and Gebauer (2020), Shakeel *et al.* (2020); Rachinger *et al.* (2019), Best *et al.* (2021); Inigo *et al.* (2017)
		Social computing	Society analysis	Shakeel *et al.* (2020), Baldassarre *et al.* (2017); De Silva *et al.* (2019)
			Social advocacy	Shakeel *et al.* (2020), Baldassarre *et al.* (2017); Hu *et al.* (2019)
		Green computing	Environmental analysis	Shakeel *et al.* (2020), Baldassarre *et al.* (2017); De Silva *et al.* (2019); Lüdeke-Freund *et al.* (2018)
			Environmental advocacy	Shakeel *et al.* (2020), Baldassarre *et al.* (2017); Hu *et al.* (2019)
		Digital technologies	Development of generation of four industries	Frank *et al.* (2019), Paiola and Gebauer (2020); Rachinger *et al.* (2019), Parida *et al.* (2019); Oskam *et al.* (2021)
			Computing transformation	Frank *et al.* (2019), Paiola and Gebauer (2020); Hu *et al.* (2019), Parida *et al.* (2019); Vicente *et al.* (2018)
B) Approach 2: the ability to capture and seize opportunities – re-designing sustainable digital values				
Approach	Perspective	Dimension	Component	Reference
Digital Sustainable seizing capabilities	Re-design values (Digital/ Sustainable)	Value agility	Innovation	Gil-Gomez *et al.* (2020), Frank *et al.* (2019); Shakeel *et al.* (2020), Inigo *et al.* (2017); Lüdeke-Freund (2020); Parida *et al.* (2019), Barth *et al.* (2017); Cantele *et al.* (2020)
			Ambidexterity	Gil-Gomez *et al.* (2020), Geissdoerfer *et al.* (2018); Čirjevskis (2019); Shakeel *et al.* (2020), Best *et al.* (2021); Inigo *et al.* (2017), De Silva *et al.* (2019); Vicente *et al.* (2018), Bocken and Geradts (2020)
		Capture value	Cost	Shakeel *et al.* (2020), Best *et al.* (2021); Hu *et al.* (2019), Oskam *et al.* (2021); Vicente *et al.* (2018), Bocken and Geradts (2020); Barth *et al.* (2017), Cantele *et al.* (2020); Madsen (2020)
			Income	Geissdoerfer *et al.* (2018), Shakeel *et al.* (2020); Best *et al.* (2021), Hu *et al.* (2019); Oskam *et al.* (2021), Vicente *et al.* (2018); Bocken and Geradts (2020), Barth *et al.* (2017); Cantele *et al.* (2020), Madsen (2020)
		Value delivery	Value network	Gil-Gomez *et al.* (2020), Velter *et al.* (2020); Geissdoerfer *et al.* (2018), Hu *et al.* (2019); Barth *et al.* (2017)
			Distribution channels	Gil-Gomez *et al.* (2020), VoDoVoZ and MaY (2017); Bocken and Geradts (2020)
		Value creation	Activities	VoDoVoZ and MaY (2017), Best *et al.* (2021); Hu *et al.* (2019), Vicente *et al.* (2018); Bocken and Geradts (2020)
			Resources	VoDoVoZ and MaY (2017), Best *et al.* (2021); Hu *et al.* (2019), Vicente *et al.* (2018); Bocken and Geradts (2020)
		Value proposition	Product	Gil-Gomez *et al.* (2020), Ghezzi and Cavallo (2020); Frank *et al.* (2019), Rachinger *et al.* (2019); Hu *et al.* (2019), Parida *et al.* (2019)
			Services	Gil-Gomez *et al.* (2020), Ghezzi and Cavallo (2020); Frank *et al.* (2019), Paiola and Gebauer (2020);

(*continued*)

Table 4

Approach	*Perspective*	*Dimension*	*Component*	*Reference*
				Rachinger *et al.* (2019), Hu *et al.* (2019); Parida *et al.* (2019), Madsen (2020)
		Value learning	Organizational learning	Geissdoerfer *et al.* (2018), Ghezzi and Cavallo (2020); Čirjevskis (2019); VoDoVoZ and MaY (2017), Best *et al.* (2021); Inigo *et al.* (2017), Parida *et al.* (2019); Vicente *et al.* (2018), Bocken and Geradts (2020); Madsen (2020), Pieroni *et al.* (2019)
			Machine learning	Paiola and Gebauer (2020)
C) Approach 3: ability to transform and reconfigure – creating new sustainable digital values				
Approach	Perspective	Dimension	Component	Reference
Digital Sustainable Reconfiguring capabilities	Sustainable results	Economic results	Business economics	Geissdoerfer *et al.* (2018), Karlsson *et al.* (2018); Yang *et al.* (2017); França *et al.* (2017); Shakeel *et al.* (2020), Inigo *et al.* (2017); Baldassarre *et al.* (2017), De Silva *et al.* (2019); Hu *et al.* (2019), Parida *et al.* (2019); Oskam *et al.* (2021), Oskam *et al.* (2018); Bocken and Geradts (2020), Cantele *et al.* (2020); Pieroni *et al.* (2019)
			Circular economics	Velter *et al.* (2020), Shakeel *et al.* (2020); Lüdeke-Freund *et al.* (2018); Parida *et al.* (2019), Oskam *et al.* (2018); Cantele *et al.* (2020), Madsen (2020); Pieroni *et al.* (2019)
			Digital economy	Karlsson *et al.* (2018), Rachinger *et al.* (2019)
		Social results	Social performance	Velter *et al.* (2020), Geissdoerfer *et al.* (2018); Karlsson *et al.* (2018), Yang *et al.* (2017); Shakeel *et al.* (2020), Inigo *et al.* (2017); Baldassarre *et al.* (2017), De Silva *et al.* (2019); Bocken and Geradts (2020), Parida *et al.* (2019); Lüdeke-Freund *et al.* (2018); Lüdeke-Freund (2020); Hu *et al.* (2019), Oskam *et al.* (2018); Oskam *et al.* (2021), Cantele *et al.* (2020); Pieroni *et al.* (2019)
			Social entrepreneurship	Geissdoerfer *et al.* (2018); Lüdeke-Freund (2020); Oskam *et al.* (2021)
			Social capital	Čirjevskis (2019); Lüdeke-Freund (2020); Cantele *et al.* (2020), Madsen (2020)
		Environmental results	Environmental function	Velter *et al.* (2020), Geissdoerfer *et al.* (2018); Karlsson *et al.* (2018), Yang *et al.* (2017); Shakeel *et al.* (2020), Baldassarre *et al.* (2017); De Silva *et al.* (2019), Hu *et al.* (2019); Parida *et al.* (2019), Oskam *et al.* (2018); Oskam *et al.* (2021), Bocken and Geradts (2020); Cantele *et al.* (2020)
			Environmental productivity	Yang *et al.* (2017), De Silva *et al.* (2019); Oskam *et al.* (2018), Cantele *et al.* (2020)
			Waste management	Yang *et al.* (2017), Baldassarre *et al.* (2017); Oskam *et al.* (2018), Barth *et al.* (2017); Madsen (2020)
	Sustained engagement	Customer engagement	Customer loyalty	Gil-Gomez *et al.* (2020), Velter *et al.* (2020); Yang *et al.* (2017), Inigo *et al.* (2017)
			Customer passion	Gil-Gomez *et al.* (2020), Ghezzi and Cavallo (2020); Oskam *et al.* (2021)
		Social engagement	Social management	Gil-Gomez *et al.* (2020), Karlsson *et al.* (2018); Čirjevskis (2019); França *et al.* (2017); Best *et al.* (2021), Baldassarre *et al.* (2017); Lüdeke-Freund (2020); Oskam *et al.* (2021), Cantele *et al.* (2020)
			Social passion	Lüdeke-Freund (2020); Hu *et al.* (2019), Barth *et al.* (2017); Cantele *et al.* (2020)
		Environmental engagement	Environmental passion	Velter *et al.* (2020), Karlsson *et al.* (2018); Baldassarre *et al.* (2017); Lüdeke-Freund (2020); Hu *et al.* (2019), Oskam *et al.* (2021); Barth *et al.* (2017), Cantele *et al.* (2020)
			Environmental management	Gil-Gomez *et al.* (2020), Baldassarre *et al.* (2017); Lüdeke-Freund (2020); Cantele *et al.* (2020)

4.2.1 Step 1: identification of problem variables. The problem variables in this study are the dimensions obtained from the content analysis, which, were used in their coded (acronym) form to build the structural self-interaction matrix (SSIM) (Table 5).

4.2.2 Step 2: formation of structural self-interaction matrix. The self-interaction matrix presents the relationship between variables in its columns and rows. According to the contextual relationships, reflecting the experts' agreement for pairwise comparison of all variables (X1–X16), we developed the structural self-interaction matrix (Table 6). SSIM is formed based on the results of a discussion among a group of experts.

In this step, the opinions of the 18 experts on the relationship between variables were compared and the "mode" of the opinions for each pair of variables (the relation with the highest frequency in the opinions of experts for those variables) was used in the final table.

4.2.3 Step 3: formation of initial reachability matrix. In this step, the initial reachability matrix was formed by converting the entries of SSIM into binary values based on the rules given in Table 7.

4.2.4 Step 4: formation of final reachability matrix. After forming the initial reachability matrix, the final reachability matrix was formed by considering transitivity in the inter-variable relationships.

4.2.5 Step 5: level partitioning. In this step, we determined the reachability (output) set, the antecedent (input) set and the intersection set of each variable. The reachability set of a variable consists of the variable itself and other variables that contribute to it. The antecedent set of a variable consists of the variable itself and other variables to which it contributes. The intersection set of a variable consists of all elements that are present in

Table 5 Codes used for the approved variables

Symbol	*Dimensions*	*Symbol*	*Dimensions*
X1	Digital technologies	X9	Capture value
X2	Business computing	X10	Value agility
X3	Green computing	X11	Environmental engagement
X4	Social computing	X12	Social engagement
X5	Value learning	X13	Customer engagement
X6	Value proposition	X14	Environmental results
X7	Value creation	X15	Social results
X8	Value delivery	X16	Economic results

Table 6 Symbols of the relations between variables in SSIM

Relation	*Symbol*	*Relation*	*Symbol*
Two-way relationship between i and j	X	i leads to j	V
No relationship between i and j	O	j leads to i	A

Table 7 Rules for the conversion of the entries of SSIM into quantitative values for the initial reachability matrix

Cell (i,j) of SSIM	*Conversion rule*
V	Place 1 in the cell (i, j) and 0 in the cell (j, i) of the reachability matrix.
A	Place 0 in the cell (i, j) and 1 in the cell (j, i) of the reachability matrix
X	Place 1 in the cell (i, j) and 1 in the cell (j, i) of the reachability matrix
O	Place 0 in the cell (i, j) and 0 in the cell (j, i) of the reachability matrix

both the reachability set and the antecedent set of that variable. For level partitioning, first, the variables whose reachability and intersection sets were identical were placed at the first level of the model. The above-described process was then repeated without the variables placed at the first level to determine the second level of the model. Repeating the same process for all variables, the nine levels shown in Figure 4 were obtained.

4.2.6 Step 6: drawing the final interpretive structural model. In this step, the levels and final reachability matrix obtained in the previous step were used to draw an initial model, which after removing transitivity, turned into the final model shown in Figure 4.

4.2.7 Step 7: analysis of driving power and dependence [matrice d'impacts croi- sés multiplication appliquée an classment (MICMAC) diagram]. MICMAC diagram is a diagram where the vertical axis represents the driving power and the horizontal axis represents the dependence of a variable. As shown in Figure 5, the research variables were classified into four groups independent, linkage, autonomous and dependent based on their position on the MICMAC diagram. Accordingly, "digital technologies" was found to be the factor with the highest independence and the highest driving power, and "economic sustainability", "social sustainability" and "environmental sustainability" were identified as the factors with the highest dependence and the least driving power.

4.3. An integrative model of sustainable business model innovation in the digital age based on dynamic capabilities

According to the first phase of the research, we proposed a model including 3 approaches, 5 aspects, 16 dimensions and 37 components. The first aspect of the model is "sustainable computing", which involves the impact of technology and sustainability requirements on the business and can be considered as a driver. The next aspect is "sustainable execution", which states that to succeed in sustainability efforts, it is necessary to pay attention to the value of digital technologies and sustainability requirements as inputs, besides considering new values such as agility and learning alongside value proposition and value creation of conventional BMs. These values are both sustainable and digital in nature. The third aspect is "sustainable engagement", the purpose of which is to create market engagement for both current and potential customers. Sustainable engagement with the business occurs when

Figure 4 Final interpretive structural model

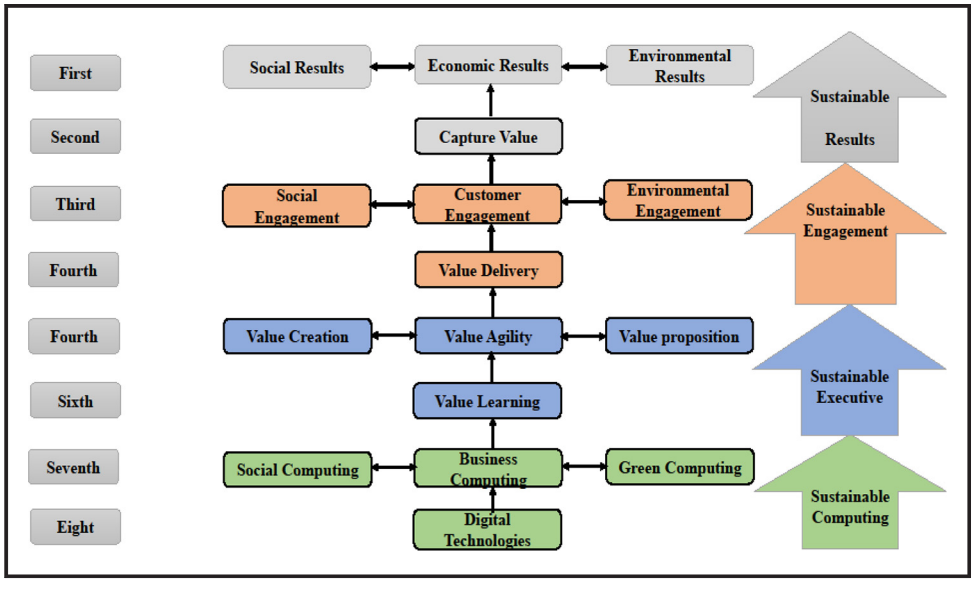
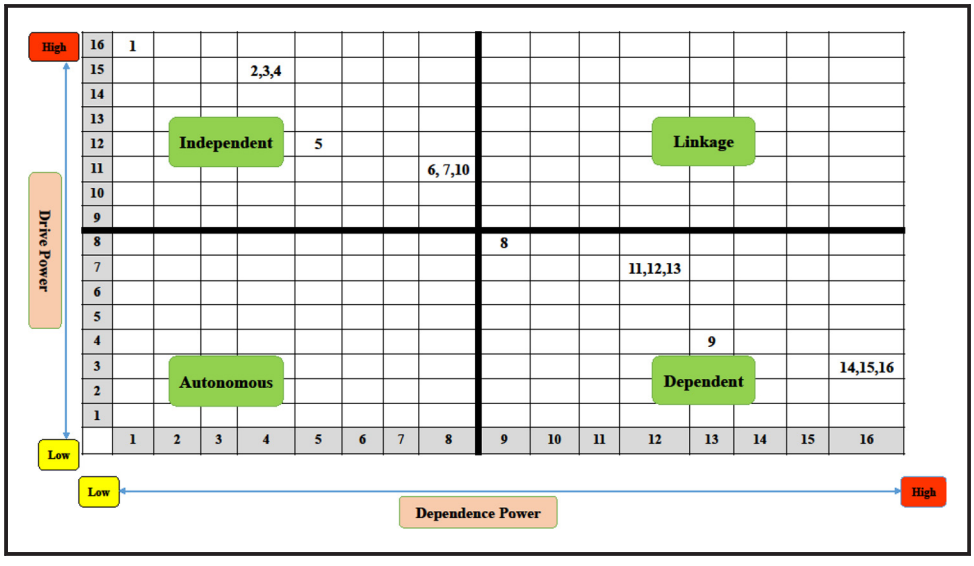


Figure 5 Driving power-dependence (MICMAC) diagram



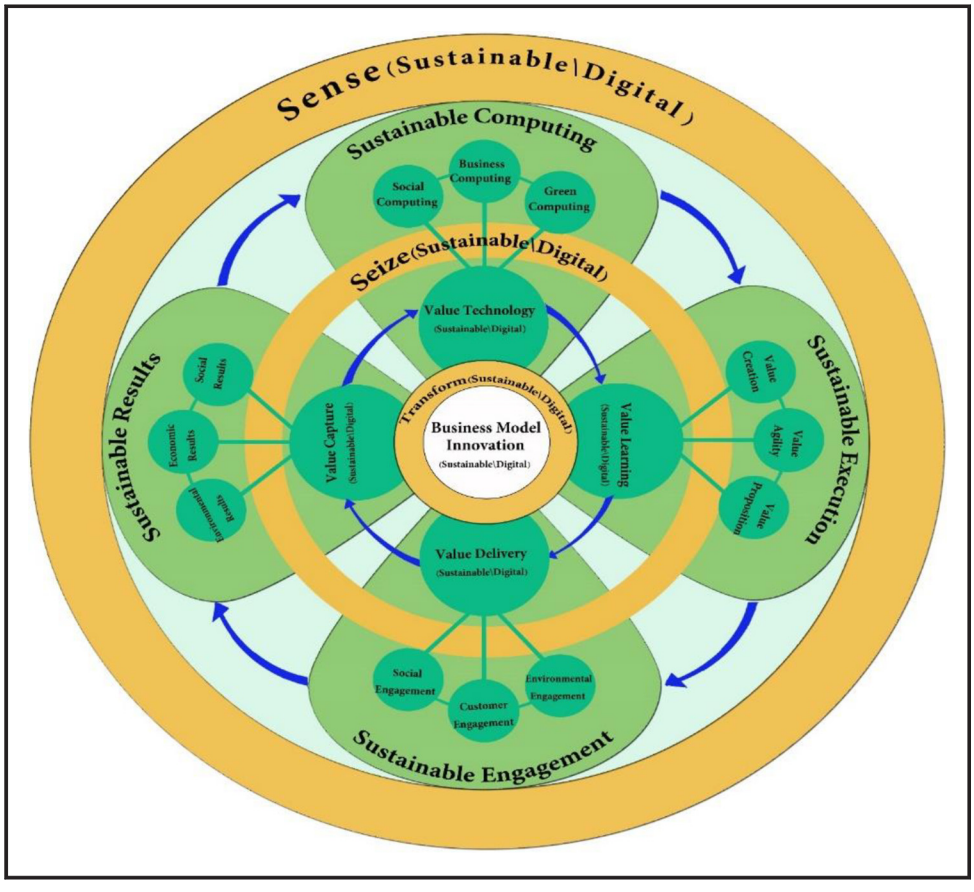
customers are informed that the business does or needs to pay special attention to environmental and social issues as well as their real needs. Finally, the fourth aspect is "sustainable results", consisting of three parts. The first part is economic results, which is a necessary but not sufficient condition and needs to be complemented with the other two parts (social and environmental results). For this purpose, businesses require to prepare, assess and publish a report on the status of their business sustainability indicators and improve them over time.

The final research model (Figure 6) can be used as a BM canvas for BM re-design and innovation in both established and nascent companies that seek to achieve sustainability in the digital age. To fully understand the approaches, aspects and dimensions of the proposed model, they are described in Table 8.

While BMs simply represent the logic of value creation by businesses, innovative value generation through deploying transformative technologies remained challenging. This justifies how companies can market the same technology through different BMs, with different economic outcomes. Obstacles to changing the BM are real, and tools such as maps are useful for helping companies to overcome this challenge (Chesbrough, 2010). We thus propose a model, representing a business canvas that organizations can adapt to new challenges of sustainability and digital transformation, while they keep an inward-looking approach to their dynamic capabilities.

Our proposed models in comparison to the previous BM canvases such as Osterwalder's BM canvas include several superiorities and innovations. First, it treats technology as a primary independent dimension to be considered at the onset of the design, in appropriate response to the speed of technological developments. Second, given the increasing importance of sustainability requirements in today's business world, unlike other canvases that merely focus on economic sustainability, this model combines the need for economic sustainability with requirements for environmental and social sustainability in business design. Third, the proposed model is the first to use the concept called sustainable engagement, representing the businesses' need for engagement with the society and the environment as well as customers, and concerns why this should be viewed as a core component of business modelling right from the beginning of the business design process.

Figure 6 Final model of sustainable business model innovation in the digital age with dynamic capabilities approach



In addition to the common values of BMs, the proposed model incorporates new values such as learning value and agility value, which are important features of a successful business in the digital age.

5. Discussion

We face a wide range of sustainability problems, including economic, environmental and social issues in various types of environmental (digital) computing (Park, 2019). Considering the notion of business computing, first introduced by Ellis in 2001 (Ellis, 2001), we expect that sustainable computing of the future plays a focal role in addressing the increasing environmental issues. This idea incorporates a variety of paradigms, procedures and policies to support the breadth and depth of digital technologies to create a rich (social) life for the environment. We are thus facing an important question of how do organizations achieve and maintain a competitive advantage in the context of the high growth and diversity of transformative digital technologies? According to Teece (2007, 2016–2019), dynamic capabilities are the result of a combination of management, learning and reconfiguration processes in which the business must carefully analyse the environment to identify changes, disseminate knowledge. They also need to effectively adapt to the environmental changes through their BMs that represent their capabilities in developing and delivering value to customers (Vicente *et al.*, 2018). However, there are two common approaches in developing a BM; the static approach refers to a blueprint for coherence

Table 8 Description of the approaches, aspects and dimensions of the final model

Approaches, aspects and dimensions of the model	*Description*
Approach 1: Ability to sense and recognize changes in values (sustainable/digital)	The first step of the approach aims to create the capability to promptly detect and sense changes in all dimensions of the business model
Approach 2: Ability to capture and seize value opportunities (sustainable/digital)	The second step of the approach aims to create the capability to properly use the opportunities identified in the previous step in all dimensions of the business model
Approach 3: Ability to transform and reconfigure values (sustainable/digital)	The third step of the approach aims to create the capability to transform and re-create the values in all dimensions of the business model
Sustainable computing aspect	The first aspect of the model consists of four dimensions starting with the value of technology and ending with green computing, social computing and business computing
Technology dimension (sustainable/digital)	The first dimension of the model acts as the foundation for all other dimensions
Green computing dimension	A dimension of the model that emphasizes the interactions between digital technologies and the environment, which can be both positive and negative
Social computing dimension	A dimension of the model that emphasizes the interactions between digital technologies and society, which can be both positive and negative
Business computing dimension	A dimension of the model that emphasizes the interactions between digital technologies and the business, which can be both positive and negative
Sustainable execution aspect	The second aspect of the model consists of four dimensions starting with the learning value and ending with value proposition, agility and value creation
Learning value dimension (sustainable/digital)	The link between the first aspect (sustainable computing) and the second aspect (sustainable execution); implies that businesses can thrive through continuous learning that factors in all internal and external changes, including digital transformation and sustainability requirements
Value proposition dimension	Represents the planning of products and services based on digitization and sustainability requirements
Agility value dimension	Providing sustainable digital products and services alone is not enough, and businesses need to be quick and agile in this endeavour and related processes
Value creation dimension	Represents key resources, partners and activities that play a direct role in the realization of value proposition
Sustainable engagement aspect	The third aspect of the model consists of four dimensions starting with value delivery and ending with environmental, customer and social engagement; Engagement means how and with what programs and actions businesses show that they care about their customers, the society and the environment
Value delivery dimension (sustainable/digital)	The link between the second aspect (sustainable execution) and the third aspect (sustainable engagement); involves customer segmentation, customer engagement and communication channels
Environmental engagement dimension	Refers to actions and programs that businesses take and implement to preserve or even improve the environment, which can show how committed they are to the environmental objectives
Customer engagement dimension	Refers to actions and programs that businesses take and implement to retain their customers and make them loyal, which can show how committed and loyal they are to their customers
Social engagement dimension	Refers to actions and programs that businesses take and implement to contribute to social wellbeing and even social development of the communities they operate in, which can show how committed and loyal they are to society and people
Sustainable results aspect	The fourth aspect of the model consists of four dimensions starting with value capture and ending with environmental, social and economic results
Value capture dimension (sustainable/digital)	The link between the third aspect (sustainable engagement) and the fourth aspect (sustainable results); While measurement and monitoring in the engagement aspect is mostly qualitative and intangible, in this dimension, it will be based on quantitative statistics; Value capture consists of two parts: costs and revenues
Environmental results dimension	Refers to quantitative figures of investment in improving the environment and the quantitative results of this investment (e.g. how much has a business invested in improving water, soil, or air quality and what have been the results?)
Social results dimension	Refers to quantitative figures of investment in the betterment of society and the quantitative results of this investment (e.g. how much has a business invested in improving the employment, education, and health conditions of the society, and what have been the results?)
Economic results dimension	Refers to quantitative figures of investment in the long-term profitability of shareholders and the quantitative results of this investment (e.g. how much has a business invested in gaining market share and improving revenue and costs and what have been the results?)

between the core components of the BM, while the transformational approach uses this concept as a tool to address change and innovation in the BM. This study specifically considers the evolution of the BM, involving voluntary and emergency change in and between permanently related core components. We further discuss that firm sustainability depends on anticipating and responding to a sequence of voluntary and emerging changes associated with its internal capabilities to maintain its performance (sustainability) while innovating its BM (Demil and Lecocq, 2010). Thus, BMI can be the result of developing dynamic business capabilities as it enables the business to take steps tailored to the needs of the customers and the environment (Vicente *et al.*, 2018). Researchers also emphasize that one of the most important aspects of dynamic capabilities is innovation, implementation and changing the BM (Fellenstein and Umaganthan, 2019).

Dynamic capabilities theory revolves around three groups of capabilities: sensing capabilities (the ability to sense and recognize external changes), seizing capabilities (the ability to properly and promptly use resources to capture new values) and reconfiguration capabilities (the ability to reconfigure the business by changing its structure, culture, strategy, leadership style and processes). On the other hand, the impact of digital transformation, as an external factor, on dynamic capabilities (an internal factor, under the control of the business) should also be examined. As we discussed in our finding, *dynamic capabilities* has three parts that combine to create new capabilities with digital transformation. In fact, businesses need to combine their in-house dynamic capabilities with digital transformation to create the dynamic capabilities of the digital age (Figure 7).

The concept of dynamic capabilities for sustainability has been introduced by different terms in literature over the past years, such as dynamic green capabilities, dynamic sustainability-based capabilities, dynamic environmental capabilities and sustainable advantage capability. Regardless of its label, we believe that the new dynamic capabilities based on sustainability can improve the performance and results of businesses in the economic, social and environmental fields (Buzzao and Rizzi, 2021). Drawing on dynamic capabilities' theory, we developed an emerging dynamic capabilities model, suitable for digital transformation and sustainability requirements (Table 9).

Based on a process perspective, we classified the final sixteen elements of our model into four process groups as shown in Figure 6 and explained below.

5.1 Sustainable computing aspect

Although digital transformation is not just the use of digital technologies (Johnson, 2018), in any case, introducing emerging technologies play a central role in the process of digital transformation, especially with the emphasis on leveraging technology capabilities in

Figure 7 Relationship between dynamic capabilities and digital transformation

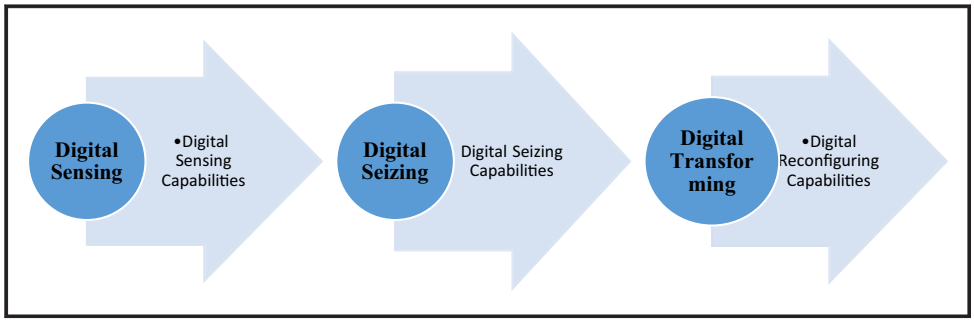


Table 9 Dynamic capabilities suitable for digital transformation and sustainability requirements

Dynamics	*Sensing*	*Seizing*	*Reconfiguring*
Digital	Digital Sensing capabilities Identifying opportunities and threats and sensing and recognizing digital changes, including new tools and technologies and their impact on the current state and future of the business	Digital Seizing capabilities Ability to use internal business resources to capture and acquire new values based on digital technologies, digitalization trends and digital transformation	Digital reconfiguring capabilities Business reconfiguration in the areas of structure, culture, strategy, leadership style and processes based on digitalization trends and digital transformation trends
Sustainable	Sustainable sensing capabilities Identifying opportunities and threats and sensing and recognizing changes in sustainability requirements in social and environmental domains as well as economic area and their impact on the current state and future of the business	Sustainable seizing capabilities Ability to use internal business resources to capture and acquire new values based on sustainability factors (economic, social and environmental)	Sustainable reconfiguring capabilities Business reconfiguration in the areas of structure, culture, strategy, leadership style and processes based on sustainability factors (economic, social and environmental)
Digital sustainability	Digital Sustainability Sensing capabilities Identifying opportunities and threats and sensing and recognizing changes in sustainability and digital transformation requirements	Digital Sustainability Seizing capabilities Ability to use internal business resources to capture and acquire new values based on sustainability and digital transformation factors	Digital Sustainability Reconfiguring capabilities Business reconfiguration and restructuring based on sustainability and digital transformation factors

advancing business performance or introducing innovative models (Kotarba, 2018; Warner and Wäger, 2019). The emergence and application of digital technologies such as Internet of Things (IoT), blockchain, big data, mobile and cloud computing, and artificial intelligence (AI) have transformed businesses and innovated BMs (Johnson, 2018; Kotarba, 2018; Warner and Wäger, 2019; Fellenstein and Umaganthan, 2019). Thus, digital transformation is the result of the interaction between digital technologies and the BM and can lead to the optimal use of business resources to achieve sustainability (Bocken *et al.*, 2019). In our proposed model, we first considered the aspect of technology and its value for three areas of business, society and environment. It is expected that digital technologies, as the main drivers of digital transformation, influence businesses. To stay responsive and competitive, business needs to transform other different dimensions including strategy (sustainability), goals and indicators (products/services), resources and processes, structure and culture. Simply put, businesses need to answer these questions:

Q1. What are the main effects of digital technologies on achieving a sustainable strategy?

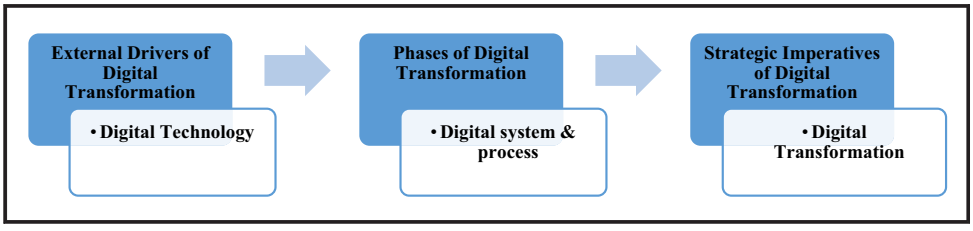
Q2. What are the impacts of digital technologies on providing products/services with the goal of sustainability?

Q3. What are the impacts of digital technologies on the current business culture and how far is it from the desired culture with the goal of sustainability?

Q4. What impact do digital technologies have on the current business structure and what should the structure be like for the digital age? And in the business structure, how should the issue of sustainability be considered?

Based on our model, the sustainable computing aspect has four components: technology value, business computing, social computing and environmental computing (Figure 8). This aspect concerns the question that how identifying and using new digital technologies can create value for businesses? Considering the controversial effects of digital technologies on business, environment and society (both positive and negative impacts), the main conclusion drawn from this aspect is the answer to the question that how BMs can mitigate the adverse effects of digital technologies and improve their positive effects in line with

Figure 8 Three stages of digital transformation



sustainability goals. Although digital technologies have been developed to make our lives easier and give us more time to rest, they have had the opposite effect. These technologies have accelerated our lives from one side, but also caused countless problems in both personal and social spheres. Digital technologies have also had negative effects on the environment by increasing the incentive for pollution and destruction of natural resources (Willard and Hitchcock, 2009). In fact, despite the promise of technology to increase productivity and connectivity, it is equally prone to pollution. Electronic waste is increasing three times faster than any other type of waste (Radjou and Prabhu, 2015). Currently, one of the most important environmental issues is related to electronic waste in the digital age (Willard and Hitchcock, 2009; Radjou and Prabhu, 2015).

According to the standards of the International Green Federation, green computing refers to measures in the field of information technology or computing that indicate technologies are environmentally sustainable or simply shows that the risk of industrial bio-pollution is decreased. On the other hand, the concept of social computing refers to analyzing and modelling users' social behaviours in media to create intelligence from interactive applications and customer data. Some notable examples of social computing operating systems are YouTube, WordPress, Tumblr, Facebook, Twitter and LinkedIn. Considering the increasing trends of using social media and huge amounts of customer-generated data, using social computing seems to be essential for BMI and consequently for business success. Customers will discuss topics that matter more in social media and businesses can directly learn about the dominant changes.

Considering the pace of changes, businesses need to take a lean sustainability-oriented approach to survive in an increasingly digital world, i.e. to learn how to achieve the best possible performance and remain sustainable with an optimum level of resource consumption. In response to this need, some companies have placed the issue of sustainability alongside digital transformation in the centre of their BM (Radjou and Prabhu, 2015). According to the network theory, businesses must use the participation and commitment of all stakeholders in their internal and external networks to assess and respond to their real needs in economic, social and environmental domains (Baldassarre *et al.*, 2017). Moreover, in line with the dynamic capabilities' theory, our proposed model posits that to have a true understanding of threats and opportunities, businesses need to examine the negative and positive effects of digital technologies in social and environmental domains as well as in the economic domain.

5.2 Sustainable execution aspect

Once the general orientations of BMI have been determined, in the next place, businesses need to enforce the orientation through implementing well-designed processes. There is a fundamental question about BMI, which is: How do BMs develop or innovate over time? (Westerman *et al.*, 2014). Due to changes imposed by innovative digital technologies, organizations need to increasingly rely on continuous learning to stay up-to-date (Berends *et al.*, 2014). BMI is a complex process in which operations and cognition are combined. It

is a multi-step, multi-mechanism learning process that can occur through "drifting" and "jumping" patterns. Besides selecting the appropriate and effective BMI, organizations need to consider how they can achieve an effective learning process to operationalise the new BM. Thus, BMI is a learning process (Westerman *et al.*, 2014). Scholars consider agility as the cornerstone ability in BMs innovation process (Clauss *et al.*, 2019). Therefore, another important subject to be considered in BMI is organizational agility. While we discuss that continuous learning can be a great achievement for businesses especially in product and service innovation, businesses need to further rely on their agility in design, development, sales and aftersales services processes. Through these agile and responsive processes, they are also expected to pay attention to the factors that make their production or their product harmful for the environment and society. While traditionally customers look for tangible products or intangible services to fulfil their needs, we now need to rely on sustainable products and services that are, in fact, solutions to both customer problems and socio-environmental problems. Therefore, we expect that in sustainable execution, companies come up with solutions that meet customer needs while significantly improving environmental and social performance throughout the product life cycle system. Producing sustainable services and products requires BMI through which business supplies more value proposition with fewer resources (Radjou and Prabhu, 2015).

The sustainable execution aspect of our model encompasses four dimensions: learning value, value proposition, value creation and agility value. While the sustainable computing aspect covers the issue of digital changes and sustainability requirements stemming from the external environment of the business, this aspect involves the development processes of BMI. We discuss that answering a fundamental question of how BMs get developed or renovated over time, is the core of this aspect. It is crucial to consider how businesses can implement an effective learning process to gain a new BM (Berends *et al.*, 2014). However, BMI is inherently associated with uncertainty and failure and its immediate goal is learning rather than the success of the business (Johnson, 2018).

Therefore, the constant changes in digital technologies make it essential for businesses to learn how to change their BM and maintain their economic performance by moving towards sustainability (Radjou and Prabhu, 2015). To respond to this requirement, we have introduced the learning value (sustainable/digital) as a new value of BMI. We further emphasized the importance of learning from digital transformation-induced internal changes and external changes in the business environment in economic, social and environmental domains. Some businesses perform better and faster in developing sustainable solutions in response to changes. These businesses are more agile and tend to be more successful in minimizing resource consumption. They deploy digital technologies to make themselves more agile in the service of sustainability (Radjou and Prabhu, 2015). We propose that due to the positive impact of human/machine learning on the ability of a business to improve its agility, higher level of efficiency in the use of key resources, activities and partnerships is expected, which ultimately contributes to a better value proposition. Hence, sustainable products and services can offer a solution to both customer problems and social-environmental problems. By sustainable products and services, we refer to processes or commodities that while meeting the needs of customers, offer significant environmental and social benefits throughout their life cycle. With a strong focus on achieving long-term value creation for stakeholders, business sustainability benefits entrepreneurs with long-term investment prospects and business organizations that highly value customer satisfaction, employee welfare and social and environmental responsibilities.

According to the dynamic capabilities theory and the resource-based theory, learning can be an important internal capability in a business that boosts business muster and improves other values in the sustainable execution aspect. In this process, value proposition, value creation and agility will be simultaneously and independently affected by learning. Value

proposition and value creation components along with agility components will bring value to the next dimension, value delivery. The agility dimension is also effective in both delivering value proposition and creating value through key resources, activities and partnerships.

5.3 Sustainable engagement aspect

The logical step after sustainable product/service production is sustainable delivery through distribution channels. To decrease the environmental footprint businesses have different options in delivery such as collaboration with specific retail organizations in the target geographic markets, or retail through catalogue submission and the use of online retail exchanges via the internet. We believe that businesses are required to go beyond thinking of their customer as a transactional entity and they need to get involved with their consumer to ultimately create strong attachments (Gupta, 2018), so they feel deeply involved in the core business. Compared to the average customer, a highly engaged customer creates a significant premium in terms of wallet share, profitability and revenue, thus, developing strong relationships with end customers can financially benefit businesses (Haghshenas and Christiansen, 2014). The use of digital transformation technologies can expand the speed up and scope of customer attachment. This justifies the reasons behind investing in digital technologies by leading companies to develop new digital channels for integrated customer relationship management that aim at increasing customer attachment to products, services or brands (Westerman *et al.*, 2014). Customers are now more environmentally concerned and they look for products and services with less harm to the planet, as they have realized that the health of the earth affects their own health (Radjou and Prabhu, 2015). Hence, we discuss that companies not only need to offer digital and environmentally friendly products and services also are expected to develop a culture of loving nature and preventing pollution through sustainable engagement with their customers and other stakeholders.

The sustainable engagement aspect consists of four dimensions: value delivery, customer engagement, social engagement and environmental engagement. In the third section of our model, the joint output of value proposition, agility value and value creation processes enters the stage of delivering value to customers and society. The purpose of this process is to create an engagement between customers and products and services based on sustainability and using digital technologies. Becoming more engaged with their consumers or achieving a desirable level of consumer engagement is a goal for lots of pioneer businesses (Gupta, 2018). Moreover, successful and purposeful engagement is an important task in environmental and sustainability activities, especially because they face many economic, technological, cultural and behavioural challenges and barriers.

According to the network theory, our model suggests that businesses need to encourage their stakeholders to become more inclined to support sustainability efforts (Cantele *et al.*, 2020). Network-wide collaboration facilitates knowledge sharing, value sharing, belief building, use of shared opportunities and commitment among network members (Cantele *et al.*, 2020). To accomplish this goal, businesses can now rely on many affordable digital tools and techniques that enhance the depth and breadth of customer engagement (Radjou and Prabhu, 2015), through the emergence of integrated customer relationship management systems (Westerman *et al.*, 2014). As customers are concerned about the harmful effects of services and products on their environment and society, sustainable business advocates can more successfully develop a network of engaged stakeholders that promote their business and its products.

5.4 Sustainable results aspect

Consumers perceive, evaluate and weigh the costs of sustainable products, considering some influential factors into account such as socio-environmental awareness. To manage

the cost equation in favour of sustainable products, the total cost to the customer must be reduced. However, consumers generally expect sustainable products to be more expensive than conventional products, although such perceptions are based on experience, not an inherent market requirement. In this case, marketing executives face two fundamental questions: Should companies use high prices for sustainable products? How much more are customers willing to pay for a sustainable product? While accounting departments traditionally used to focus on tangible cost and short-term clear plans, the concept of sustainability costs and revenues is neither transparent nor short-term. For this reason, financial sectors are required to consider sustainability metrics in their decisions and to develop decision-making frameworks for social and environmental performance. Here, the question arises how should they measure non-financial performance? There are no generally accepted methods for assessing social and environmental performance. While some advocate that sustainability initiatives would increase customer loyalty and decrease the cost through waste management, the social dimension of sustainability is often overlooked.

Social performance is related to the realization of a company's social mission and alignment with community interests by adding accepted social values and performing in line with social responsibility. Social enterprises increasingly use digital technologies for the field of social sustainability such as health, attention to the elderly, education and social development, social learning, online education, especially for adults, solving social problems and problems (Radjou and Prabhu, 2015). Applying transformative technologies such as IoT, sustainable BMs are becoming capable of not only measuring the needs and attachments of consumers but also can change customers' behaviour to preserve and maintain the environment (Radjou and Prabhu, 2015). Businesses need to address the requirements of all three pillars, i.e. economics, society and the environment, from a systematic perspective; these three domains are closely correlated.

In our model, sustainable results represent four dimensions: value capture, economic sustainability, social sustainability and environmental sustainability. In this aspect, the first goal is to determine whether the long-term benefits generated for stakeholders result in economic sustainability? In the next step, it is necessary to identify the appropriate indicators for measuring the extent to which efforts and programs have been successful in achieving their social and environmental objectives. Finally, it is necessary to determine whether the business has been successful in transforming into a sustainable business.

Although sustainability programs appear to increase costs in the short term, they can generate innovative revenue streams (Willard and Hitchcock, 2009). Businesses can earn higher revenues by employing low-cost initiatives such as product as a service and waste reuse to improve customer loyalty and engagement, especially with the new generation of consumers who are more sensitive to sustainability issues (Radjou and Prabhu, 2015). The social dimension of sustainability is often neglected as it is easier to discuss and measure its environmental dimension. However, we call for attention to the social dimension of sustainability and invite businesses to contemplate how they can maximize the benefits of a business for society as well as for the business itself (Willard and Hitchcock, 2009), similar to what we expect from social enterprises. The contribution of digital technologies to social sustainability is also remarkable, especially in addressing elderly issues and justice promotion through digital health and online platforms. According to the resource-based theory, we discuss that to achieve sustainability, businesses need to muster, direct and manage their internal resources (capital and financial resources, human and physical resources) all in line with their orientation for sustainable results. It is expected that this investment enables companies to maintain and improve their economic, environmental and social performance and also to design and develop proper indicators for periodic measurement of performance for continuous improvement purposes.

6. Conclusion

In this exploratory mixed-method study, we aimed at identifying key elements of BMI considering digital transformation and sustainability concepts. Through the first stage of our study by deploying meta-synthesis we extracted 32 concepts in 16 dimensions including four main approaches presented in Table 4. To determine the interrelationship between these main factors and 16 dimensions as focal notions of our model, we followed the ISM method that the results are presented in Figure 4. As it is logically presented, at the lowest level we are facing digital technologies which drive business computing, social and green computing concepts. We labelled them as "sustainable commuting" and further discussed them in our discussion Section 5.1. This is the starting point of re-thinking BM configuration, driven by transformative technologies while keeping sustainability goals in mind. At the next level, value learning played a focal role in BMI while it drives value creation, value agility and value proposition. The reason behind the importance of "learning" and "agility" for BMI in this context is further discussed in Section 5.2 that we consider as "sustainable execution". Moving to the next level of our ISM, value delivery with three main components of social engagement, customer engagement and environmental engagement has been introduced. In Section 5.3, we discussed why "sustainable engagement" is essential in sustainable digital BMI and what important factors should be considered by businesses. Finally, we expect that all of these factors and their correlation lead to "sustainable results" which are derived by value capture and would lead to social, economic and environmental results. However, we need to emphasise that the proposed model by this study is a generic integrative framework, correlating influential core factors that are essential in sustainable BMI driven by transformative digital technologies. We thus ask practitioners to consider their business and technological specific requirements by answering the questions we raised in each step. We also call for further context-based studies to contextualize and specify our model for deploying different disruptive technologies such as IoT, AI, big data and blockchain with the aim of sustainable innovative BM development.

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Corresponding author

Nastaran Hajiheydari can be contacted at: n.hajiheydari@sheffield.ac.uk, nhheidari@ut.ac.ir