Building SMEs' resilience in times of uncertainty: the role of big data analytics capability and co-innovation

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Received 15 July 2021
Revised 23 November 2021
27 December 2021
31 January 2022
Accepted 2 February 2022

Abstract

Purpose – This paper aims to enhance the small and medium enterprises' (SMEs) ability to develop resilience in the face of any turbulences, addressing the question on how these organizations can maintain business continuity when faced with a critical event.

Design/methodology/approach – A mediated regression analysis is conducted to investigate the relationships among big data analytics (BDA) capabilities, coinnovation (CI) and organizational resilience (OR) with reference to 192 big data SMEs in Europe.

Findings – Research reveals that the BDA capability and CI are positively associated with OR. Moreover, this study discovers the mediating impact of CI on the relationship between BDA capability and OR.

Originality/value – This paper provides important implications for considering CI as a viable strategy especially in a time of crisis and shows how SMEs are more able to recognize business opportunities. The microfoundations of the resilience building capacity of SMEs are also identified. These microfoundations become recommendations for practitioners to enhance SMEs' responsiveness in light of coronavirus-related crises.

Keywords SMEs, Coinnovation, Organizational resilience, Big data analytics capability

Paper type Research paper

Transforming Government: People, Process and Policy
Vol. 16 No. 2, 2022
pp. 203-217
Emerald Publishing Limited
1750-6166
DOI 10.1108/TG-07-2021-0120

1. Introduction

The current megatrends of the coronavirus disease 2019 (COVID-19) pandemic crisis and advances in technologies, such as big data analytics (BDA), are waving the global business environment, making it increasingly turbulent, uncertain and changing (Lee and Trimi, 2021). In this scenario, many organizations, especially small and medium enterprises (SMEs), are experienced a total chaos because of the severe decline of the work, income and confidence, facing with a huge existential challenge (Lu *et al.*, 2020; Bodziany *et al.*, 2021). Under these conditions, SMEs are prompted to be in a state of urgency for resilience (Aghina *et al.*, 2018).

Vulnerability to external shocks and the need to remain competitive are critical issues for SMEs being generally less resilient than larger firms because SMEs take longer to wholly or partially to "normal operations" after a critical event. In fact, crises such as the COVID-19 pandemic trigger inordinate effect on SMEs that generally struggle with profitability and liquidity given their limited internal resources (i.e. financial, technical and human) compared to large firms (Del Vecchio *et al.*, 2018). Additionally, poor planning, inadequate staff training and inconsistent relationships between operating units and management and control mechanisms cause a low capacity to scan the context by diminishing SMEs' ability to react to changes in complex environments (Figueiredo *et al.*, 2020). Anyway, SMEs are more flexible, thanks to their small size, private ownership structure and relatively flat hierarchical organization, all of which can be helpful to sustain their ability to be innovative even more when the economy takes a turn for the worse (Juergensen *et al.*, 2020).

Scholars have pointed out that in a pandemic time, new practices need to be addressed to manage innovation and both timeless and openness become critical success factors to absorb environmental uncertainty (Chesbrough, 2020). Some managerial practices include stakeholders' involvement in value cocreation activities, boundary spanning to establish interorganisational knowledge exchanges and acquisition of dynamic capabilities.

However, the identification of key levers that support resilience and continuous adaptation to the environment is still changing for SMEs. Martinez-Lozada and Espinosa (2020) highlight the need for empirical studies to adopt systemic approaches aimed at dealing with and understanding the relationships among necessary components to build resilience in SMEs.

The study proposes relationships to shape organizational resilience (OR) in SMEs because the limited, yet emerging literature on SMEs in the wake of COVID-19 lacks in identification of a set of strategic responses that would bring about survival during and post pandemic (Fitriasari, 2020; Liguori and Pittz, 2020). The paper's purpose is critically important because SMEs are an essential part of the economic structure in countries across the globe and represent a crucial catalyst for socioeconomic development at local and global level (OECD, 2017).

The study clarifies the conditions enhancing SMEs' chances of survival in light of dynamic capability (DC) perspective and service logic. On the one hand, the DC theoretical paradigm (Teece and Pisano, 1994) can sustain a better understanding of how firms develop competitive capabilities by adopting new technologies, such as BDA capabilities. Moreover, we answer the call for future research on the opportunities and interlinkages associated with the digital technologies for SMEs (Zutshi *et al.*, 2021). On the other hand, service science (Spohrer and Maglio, 2008) points out the necessary shift of company strategies to collaborative and collective approaches, such as coinnovation (CI), that contribute to the survival when facing instability. In this regard, the adoption of innovative models of

interactions based on technological platforms of collaboration by SMEs has low consideration in literature, whereas it is a consolidated pattern within large companies (Del Vecchio *et al.*, 2018), despite the increasing attention toward policies supporting collaborative innovation in SMEs (De Marco *et al.*, 2020).

Moving from the research question on how SMEs can maintain business viability when faced with a critical event, a mediated regression analysis was conducted to investigate the relationships among BDA capabilities, CI and OR with reference to a sample of big data SMEs in Europe. The research shows the significant role of the BDA capabilities and CI as key drivers in developing the resilience of big data SMEs and, consequentially, their opportunities for surviving in a complex scenario. Then, the research extends the literature on OR in three directions. First, it provides important implications for considering CI as a viable strategy, especially in a time of crisis. Second, we show how big data SMEs are more able than other companies to seize business opportunities. Third, the microfoundations of the resilience building capacity of SMEs are identified. These microfoundations become recommendations for practitioners to help enhance SMEs' responsiveness in light of coronavirus-related crises.

The remainder of the paper is structured as follows: Section 2 provides an overview of BDA capability, CI and OR and the hypothesized relationships between them. Section 3describes the research methodology. Section 4 proceeds with the findings. Lastly, Section 5 covers the discussion together with the concluding remarks.

2. Theory and hypotheses

2.1 Big data analytics capability, coinnovation and organizational resilience

The BDA capability investigates the big data phenomenon focusing on the management and incorporation of big data into organizational processes, rather than on big data's computational and technological infrastructural aspects (Lozada *et al.*, 2019). In particular, the BDA capability refers to a company's management ability, that is, the ongoing deployment of big data resources at the strategic aims to create value and develop a competitive advantage for the firm (Wamba *et al.*, 2017). Thus, literature identifies tangible resources and infrastructure, human resources including people with both technical and managerial skills for big data and intangible resources such as data-driven culture and organizational learning (Gupta and George, 2016).

CI is linked to the approaches of open innovation internally and externally originated, based on the sharing of resources that are mainly intangible one (Chesbrough, 2003) and collaborative innovation coming from partnerships with various actors to share ideas and technical knowledge (Bonney *et al.*, 2007). Thus, CI refers to the process that allows the active participation of multiple actors (i.e. users, customers, suppliers, partner organizations, universities, etc.) in collaborative networks to create value in terms of new products, services, processes or business models (Saragih *et al.*, 2019).

OR represents a firm-level capability to adapt and/or dynamically relate to its environment (Williams *et al.*, 2017; Ciasullo *et al.*, 2020). It is a fuzzy concept that can be taken as an umbrella that encompasses many dimensions (Ramezani and Camarinha-Matos, 2020) such as:

- capacity to rebound from trauma and recover (i.e. stability);
- capability to maintain a desirable state (i.e. bouncing back to a new equilibrium condition or an accepted state); and
- capacity to withstand stress with the focus on persistence thresholds (i.e. gradual adaptation and transformation).

However, we consider resilience as a viable property of systems (such as organizations) that can be fostered even if dynamically orchestrated at intra- and interorganizational levels. Then, a resilient organization will always find "*ways to take chances and take advantage of situations*" (Aldianto *et al.*, 2021, p. 3). Focusing on SMEs, resilience is the successful adaptation in maintaining business viability by acquiring, generating and combining internal and external knowledge resources to perceive, explore and address rapidly changing environments.

2.2 Hypotheses development

2.2.1 Big data analytics capability and the hypothesized relationships. Business innovation has become a more inclusive process, in which different actors are involved in value cocreation practices, because of the increase in the use of big data and its incorporation into the core of the processes related to innovation management (Acharya *et al.*, 2018; Troisi *et al.*, 2021). More in depth, BDA capability and CI share a key and complementary feature: they are managed via digital platforms and both depend on how the company uses technology to achieve greater value and long-term competitive advantage. BDA capability also enhances the joint creation of knowledge applied to specific purposes: the company could offer valuable information provided by big data as an input to the cocreation of innovative solutions to problems or challenges stemming from the uncertain scenarios (Urbinati *et al.*, 2019; Dubey *et al.*, 2021). In this logic, BDA capability enables people participation in decision-making and problem-solving, also fostering organisational initiatives aimed to advance the extant sources of competitive advantage, such as CI. Therefore, as Figure 1 shows, we predict that:

H1. BDA capability is positively associated with co-innovation.

To help mitigate the effects generated by critical events, scholars suggest the shift to the digitalization as combination of digitization and actor connectivity (Liguori and Pittz, 2020; Papadopoulos *et al.*, 2020). The employment of integrated platforms (i.e. social media platforms, augmented reality, cloud computing platforms, artificial intelligence, Internet of Things, etc.) contributes to forecast change and provide the means for effective and efficient organizational responses by enabling flexible business processes, remote collaborations and real-time connectivity between all internal and external stakeholders involved in the firm's ecosystem (Ashrafi *et al.*, 2019). In sum, digitalization has the potential to reduce the magnitude and reach of

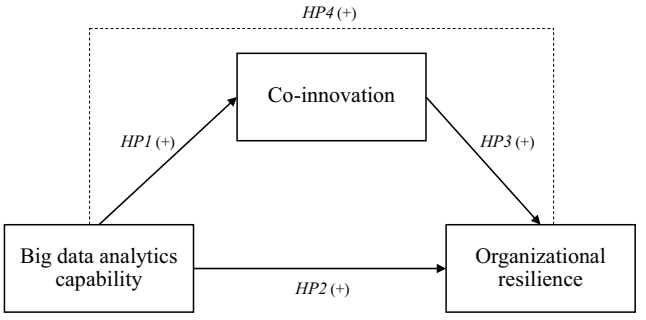

Figure 1.
The conceptual model

change, also increasing the agility and resilience of organization (Miceli *et al.*, 2021). Hence, as Figure 1 shows, we argue that:

H2. BDA capability is positively associated with organizational resilience.

2.2.2 Coinnovation and the hypothesized relationships. To overcome the crisis and even succeed in adverse times, innovation should be considered the top strategic priority (Lee and Trimi, 2021). By innovation, in fact, organizations can adapt to environmental changes and reduce the impact of threats and risks (Aldianto *et al.*, 2021) by improving organizational processes and dynamics. Anyway, in such a complex scenario, companies should not innovate in isolation, because the innovation resulting from collaboration and participation is much more effective than that which is undertaken on a solitary basis, especially in the time of crisis (Criado and Guevara-Gómez, 2021). In fact, innovative results are more effectively achieved by matching the sociotechnical processes of organization with external knowledge and skills in a network perspective (Iansiti and Levien, 2004) by shaping innovative ecosystems. Thus, the SMEs need for an out-of-the-box thinking nurtured by collaboration and positive contributions to the business continuity coming from users, customers, technological providers and so on. The ongoing experimentation leads to new ways of exploration that generate more knowledge (Chesbrough, 2020). In doing so, in fact, SMEs build and develop the dynamic abilities that allow preventing, anticipating, responding effectively to and survive an unforeseen situation. In this sense, openness becomes property of a system that aims to adapt to the constantly changing environment. Therefore, we predict that:

H3. Co-innovation is positively associated with organizational resilience.

In the digital age, innovation requires a creative integration of seemingly unrelated actors, idea, technologies to create extraordinary outcomes and possibilities (Lee and Trimi, 2018). Thus, innovation is based on the centrality of a complex and distributed reticulum of ties and relationships in which firms are embedded. In this context, big data represent the main driver of CI (Lozada *et al.*, 2019): in fact, the adoption of big data approaches and digital tools allows acquiring additional knowledge and skills for nurturing open and collaborative innovation strategies, so that new cooperative ecosystems emerge (Lacam, 2020).

The interconnection between big data and CI develops intentional and direct collaborative innovation processes as well as unintentional CI processes implemented by indirect relationships between actors (Chen *et al.*, 2019; Bresciani *et al.*, 2021). However, both direct and indirect forms of big data-driven CI permit to share knowledge resources that are incorporated into the data generated by customers, users and partners in digital and physical environments (Troisi *et al.*, 2018). In this direction, SMEs collaborate to access the data and analytical capabilities that support innovation efforts (Zeng and Glaister, 2018). In doing so, the barrier of high investments needed for the deployment of a data policy can be overcome (Caputo *et al.*, 2019).

The mix of big data and CI makes companies more competitive and paves the way to new entrepreneurial opportunities (Eftekhari and Bogers, 2015). In the case of SMEs, agile sociotechnical systems enable a fast adaptation to the increasing creation and storage of detailed and segmented data that allow the simulation of different innovation scenarios and analysis of the opportunities and risks coming from markets (Lacam, 2020), by improving the survival chances to the outside disturbances and threats. Consequently, we postulate that:

H4. Co-innovation positively mediates the relationship between BDA capability and organizational resilience.

3. Method

3.1 Sample selection and data collection

In January 2021, sample was extracted from Crunchbase database containing startups worldwide operating in technology and big data industries, already successfully used for research on entrepreneurship and COVID-19 crisis (Brown and Rocha, 2020; Kuckertz, 2021). We extracted European SMEs which have up to 250 employees and an annual turnover of up to €50 m or a balance sheet of no more than €43 m and represent the backbone of the European economy (European Commission, 2019). In addition, European SMEs have been directly affected by the COVID-19 outbreak on the supply and demand sides alike (OECD, 2020). These aspects make European SMEs interesting research setting to investigate the OR after the height of the coronavirus second wave. After data cleaning run in January 2021, 715 SMEs, for which information on contacts and industries were available, formed the sample.

3.2 Data collection

Field work was conducted between February 2021 and May 2021 through an online questionnaire uploaded onto an online survey platform and applied to chief executive officers, chief information officers, chief data officers, chief analytics officers, general managers, research and development directors and innovation managers.

The questionnaire consisted of three sections and 32 closed questions. The first section described the survey purpose, the identity of the researchers, the average time required to complete the survey and guarantees of the confidentiality of answers. The second section comprised five questions useful to define the sample profile in terms of industry, size, age and collaborative contracts' (CC) number and duration. The third section contained 13 questions on BDA capability, 11 questions on CI and three questions on OR. A pilot test was conducted involving a convenience sample of 20 executives. In total, 192 valid questionnaires were returned, representing a response rate of 26.8%. Table 1 shows the general profile of the respondent SMEs.

Table 1.
Sample profile

SME's characteristics	Categories	(%)
Industry	Industrial	44
	Service	56
Size (number of employees)	<10	22
	10–49	30
	50–250	48
Age (years)	1–5	27
	6–10	18
	11–15	16
	16–20	14
	21–25	11
	26–30	9
	>30	5

3.3 Measures

To measure each construct, we used items both derived from the literature and adapted from the original source (below list). BDA capability was the independent variable of the model measured by adopting the Singh and Singh's (2019) scale. For measuring CI, we used Abhari *et al.*'s (2017) scale in its original form. The OR as mediating variable was captured by adapting Melián-Alzola *et al.*'s (2020) scale. We made minor modifications in wording of the items based on the feedback from pretest to improve scale performance. All scales were designed in five-point Likert format anchored as 1 (strongly disagree) and 5 (strongly agree). Finally, CC number and duration (CC duration) were used as control variables.

Measurement items:

(1) Big data analytics capability (Singh and Singh, 2019)

- BDA1 Our firm invests in big data analytics software (e.g. SAS Enterprise Miner, Tableau).
- BDA2 Our firm invests in processes which ensure availability of high-quality and timely data for employees.
- BDA3 Our firm currently utilizes some form of distributed file systems (e.g. Hadoop Distributed File Systems - HDFS).
- BDA4 Our firm currently utilizes some form of distributed database systems (e.g. NoSQL or Cassandra).
- BDA5 Our firm has taken initiatives to increase pool of individuals skilled in big data analytics.
- BDA6 Our firm encourages employees to leverage their big data analytics skills to solve problems.
- BDA7 Our firm has managerial resources to take relevant actions on insights derived from big data analytics.
- BDA8 Our firm incentivizes employees to get certified in big data analytics technologies.
- BDA9 Our firm's top management encourages employee to come up with innovative big data initiatives.
- BDA10 Our firm focuses on forging strategic contacts with analytics knowledge leaders in the field.
- BDA11 Our firm invests in documenting processes and procedures for big data analytics.
- BDA12 Our firm invests in knowledge management systems.
- BDA13 Our firm participates in big data analytics conferences.

(2) Co-innovation (Abhari *et al.*, 2017)

- CO1 The platform enables me to submit new product ideas.
- CO2 The platform enables me to describe/present my product ideas.
- CO3 The platform enables me to monitor my idea evaluation process.
- CO4 The platform enables me to revise/resubmit my product ideas.
- CO5 The platform enables me to review different product ideas.
- CO6 The platform enables me to vote for different product ideas.

- CO7 The platform enables me to contribute to product design/development.
- CO8 The platform enables me to contribute to product commercialization.
- CO9 The platform enables me to share my knowledge.
- CO10 The platform enables me to solicit votes/support.
- CO11 The platform enables me to discuss new ideas with community.

(3) Organizational resilience (adapted from Melián-Alzola *et al.*, 2020).

- OR1 In the face of change, our firm achieves a new organisational equilibrium by adapting to changes in the environment (e.g. offering new products or services, incorporating new technologies, negotiating with key actors).
- OR2 In the face of change, our firm recovers and strengthens at a strategic and operational level (e.g. recovering market share, improving its competitive position).
- OR3 In the face of change, our firm adapts strategically and operationally to new environmental conditions.

3.4 Data analysis

A mediation analysis is adopted using the PROCESS macro in SPSS v 22 software package (Hayes, 2017). The mediation analysis allows going beyond the descriptive to a more functional understanding of the relationships among variables (Preacher and Hayes, 2004).

4. Findings

Table 2 presents descriptive statistics and correlations for the key variables used. All correlation coefficients are well under 0.7, indicating that there is no serious multicollinearity.

Table 3 shows that the relationships between BDA and CI (*H1*), between CI and OR (*H3*) and between BDA and OR (*H2*) were significant, as regression analyses confirmed [respectively, equation (1)–(3)]. The relationship between BDA, CI and OR (*H4*) was nonsignificant when the CI was introduced in the regression model [equation (3)]. It holds the conditions necessary for mediation according to Baron and Kenny (1986). The control variables were included in all the equations used but only CC duration was positive.

To establish whether the mediation was significant, the three effects of mediation analysis were calculated as Table 4 displays. The results revealed a significant direct effect of BDA on OR when controlling for CI. This supports the prediction that CI mediates the effect of BDA on OR. Specifically, 44% of the total effect is mediated by CI.

Table 2. Descriptive statistics and correlation matrix

Variable	Mean	SD	1	2	3
BDA	3.754	0.622	1.00		
CI	4.116	0.314	0.294	1.00	
OR	3.602	0.400	0.127	0.152	1.00

Notes: Number of observations = 192; Std. dev. = standard deviation

5. Discussion and conclusion

Findings support the research hypotheses based on review of managerial and strategic literature, painting an interesting picture of the linkages between BDA capability, OR and CI in SMEs coping with adversities.

The positive significant impact of BDA capability on CI is confirmed in line with prior contributions, which also claimed the same positive linkage (Urbinati *et al.*, 2019; Akhtar *et al.*, 2019; Lozada *et al.*, 2019). Thus, CI can be activated through BDA capability that actualizes colearning activities in a domain of knowledge characterized by the intensive and shared use of data, managing digital tools and technological platforms among and between companies, users, customers and other socioeconomic actors to exchange and integrate resources, ideas and information for cooperative innovating (Saragih and Tan, 2018). In this logic, BDA capability helps in sharing knowledge, especially through data integration and data analysis (Merhi and Bregu, 2020), to improve the innovation response and optimise business processes to achieve dynamic capabilities (Božič and Dimovski, 2019). Hence, BDA capability acts as a knowledge asset of strategic importance for CI processes, increasing the absorptive capacity of the companies and reducing their time, costs and risks (Troisi *et al.*, 2018; Chen *et al.*, 2019).

In addition, the study results have corroborated the positive significant impact of CI on OR. Hence, CI can be considered as a new approach for successfully managing uncertainties because CI contributes to organizational capacity for resilience. An opportunity for a faster and easier overcoming of the crisis adverse consequences in SMEs entails their greater openness (Paunović and Aničić, 2021). Chesbrough (2020) highlights an even greater significance of opening up in innovation management during the crisis recovery periods.

Research outcome also supported the positive significant impact of BDA capability on OR, enhancing the known linkage between data analytics and resilience (Papadopoulos

	Dependent variables		
Independent/control variables	Equation (1) (*H1*) CI	Equation (2) (*H2*) OR	Equation (3) (*H3, H4*) OR
CI			0.247 (0.000)
BDA	0.074 (0.000)	0.066 (0.004)	0.038 (0.191)
CC number	0.019 (0.605)	0.270 (0.915)	0.156 (0.188)
CC duration	0.421 (0.000)	0.340 (0.000)	0.128 (0.003)
Adjusted R^2	0.470	0.083	0.402
F-value	50.876 (0.000)	6.461 (0.000)	41.669 (0.000)

Note: The table shows standard coefficients and significance in parentheses

Table 3. Regressions associated with the hypotheses

Type of effect	Level of effect	SE	LLCI	ULCI	*P*
Total effect of BDA on OR	0.4848	0.0708	0.3455	0.6242	0.000
Direct effect of BDA on OR	0.2694	0.0646	0.1423	0.3965	0.000
	Level of effect	Boot SE	Boot LLCI	BOOT ULCI	
Indirect effect of BDA on OR	0.2155	0.0403	0.1436	0.3037	

Notes: Confidence interval to 95%; number of bootstrap samples 5,000

Table 4. Total, direct and indirect effects

et al., 2020). According to this evidence, the cyber resilience is proposed to indicate how interconnected hardware (i.e. infrastructure) and software (i.e. capability) components of BDA constitute a gateway for business viability. This concerns all industries investigated: in fact, not only service SMEs but also industrial one demonstrates to be aware of the pivotal importance to shift from hardware to software via digitalization, as digital servitization literature confirms (Ciasullo *et al.*, 2021; Gebauer *et al.*, 2021).

Finally, the study discovered the mediating impact of CI on the relationship between BDA capability and OR. A duality view (Farjoun, 2010) is adopted to interpret the mediating role of CI: it is oriented to the adaptability in the face of change due the impact of BDA capability on CI; at the same time, it is oriented to the stability due its impact on OR. Thus, the orientation to stability and adaptability referred to CI are interdependent and mutually enabling rather than contradictory. This complementarity starts a virtuous cycle with regard to the management of change, contributing to the coevolution of open knowledge ecosystems.

Overall, research findings suggest the conceptual evolution of the resilience from viable property to metacapability of systems under specific conditions. Depending on such conditions, resilience as metacapability can be a source of sustainable competitive advantage and, thus, explains why some firms are more resilient and thereby more successful than others (Duchek, 2020). The above-mentioned conditions are related to the synergistic and systematic combination of entrepreneurial and service orientations. In particular, entrepreneurial orientation consists of the innovativeness, proactiveness and risk willingness, whereas service orientation embraces responsive approaches to satisfy immediate actor needs and proactive approaches that overcome these needs (Eggers, 2020). Both orientations are amplified, thanks to the BDA capability by reinforcing a data-driven culture. Thus, inside–out and outside–in knowledge flows are incorporated into and dynamically orchestrated through integrated platforms by shaping a wider and varied knowledge base, even if this knowledge is far away from the system's core business. This leads to an enrichment of the learning activities and a collective sensemaking that put new knowledge into innovative practice actualized in new products, services, processes, solutions, value propositions, markets and business models. On these bases, we introduce technical and managerial cognition capabilities as forming the microfoundations of OR of SMEs in the face of a "black swan" external shock.

5.1 Theoretical implications

The paper contributes to the literature on OR in three directions. First, it provides implications for considering CI as a viable strategy, especially in a time of crisis. This important theoretical implication is in line with Ferrigno and Cucino (2021) who investigated SME innovation in a context of crisis by emphasizing how SMEs have implemented collaborative behaviors to develop innovative projects during the recent COVID-19 outbreak. Second, we show how big data SMEs are more able than other companies to recognize business opportunities in line with Eggers (2020). Third, the microfoundations of the resilience building capacity of SMEs are identified.

In addition, this study enhances the body of knowledge on how SMEs cope with adversity by emphasizing some strategic issues of potential of BDA capability for overcoming the COVID-19 pandemic impact, whereas the emerging literature has mainly addressed the role of digital technology as a structural tool. Thus, the study moves away from the main current of analysis focused on big data from a technical or engineering perspective, but rather focuses on delving into the explanation of big data implications as an organizational capability typical of the networks supporting CI. Moreover, although the

adversities call for greater focus on using technologies to enhance SMEs' resilience, we underline the essential role played by CI because digital technologies alone are not sufficient to resolve the barriers to the resilience of such companies. Finally, the paper is the first empirical work that tests the research model in its current forms, despite previous studies have independently studied the relationships among the variables used.

5.2 Managerial implications

Practically, we propose recommendations for building strategic resilience effectively and efficiently in SMEs, looking at the COVID-19 as an opportunity to rethink strategies and plans in response to the crisis. The most important challenge for the management is to develop a data-driven culture and a digital preparedness both within the firm and in the entire CI network to safeguard business resilience. Despite the COVID-19 pandemic has had unprecedented impacts on business and economies (Lim, 2021), the marketplace has already been volatile, uncertain, ambiguous and complex prior to the pandemic and will likely continue in the post pandemic era (Kumar *et al.*, 2021). In this regard, it is important that SMEs continue to leverage on BDA to coinnovate and remain resilient in the future. SMEs can do so by using the capabilities gained and enhanced during the pandemic to empower other functional areas of business so that new capabilities and strategies can be pursued, for example, challenger marketing, which relies on knowledge infrastructures by BDA to empower marketers to unteach and teach customers in favor of products offered by challenger SMEs.

5.3 Limitations and further research

The main limitation of the study is related to the generalization of the results for three reasons. First, the hypothesis model was tested in a sample of SMEs located in Europe. In future, the research could be replicated on SMEs in non-European developed and developing countries, also conducting a comparison with large companies. Second, the impact of the crisis varies substantially across industries and this will require detailed sectoral analyses. Moreover, COVID-19 was chosen as study setting but minor-scale disturbances could influence the firm's response to build resilience. Third, the fast growth rate of technological techniques and the young field of big data management represent a limitation *per se*.

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