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Dynamic digital capabilities and supply chain resilience: The role of government effectiveness

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A R T I C L E I N F O

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A B S T R A C T

Organizations in recent times are increasingly investing in building supply chain resilience following disruptions due to natural disasters, geo-political crises, and pandemics. A lack of government support has exacerbated the disruption to supply chains in some regions of the world. The positive influence of digitalization on social inclusion, government accountability, and creating a more open environment is well understood. Despite this, different countries have shown varying degrees of digital responsiveness during the pandemic as they attempted to deal with the effects of various COVID strains. The influence of government policies on the supply chain has not been examined in the literature so far and, hence, to address this research gap, we examine the interaction effect of government support effectiveness i.e., tax credits, interest deferral, digital investment, soft loans on dynamic capabilities i.e., digital adaptabilities and digital agilities and on supply chain resilience, using a multi-method approach. To understand how digital adaptability and agility improve supply chain resilience, we conducted 13 semi-structured interviews. Additionally, we pretested our measurement instrument using qualitative semi-structured interviews to validate our hypothesized relationships. We collected data at a specific point of time using a survey-based instrument (N = 203) to address our research questions. Based on data analyses of both the qualitative and survey-based data, our findings indicate that digital adaptability is an important driver of digital agility. Furthermore, the results indicate that government effectiveness is crucial to enhancing supply chain resilience by enhancing digital adaptability and agility. Our research makes some useful contributions to the dynamic capability view by enhancing theoretical understanding, of the role of government in building digital capabilities in uncertain times, to improve supply chain resilience. It also bridges the research gaps between macro and micro perspectives, as identified by management scholars. Lastly, we noted the weaknesses and limitations in the study and therefore we have offered multiple research directions forward, that could help researchers to further develop our current work.

1. Introduction

In recent times, academics and policymakers have paid significant attention to the turbulence in the supply chain resulting from various sources of disruption (Tang, 2006; Ivanov and Dolgui, 2022; Xu et al., 2022). The turbulence in a supply chain is often commonly referred to as: "*supply chain disruption*". Craighead et al. (2007, p. 132) defined supply chain disruption as follows: " …. *supply chain disruptions are unplanned and unanticipated events that disrupt the normal flow of goods and materials within a supply chain*". We have witnessed severe disasters in the form of earthquakes, floods, tsunamis, terrorist attacks, SARS, financial crises, geopolitical crises, and more recently the COVID-19

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crisis. Supply chain disruptions have occurred at different times for various reasons (Tomlin, 2006; Chopra and Sodhi, 2014). Some are man-made such as wars and terrorism whilst others are natural events such as hurricanes, earthquakes, and pandemics. The effects of both kinds of disruptions may be short-term or long-term and can be detrimental to the organization's performance (Craighead et al., 2007).

To tackle such kinds of supply chain disruptions, organizations have significantly invested in building capabilities to reduce the damaging impacts of such disasters on supply chain performance (Ambulkar et al., 2015; Ivanov et al., 2017, 2021; Ivanov and Keskin, 2023). For instance, the Chinese firm JD.com during the pandemic crisis have tackled the demand and supply uncertainties, resulting from COVID-19. They have done this in China and worldwide, through a coordinated supply chain design based on a digital-enabled platform (see, Shen and Sun, 2021). As a result of the COVID-19 crisis, the role of emerging technologies has increased significantly in all parts of life (Lee and Trimi, 2021; Papadopoulos et al., 2020; Dubey et al., 2021; Ivanov, 2022; Ivanov et al., 2022; Ivanov and Dolgui, 2022, 2022a). According to Choi (2021), some businesses have even attempted to transform their business models with digital-enabled disruptive technologies, so that employees can coordinate business activities continuously. In developing economies like India, top manufacturing firms like Tata Steel have significantly invested in digital-enabled technologies throughout their steel manufacturing plants and mines. Tata Steel have also provided a safe working environment to their employees amidst growing COVID-19 cases and the threat this posed to productivity (The Economic Times, 2020).

Many such initiatives across the globe demonstrate the role of digital-enabled technologies to improve resilience (Ivanov and Dolgui, 2022a). By allowing existing supply chain networks to cope with long-term disruptions such as the pandemic, that are on a scale and length that we have not faced in peacetime (Dilyard et al., 2021). Sousa-Zomer et al. (2020) argue that successful digital transformation initiatives result in sustained and improved performance. The practitioner-based literature reports the success as well as the failure of digital transformation in businesses (Bharadwaj et al., 2013; Hess et al., 2016). This is because integrating and exploiting such new digital technologies often presents complex challenges to the organization (Van Alstyne et al., 2016). As a result, digital technologies, especially during the COVID-19 crisis, have become one of a top management team's key priorities (Fernandez and Shaw, 2020; Papadopoulos et al., 2020; Chaubey and Sahoo, 2021).

Despite its increase in popularity, the role of digital technologies in enhancing supply chain resilience remains poorly understood both in theory and its application (Ivanov et al., 2019; Shen and Sun, 2021; Dolgui and Ivanov, 2022; Queiroz et al., 2022; Minner, 2022; Battistoni et al., 2023). Kamalahmadi and Parast (2016, p. 121) define supply chain resilience as: "… *the adaptive capability of a supply chain (SC) to reduce the probability of facing sudden disturbances, daresisting the spread of disturbances by maintaining control over structures and functions, and to recover and respond by immediate and effective reactive plans to transcend the disturbance and restore the SC to a robust state of operations*". Hence, we argue that a resilient supply chain can absorb sudden disruption and regain its original configuration, resulting in competitive advantages (Hägele et al., 2023). Balakrishnan and Ramanathan (2021) argue that digital technologies have played a significant role in improving supply chain resilience during the pandemic crisis resulting from various strains of COVID. To sustain a competitive advantage during turbulent times, organizations need to invest in upgrading their digital capabilities (Warner and Wäger, 2019; Ivanov, 2021; Queiroz et al., 2021). Hence, we understand that organizations need to develop both their digital abilities and adaptabilities to enhance supply chain resilience to remain competitive in the digital era. Despite the rich body of literature on digital capabilities and how to build them (Büyüközkan and Göçer, 2018), there are few, if any, empirical studies utilizing hard factual data to confirm the largely anecdotal evidence. This is one of the research gaps we have identified. Our first research question (RQ1) aims to bridge this gap.

RQ1. *What are the effects of digital capabilities on supply chain resilience?*

Effective governance is all about efficient labour division, more investment, and quick implementation of social and economic issues, which help accelerate economic growth (Kaufmann et al., 2010; Wen et al., 2021). Wen et al. (2021) argues that technological innovation in the last few decades has played a significant role in the growth of economies. Institutional scholars clearly advocate the role of institutional machinery in the advancement of technological innovation and its influence on economic growth (Galang, 2012; Wen et al., 2021). Government effectiveness is regarded as one of the important indicators of effective governance (Langbein and Knack, 2010; Galang, 2012).

Garcia-Sanchez et al. (2013, p. 574) argue that: "… *government effectiveness is associated with a countries' economic and social growth, and this reflects that public organizations and their personnel perform actions and procedures of their mission well, that is, by achieving social well-being*". Government policies shape human interactions, which affect the incentives of economic agents (Alam et al., 2017). Kaufmann et al. (2010) argue that institutions and government policies shape their economic environment. For instance, national banks offering soft loans to firms to invest in digital capabilities so they are in a better position to tackle the challenges resulting from the COVID-19 crisis. In turn, the common citizen acquires skills, and firms can build their capital reserves and generate more output. Hence, an effective government creates the right social, economic, and technological conditions to foster economic growth for both the public and private sectors. Policy effectiveness attracts investment which fuels growth and generates employment opportunities. To generate significant output, government policies should encourage investment in cutting-edge technology and robust digital infrastructure to support significant business growth (Brunetti et al., 2020; Grover and Sabherwal, 2020).

By way of a contrast, poor governments can hinder growth if there is a lack of transparency in their policies. This might create a sense of insecurity and reduce trust in the mind of investors, which might discourage them from investing further in the social and economic system of a nation (Bénabou and Tirole, 2016). This kind of social and economic environment impacts the motivation of the common citizen to go and acquire new skills and makes private firms skeptical about investing in technology. Technology adoption is therefore significantly influenced by government agencies' efficiency and effectiveness (Galang, 2012). Poor government agencies often delay their investment in key cyber-technical and human resource (skills) infrastructure, which are critical for developing digital capabilities (Mazzucato and Kattel, 2020).

Inefficiency and a lack of government effectiveness contributes to the digital divide in society (Beaunoyer et al., 2020). Paradoxically, digital technologies have further accelerated the involvement of government and non-government organizations in the development of more sustainable societies (Van Ooijen et al., 2019; Dwivedi et al., 2022a). During the COVID-19 crisis, we have seen that different countries have adopted differing approaches to tackle issues resulting from strict social distancing practices and lock downs, aiming to minimize the negative effect on the economy through changing patterns of work from the office to home. This has increased the reliance of managers and workers on digital tools and technologies, with the need for them to quickly acquire the skills needed to conduct their job function often at home.

This support may take the form of deferred tax payments, offering loan capital to invest in digital capabilities, and rebates on "demurrage expenses" or "wharfage charges" resulting from social distancing norms and lock downs. Through such initiatives organizations can seize the untapped potential of digital tools and technologies to change where and how people work (Shareef et al., 2021; Mansour, 2022). Whilst there is a rich body of literature on the role of digital capabilities in enhancing supply chain resilience (Balakrishnan and Ramanathan, 2021; Dennehy et al., 2021; Zouari et al., 2021), studies on the role of government policy effectiveness in building supply chain resilience through digital transformation are rare. We note this as a clear research gap. Therefore, we propose our second research question as follows.

RQ2. What are the impacts of government policy effectiveness on the relationship between digital capabilities and supply chain resilience?

We have gathered data: qualitative and quantitative to answer RQ1 and RQ2 from Indian Cement manufacturing firms. To support the theoretical framework, our research hypotheses informed by the dynamic capability view (DCV) (Teece et al., 1997; Schilke, 2014).

Our study builds on previous literature concerning digital adaptability, digital agility, supply chain resilience, and government effectiveness. Hence, we advance theoretical understanding at the intersection of operations management with information management (Kumar et al., 2018). Our data shows that digital agility is often regarded as useful for uncertain environments (Warner and Wäger, 2019; Grover and Sabherwal, 2020; Grover, 2022). We propose that digital agility capability under the influence of digital adaptability plays a significant role in building supply chain resilience during uncertain environments.

Previous studies have acknowledged the need to build digital agility capability. However, this literature fails to acknowledge that digital adaptability is the key to building digital agility. The ability to achieve technological change in a dynamic environment is critical to dynamic agility and supply chain resilience. A large body of literature acknowledges the government's role in adopting technological innovation (Galang, 2012; Wen et al., 2021). However, there is a lack of understanding of issues related to the role of government policy effectiveness on the impact of digital adaptability and digital agility on supply chain resilience. Our data suggest that government effectiveness plays a significant role in enhancing the effects of digital agility and digital adaptability on supply chain resilience. The organization of the article is presented below in Fig. 1. As outlined in the figure the article contains six sections covering the theoretical approach, methods, analysis, discussion, future research areas and limitations, and finally the conclusion. In the next section we present the theoretical framework and associated research hypotheses.

2. Theoretical framework and research hypotheses

The central interest of mainstream research is whether digital capabilities can enhance supply chain resilience. We have proposed a theoretical framework in which we have directly linked digital adaptability (DADAP) with digital agility (DAGIL) and supply chain resilience (SCR) (see Fig. 2). Our theoretical framework is informed by the dynamic capability view. Following Teece et al. (1997) the dynamic capability view (DCV) has gained significant attention from organizational scholars. Organizations often develop dynamic capabilities when exposed to highly competitive pressures and dynamic environments by integrating, building, and reconfiguring internal and external competencies (Teece et al., 1997; Eisenhardt and Martin, 2000). The DCV is often considered an extension of the resource-based view (RBV) (Barney, 1991; Peteraf, 1993).

RBV is a popular theoretical lens that helps understand how the combination of resources and capabilities generates superior performance (Hitt et al., 2016; Chahal et al., 2020). It assumes that organizational resources are difficult to replicate (Barney, 1991). However, the RBV does not offer an adequate explanation of how resources and capabilities sustain competitive advantage in the highly turbulent environment (Eisenhardt and Martin, 2000; Zhou and Li, 2010; Schilke, 2014). Critics further argue that RBV does not provide an adequate explanation for the differential outcomes occurring, even though there is interplay of the same resources, in different settings (see, Aragon-Correa and Sharma, 2003; Brandon-Jones et al., 2014). Ling-Yee (2007, p. 360) further referred to this condition as "*contextual insensitivity*". Hence, it is understood that in a rapidly changing environment, too much focus on building existing resources may limit the firm's ability to transform its capabilities to exploit new market opportunities (Zhou and Li, 2010).

Thus, the DCV is considered a better perspective for analyzing dynamic market conditions than the RBV. However, creating dynamic capabilities is highly complex. Therefore, such an approach poses a significant challenge to those practitioners engaged in building dynamic capabilities to achieve a desired competitive advantage (Di Stefano et al., 2014). Teece (2014) argues that a dynamic capability is a higher-order capability. That is grounded in the earlier conception of DCV proposed by Teece et al. (1997). Therefore it acts as a theory of competitive advantage of a firm operating in a highly dynamic and turbulent environment (Fosso Wamba et al., 2020).

We can argue that the dynamic capabilities of a firm are those capabilities that allow the firm: "… *to integrate, build, and reconfigure internal and external resources/competencies to address, and possibly shape, rapidly changing business environments*" (Teece, 2012, p. 1395). Based on Teece (2018, p. 43) we argue that: "… *dynamic capabilities are multi-faceted, and firms will not necessarily be strong across all types. A firm might excel at sensing new opportunities but be relatively weak at identifying new business models to exploit them. Or a firm might be good at developing new business models yet be mediocre at implementing and refining them*".

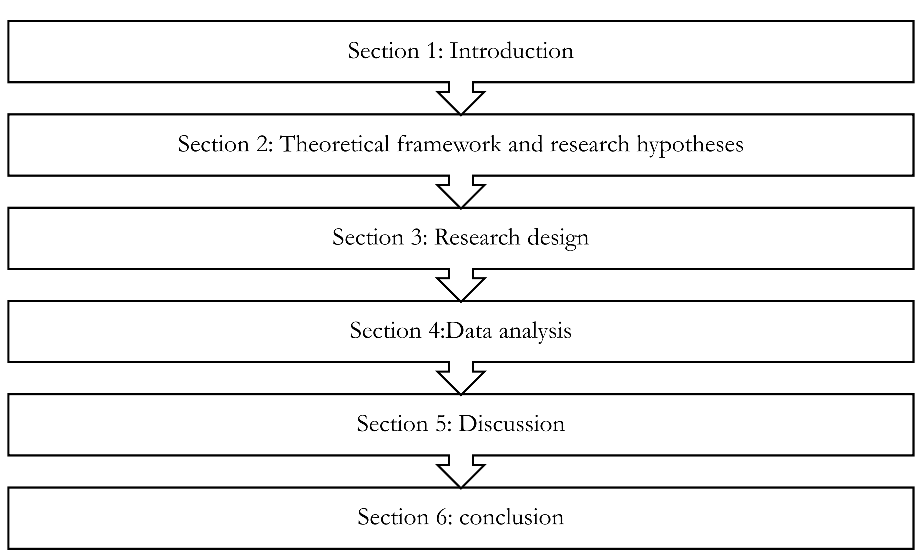

Fig. 1. Organization of the manuscript.

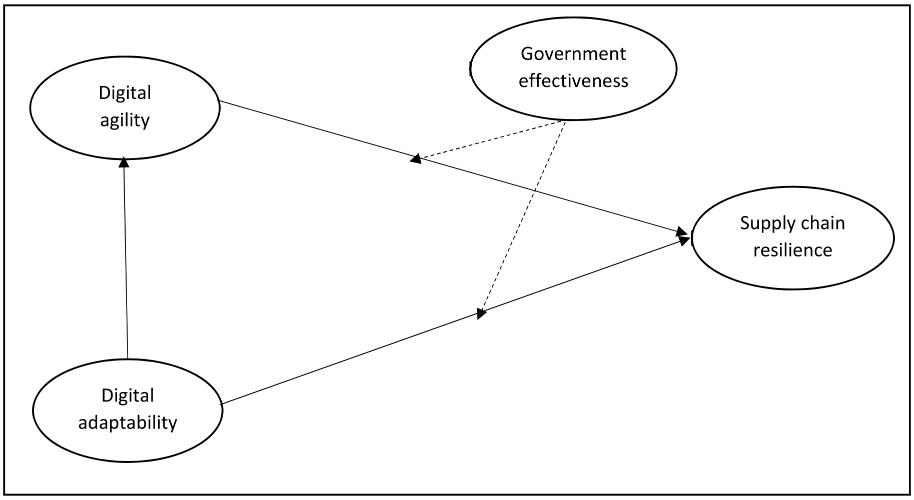

Fig. 2. Theoretical framework.

Hence, we argue that strong dynamic capabilities must have strong sensing, seizing, and transforming abilities. To provide clarity, we provide the definition of some important key terms used in our study (see Table 1).

Table 1
Key definition.

Digital technologies (Warner and Wäger, 2019, c.f. Bharadwaj et al., 2013, p. 471, p. 471)	*"Digital technologies are defined as a combination of information, computing, communication, and connectivity technologies that can transform business strategies, business processes, firm capabilities, products and services, and key interfirm relationships in extended business network"*.
Digital capability (Sousa-Zomer et al., 2020)	Digital capability is defined as the ability of the organization to use digital technologies to gain a competitive advantage in the digital environment.
Digital agility (DAGL) (Grover, 2022, p. 709, p. 709)	*Digital agility is characterized by: "… four tenets that characterize agile organizations: modular design and packaged capabilities, use of platforms over pipelines, ability to foster concurrency and agency through data, and a digital culture that promotes ambidexterity"*.
Digital adaptability (DADAP) (Lee, 2021; Puckett, 2022)	The capability of an organization to adjust its approach towards the dynamic situation, powered by digital technologies is termed digital adaptability. The tenets of digital adaptability are the learning abilities of the organization to adapt to new technologies to improve their supplier relationships, customer relationships, and new product development capabilities in the wake of dynamic changes in the market due to various reasons that include trade restrictions, natural disasters, geopolitical crises, or pandemics.
Digital culture (Grover, 2022, p. 712, p. 712)	*"Digital culture has been described as a distinct type of culture that reflects a digital mindset"*.
Supply chain resilience (SCR) (Ponomarov and Holcomb, 2009, p. 131, p. 131)	*"Supply chain resilience is defined as the adaptive capability of the supply chain to prepare for unexpected events, respond to disruptions, and recover from them by maintaining continuity of operations at the desired level of connectedness and control over structure and function"*.
Government effectiveness (GOVE) (Garcia-Sanchez et al., 2013, p. 567, p. 567)	*"The notion of government policy effectiveness is oriented to more closely matching services with citizen preferences and moving governments closer to the people they are intended to serve, thus ensuring greater accountability of the public sector"*.

2.1. Theoretical framework and underpinning theory

We have conceptualized the theoretical framework to bridge the research gaps that we have noted in our study. Throughout this section, we explain each category of the model together with the associated hypotheses for further testing and the control variables. Before this, we detail the underpinning theory behind the model.

2.1.1. Underpinning digital capability theory

We have witnessed an exponential rise in the application of emerging technologies, such as electronic communication devices, big data and predictive analytics tools, artificial intelligence, cloud technology, distributed ledger technology, and robotic process automation to tackle the problems of complex business processes and the high degree of external uncertainties (Holmström et al., 2019; Warner and Wäger, 2019; Sousa-Zomer et al., 2020; Ivanov and Dolgui, 2021a, 2021b; Krakowski et al., 2022).

Digital capability is often referred to as the abilities of digital technologies that respond to rapid change in the external environment (Warner and Wäger, 2019; Gillani et al., 2020; Ye et al., 2022). Warner and Wäger (2019) have attempted to provide an operational definition of digital capabilities based on the classical definition of DCV (Teece et al., 1997; Eisenhardt and Martin, 2000). Furthermore, Sousa-Zomer et al. (2020) attempted to operationalize the definition of digital capabilities. Overall, the most important dimension that characterizes digital technologies in the current scenario of continual disruption is the ability to sense changes in the external environment.

Birkinshaw et al. (2016) argues that sensing capabilities help with scanning the external environment for unexpected events that could disrupt the organization. Teece and Linden (2017) argue that sensing occurs at all levels of the organization. Whereby the lower-level managers provide information and detailed insights to their middle and top-level managers. Dong et al. (2016) further argue that sensing capabilities are not only built with the support of the internal members of the organization, but they can also be strengthened through cooperation with partners in the entire value chain.

Teece (2018) argues that business model innovation takes more time to evolve compared to technological innovation. This may be due to the nature of business model innovation which is far more context-based, and more disruptive, but also more difficult to imitate in comparison to technology innovation. Hence, digital capabilities must possess the seizing ability. In simple words seizing capability is,"… *where action and commitment enter the picture while accounting for the very real risk of pursuing dead-end strategies based on incomplete or biased information*" (Day and Schoemaker, 2016, p. 63).

2.2. Digital adaptability (DADAP)

We argue that digital transformation, which relies upon the extensive application of digital technologies to tackle complex changes in the environment recognizes digital adaptability and digital agility, as their core competencies. Fainshmidt et al. (2016) argues that like resources then dynamic capabilities can be classified into higher-lower order levels. Despite increasing interest among scholars investigating dynamic capabilities and their characteristics, the different levels of dynamic capabilities are not well understood. Our study conceptually defines digital adaptability as a higher-order and digital agility as a lower-order dynamic capability. Therefore, we argue that digital adaptability generates higher performance outcomes, directly and indirectly through lower-order dynamic capabilities.

Following COVID-19, the recovery from it and the geopolitical crisis caused by the Ukraine War, organizations across the globe are facing enormous challenges in responding to rapidly changing customer demand and buyer expectations whilst also achieving efficiencies in their supply chains (Tate et al., 2022). In response to both long-term and short-term crises, organizations are extensively expanding their global network of suppliers, distribution centres, warehouses, and manufacturing units. They are increasing inventory throughout their supply chain and building storage capacity to counter growing uncertainty and geo-political risks. As well as buffering growing risks in their supply chain they are trying to deal with customers' needs efficiently and effectively (Rapaccini et al., 2020; Ardolino et al., 2022).

The recent situation of a series of disruption shocks since 2016 (i.e., Brexit, US-China trade War, COVID-19, post-COVID recovery, Ukraine-Russia War) has contributed to increased complexity and uncertainty of managerial and operational decision making and threats to their KPI's. That is being amplified throughout the global supply chain network (Kano et al., 2022; Tate et al., 2022; Tseng et al., 2022). To tackle this era of ongoing disruption, organizations are now under pressure to quickly adapt their supply chain know-how, strategies, capabilities, and assets. Lee (2021, p. 175) argues that: "… *another critical dimension of quick adaptation is the integration of supply, innovation, and demand*".

Digital technologies help organizations adapt to the new trading norms resulting from the pandemic and the ongoing geopolitical crisis in Ukraine resulting in rising energy and food prices. For instance, the rise in geopolitical risks, whilst prior 2016 we saw the rise of the free trade/low barrier/efficient transactions global supply chain. Now we are observing the transactional costs of trade increase through embargoes and barriers posed on Russia, retrenchment in trade between the West with China (i.e., tariffs and quota increases) and institutional trends – and infrastructure investments towards protectionism in the US and EU (For instance, indigenous semi-conductor and car battery plant development).

This is leading to pressure being placed on organizations by institutions such as the US government, EU, NATO, UK, Japan, and Taiwan to explore ways to decouple Russia, its suppliers, indirect suppliers (in China) and distributors from their supply chain. To begin re-routing their trade and freight flows away from Russia as organizations start to reconfigure their global supply network design. For instance, targeted sanctions on specific technologies, financial sanctions and 'self-sanctioning' by private companies are effectively decoupling Russia from supplies of high-tech goods.

Hence, we try to define digital adaptability as the capability of the organization to sense long-term changes in their demand and supply situations (e.g., economic situations, geopolitical equations, rapid changes in consumption and production behaviours, technological advances etc), and to tackle such changes by flexibly adjusting the configuration of their organizational structures (e.g., developing alternate sources, relocating production facilities, identifying new market base) (Alfalla-Luque et al., 2018; Aslam et al., 2018).

Therefore, digital technologies play a significant role in structural sensing, which is crucial for organizational adaptability (Ivanov, 2022; Choi et al., 2022). Hence, we define digital adaptability as the ability of the organization to cope with long-term, fundamental changes, such as structural shifts in their markets due to unprecedented events.

2.3. Digital agility (DAGL)

Organizational agility is defined as a unique capability that prepares the organization to sense the dynamic changes in their environment and to rapidly respond to the changes, by reconfiguring resources and processes and/or by building strategic partnerships (Teece et al., 2016; Alfalla-Luque et al., 2018; Fosso Wamba and Akter, 2019; Fosso Wamba et al., 2020). Roberts and Grover (2012, p. 232) further explain that firms demonstrating agility are those that: "… *can adapt to and perform well in rapidly changing environments by capitalizing on opportunities for innovation and competitive action, such as launching new products and services, entering new market segments, and developing strategic alliances*". In simple words, agility may be viewed as an organizational capability (Teece et al., 2016) and a set of organizational activities that generate output (Roberts and Grover, 2012). Indeed, sensing capability along with speed are considered important aspects of agility (Roberts and Grover, 2012).

Besides these two characteristics, the existing literature also considers seizing capability as one of the desired capabilities. For instance, Sambamurthy et al. (2003) argue that organizational agility serves as a means to sense new opportunities for innovation. That can be used to seize emerging opportunities by creating a bundle of tangible and intangible resources and collaboration with both speed and surprise.

Organizational agility is often considered an extension of organizational flexibility since it allows any organization to adapt its internal processes and structures to dynamic changes in the environment (Lu and Ramamurthy, 2011). Teece et al. (2016) further argue that organizational agility emphasizes an entrepreneurial mindset whilst making important decisions in a highly uncertain environment.

Organizational agility can be further enhanced by several IT-enabled supporting, monitoring, or learning systems (Lu and Ramamurthy, 2011; Fosso Wamba and Akter, 2019; Grover, 2022). Hence, we can argue that information technology (IT) becomes essential in building the digital platform that shapes agility within an organization. For instance, Lee (2021, p. 175) defined agility in the digital era as: "… *digital technologies such as the IoT, big data, and artificial intelligence that enable fast and smart sensing of both demand and supply conditions in real-time*".

Therefore, digital agility can be defined as organizational capability powered by digital technologies that enable the organization to rapidly sense, seize and transform emerging opportunities and reduce their risks in a highly turbulent environment.

2.4. Digital adaptability, digital agility, and supply chain resilience

We grounded our arguments based on the theoretical tenets of dynamic capabilities proposed by Fainshmidt et al. (2016). In this study, we theorize dynamic *adaptability* as a higher-order capability that directly influences supply chain resilience, whereas we theorize dynamic agility as a lower-order capability that partially mediates between digital adaptability and supply chain resilience. Whilst there is limited understanding of the effect of digital adaptability on digital agility, there is a rich body of literature focusing on the relationship between knowledge, information sharing, and agility (Sambamurthy et al., 2003).

Digital adaptability is a capability of the organization that can support various IT needs (Heart et al., 2010; Grover, 2022). Digital adaptability can be pursued through a combination of the various digital technologies that integrates data drawn from multiple sources allowing a seamless flow of information that enables managers to make decisions during uncertain times (Tallon and Pinsonneault, 2011). Hence, based on existing studies we argue that adaptability helps support the internal reconfiguration needed to respond directly to the nature of the disruptions being faced (Galaitsi et al., 2021).

Aslam et al. (2020) argues that supply chain adaptability has a direct effect on supply chain agility. Little is known empirically about the effect of digital adaptability on digital agility, there is however a growing stream of organizational field research on the link between adaptability, agility, and resilience (Nold and Michel, 2016). Hence, we can theorize based on the preceding discussions that digital adaptability can support agility when changes occur too fast. It further helps to increase system resistance, robustness, and security. Therefore, we can hypothesize as follows.

H1. Digital adaptability has a positive effect on digital agility.

H2. Digital adaptability has a positive effect on supply chain resilience.

H3. Digital agility has a positive effect on supply chain resilience.

2.5. The moderating effect of government policy effectiveness (GOVE)

Amidst the ongoing high level of disruption uncertainties, organizations are quite skeptical about investment in any innovation (Ciravegna and Michailova, 2022). In such a situation, government policies and legal environments certainly encourage organizations to carry out their innovation activities (Grover and Sabherwal, 2020; Bradley et al., 2021). Governance is a critical element in tackling the pandemic and post-pandemic crisis (Chen et al., 2020). Thus, we can argue that government effectiveness is one of the most important dimensions of effective governance. Governance includes the traditions and institutions through which authority is exercised in a country (Diarra and Plane, 2014). Government effectiveness can be best understood as the government's ability to design and implement concrete policies effectively; and which gets the respect of citizens and the state for the institutions that govern the economic and social relations between them (Kaufmann et al., 2011).

Hence, we argue that government effectiveness is the process by which governments are selected, monitored, and replaced. Cai et al. (2010) have found that government support and legal support play an important role in building trust, which is essential for information sharing in the supply chain network.

Martínez-Córdoba et al. (2021) further argues that government legitimacy plays an important role in maintaining political stability and credibility. During a crisis, the public relies on government information which subsequently helps to shape individual citizen behaviour. Hence, government procurement strategy played a significant role in the supply and distribution of critical items during the COVID-19 crisis (Nikolopoulos et al., 2021). This is evident, for instance, in the supply of masks, lateral flow tests, surgical wipes, hand sanitizer, oxygen, ventilators, etc.

In some disruption cases, due to a lack of proper governance and accountability, the healthcare supply chain or the food supply chain were the worst affected causing serious health implications, because of the supply shortages on the lives of the citizens (Yadav, 2015). Hence, in simple words, the government's effectiveness in their procurement requires creating mechanisms through which the key stakeholders managing the supply chain activities are held accountable by the citizens (or groups acting on their behalf) for key outcomes of the supply chain (Yadav, 2015).

During the COVID-19 pandemic, several governments of developing countries implemented policy measures in the form of tax incentives, free trade agreements, and subsidies to buffer the negative economic and financial impact (Grover and Sabherwal, 2020; Meyer, 2020). Moreover, the governments' belief and commitment to digitalization have further accelerated the investment in digital technologies such as big data analytics, AI, IoT, and distributed ledger technology (Li et al., 2020). The adoption of these technologies has significantly improved transparency and as result supply chain resilience has improved despite strict policy measures (i.e., lock downs, social distancing, travel restrictions, mask mandates) adopted by the government (Belhadi et al., 2021).

However, there is little known about the interaction effects of government (policy measure) effectiveness on the paths joining digital adaptability/digital agility and supply chain resilience. Based on the observations, we draw our research hypotheses to be tested in this study as follows.

H4a. The government's policy measure effectiveness positively moderates the path joining digital agility and supply chain resilience.

H4b. The government's policy measure effectiveness positively moderates the path joining digital adaptability and supply chain resilience.

2.6. Control variables

To completely account for the differences amongst the different cement manufacturing organizations, we also included the size of the firm as a control variable. In this case, we have used several employees and revenue as two measures of firm size. The bigger size permits an organization to sustain failures longer (compared to smaller firms) regarding their investment in digital technologies to promote better adaptation (Liang et al., 2007). Hence, we argue that organizational size is an important control variable.

3. Research design

The empirical study follows two-sequential steps (Choi et al., 2016). Firstly, we conducted in depth qualitative interviews to: (i) understand the different capabilities relevant to organizational resource reconfiguration and their potential implications in building supply chain resilience, and (ii) to understand and make relevant the preliminary survey-based instrument to the cement industry, which has suffered during the period of COVID-19 pandemic. Secondly, to test our theoretical framework and research hypotheses, we have adopted a survey-based method following that of Flynn et al. (1990). Boyer and Swink (2008, p. 339) note: "*A survey provides a low cost, non-invasive means for measuring aspects of an operational or supply chain issue. Measures included in a survey can be designed to target specific factors or attributes which may not be directly observable. For example, many behavioural variables affecting an operational process are "latent,'' and can be assessed only via perceptual measures*".

Despite criticisms of the survey-based method, we concur with Flynn et al. (1990) and Boyer and Swink (2008) that the use of perceptual measures is not necessarily wrong. The choice of perceptual measures is necessitated by the nature of the variables. For instance, in our study, we are trying to measure digital agility, digital adaptability, government policy measure effectiveness, and supply chain resilience in the context of the COVID-19 and the Ukraine crisis, which are functions of behaviours and organizational norms. Hence, in our study the use of perceptual measures is necessary.

3.1. Semi-structured interviews

We carried out 13 qualitative semi-structured interviews (see Appendix 1 and Appendix 2), with top-level managers from cement manufacturing firms over three months, which captured top managers personal experiences in two parts. The cement industry is an essential sector that contribute to the gross domestic product (GDP) of the developing nations (Schlorke et al., 2020) and has been worst affected during the pandemic and recovery period.

In the first part, we asked managers to elaborate on the role of digital capabilities on building supply chain resilience in the wake of the pandemic crisis. The agility and adaptability of digital technologies were the most cited aspects by the managers during the interviews. For instance, nine respondents stressed the importance of building digital agility and six respondents stressed digital adaptability. However, interestingly some respondents also highlighted the role of governance in building such capabilities as the cement industry is an industry that heavily focuses on local demand. Digital capabilities have an enormous impact on the total delivered cost of the finished product and the role of government policies have a significant impact on the adoption of digital capabilities as the government is one of the major growth drivers of the cement industry.

In the second part we further validated our theoretical framework and research hypotheses by questioning each of these managers on how digital capabilities can help to improve supply chain resilience in general and how the role of government effectiveness can influence the effects of digital capabilities on supply chain resilience. To an extent most of the managers agreed that digital capabilities have a significant impact on supply chain resilience. However, some disagreed as they find that most cement manufacturing organizations are yet to embrace digital capabilities in comparison to other manufacturing companies in India. Reflecting on the different perspectives in the literature published in academic outlets, it is well understood that irrespective of any sector or any nation, the role of digital capabilities on supply chain resilience would be always valuable. We further asked these managers to fill in the survey-instrument to assess the level of difficulty they face in terms of comprehending the questions. Out of these, 13 managers returned their input on the clarity of the item and the difficulty they faced whilst filling out the questionnaire. The constructs in the model were operationalized as reflective constructs (see Appendix 2). We have provided excerpts from the interview and a summary of interview findings (see Appendix 3).

3.2. Questionnaire development and survey

3.2.1. Questionnaire development

To develop a questionnaire for this study we followed two approaches: (a) an in depth literature review of existing academic literature and (b) pretesting of the survey instrument. We have identified scales and their measurement items following a pragmatic integration and grouping of items based on the context of the study (see Appendix 4). Previous studies have their own instruments to gather data depending upon their own context which is characterized by the nature of the industry and their own set of practices. Despite some degree of variations in the wording of the questions, we found that previous studies offered us rich insight to frame our own questions that help address the research gaps.

The items selected in our study is based on an in depth literature review and semi-structured interview based on our theoretical framework and the settings of the study. We pretested our survey-based questionnaire with 12 experts drawn from reputable cement manufacturing companies. We invited critical input from these experts on the wording for each of the 23 items to ensure that our wordings did not sound vague to the respondents. Most of the input were based on the wording as some of the questions were not relevant for the cement manufacturing companies or some sentences were too long. We also received some useful input related to repetitive items. As an outcome of expert opinion, four items were eliminated. Therefore, because of the expert opinion, there were 19 items broken down as follows: digital adaptability (five items), digital agility (5 items), government effectiveness (4 items), and supply chain resilience (5 items).

Finally, we developed a questionnaire aimed for single respondents. Despite several limitations of the single informant questionnaire (see, Ketokivi and Schroeder, 2004), we feel that the single informant is the most relevant approach in our case. We understand that the single informant questionnaire may lead to a common method bias (CMB) which is one of the major limitations associated with survey-based studies (see, Guide and Ketokivi, 2015). Despite several limitations we understand that survey-based study is the well suited for our case. We took utmost care to minimize the CMB which is termed as "*procedural remedies*" (MacKenzie and Podsakoff, 2012, p. 542). We further discuss our procedural remedies in the common method bias section (Section 4.2).

3.2.2. Survey

We surveyed between September 2021–February 2022, in Indian cement manufacturing organizations that rely on the use of digital technologies capabilities to make decisions related to their supply chain activities. The samples were drawn from the database of the CMA (known as the Cement Manufacturers Association of India), the leading trade association body of the cement industry in India (Luo et al., 2017).

The authors distributed the questionnaires to senior-level managers (regional head/vice president/general manager) of 450 cement manufacturing units and ready-mixed concrete plants of 80 organizations, in India. We selected these 450 units based on the input received from the spokesperson of the CMA regarding them having a relatively high level of use of digital technologies. We also selected our organizations in a way that represents a wide range of geographical and cultural diversity.

Our data collection approach is the best suited in the Indian context where personal relationship plays a significant role in collecting responses (Dubey et al., 2019). Collecting data in India from manufacturing organizations is often very difficult unless it is gathered through the development of individual personal relationships with the industry. With the support of CMA India, we could reach the right respondents who have an interest in digital capabilities and supply chain disruptions. These informants were the key members of the company's digitalization initiatives at the plant, sales, and warehouse levels. The informants had not only technologies to improve their visibility in the entire supply chain but also to help them forecast their future demands at the micro-level. Hence, we are assured that these managers are likely to provide a better evaluation of the role of digital adaptability, digital agility, government effectiveness, and supply chain resilience at their organizational level.

We finally gathered 203 useable responses (after two follow-up letters) for data analysis, showing an effective response rate of 45.11% (see Table 2). We assessed non response bias using the student's t-test. We

Table 2
Sampling frame (N = 203).

Title	Numeric value	%
Yearly sales revenue		
Below $ 15 million	1	0.49
$16–30 million	7	3.45
$ 31–50 million	15	7.39
$51–100 million	53	26.11
$101–250 million	115	56.65
Over $251 million	12	5.91
Number of employees		
0–100	5	2.46
101–200	110	54.19
201–500	54	26.60
501–1000	27	13.30
Over 1001	7	3.45
Designation		
Regional Head	38	18.72
Vice President	70	34.48
General Manager	95	46.80

conducted *t*-test on two data waves gathered [early set of data (September 2021–November 2021) and the late set of data (December 2021–February 2022)]. The findings of the wave analysis suggest no significant differences ($p > 0.05$) across the means of each theoretical construct between early and late respondents (Armstrong and Overton, 1977). We present the profile of the organizations that participated in this survey in Table 2.

4. Data analysis

We examined our theoretical framework using cross-sectional data with the help of variance based structural equation modelling software. Despite recent criticisms, we evaluated the arguments of some scholars to finally decide to proceed with the variance based PLS-SEM technique to validate the theoretical framework (see, Peng and Lai, 2012; Hair et al., 2020). WarPLS 7.0 was used for two main reasons. Firstly, "*WarPLS 7.0 explicitly identifies the non-linear functions connecting pairs of latent variables in SEM models and it determines multivariate coefficients of association*" (Kock, 2021, p. 6). Secondly, this software provides a unique combination of the PLS algorithms and factor-based PLS algorithms for SEM. Kock (2021, p.6) argues that: "… *factor-based PLS algorithms generate estimates of both true composites and factors, fully accounting for measurement error*".

4.1. Measurement model

The constructs used in the study are reflective. Hence, based on the recommendations of Fornell and Larcker (1981) we reported the values of composite reliability (SCR), the individual factor loadings of each construct item (λi) and average variance extracted (AVE) (see Table 3). The values reported in Table 3 exceed the threshold limit for SCR, factor loadings and the AVE (i.e., λi≥0.5; SCR≥0.7; AVE≥0.5) (see, Fornell and Larcker, 1981). Thus, we can claim that our reflective constructs possess convergent validity.

Furthermore, we have assessed "unidimensionality" following Flynn et al. (1994) to demonstrate whether the measuring items indeed represent a construct (see Table 4). Gerbing and Anderson (1988) suggest that there are two conditions that must be met to establish "unidimensionality". Firstly, an empirical representation of a construct must be significantly associated with the theoretical item. Secondly, the items must be loaded on a single construct (see Table 4).

After assessing the convergent validity, we have further examined the discriminant validity following Fornell and Larcker's (1981)

Table 3
Convergent validity (N = 203).

Construct	Items	Factor Loadings	Variance	Error	SCR	AVE
Digital Adaptability (DADAP) (α = 0.91)	DADAP1	0.88	0.77	0.23	0.93	0.73
	DADAP2	0.82	0.67	0.33		
	DADAP3	0.85	0.72	0.28		
	DADAP4	0.86	0.74	0.26		
	DAPAP5	0.88	0.77	0.23		
Digital Agility (DAGL) (α = 0.93)	DAGL1	0.89	0.79	0.21	0.95	0.78
	DAGL2	0.89	0.79	0.21		
	DAGL3	0.86	0.74	0.26		
	DAGL4	0.87	0.75	0.25		
	DAGL5	0.91	0.83	0.17		
Government Effectiveness (GOVE) (α = 0.76)	GOVE1	0.84	0.70	0.30	0.85	0.61
	GOVE2	0.91	0.82	0.18		
	GOVE3	0.84	0.70	0.30		
	GOVE4	0.44	0.20	0.80		
Supply Chain Resilience (SCR) (α = 0.93)	SCR1	0.91	0.82	0.18	0.95	0.82
	SCR2	0.90	0.81	0.19		
	SCR2	0.92	0.85	0.15		
	SCR4	0.89	0.80	0.20		

Notes: DADP-digital adaptability; DAGL-digital agility; GOVE-government effectiveness; SCR-supply chain resilience.

Table 4
Unidimensionality (N = 203).

	DADAP	DAGL	GOVE	SCR	SE	p-value
DADAP1		0.88			0.05	***
DADAP2		0.82			0.05	***
DADAP3		0.85			0.05	***
DADAP4		0.86			0.05	***
DADAP5		0.88			0.05	***
DAGL1	0.89				0.05	***
DAGL2	0.89				0.05	***
DAGL3	0.86				0.05	***
DAGL4	0.87				0.05	***
DAGL5	0.91				0.05	***
GOVE1			0.91		0.05	***
GOVE2			0.90		0.05	***
GOVE3			0.92		0.05	***
GOVE4			0.89		0.05	***
SCR1				0.84	0.05	***
SCR2				0.91	0.05	***
SCR2				0.84	0.05	***
SCR4				0.44	0.06	***

Notes: DADP-digital adaptability; DAGL-digital agility; GOVE-government effectiveness; SCR-supply chain resilience; three asterisks *** stand for <0.001.

criterion. We obtained the inter-correlation matrix and further replaced the leading diagonal elements with the square root values of AVEs (see Table 5). We found that the square-root of the AVE of each construct is greater than the correlation values in the corresponding row and column. Hence, we conclude that the constructs possess discriminant validity.

4.2. Common method bias (CMB)

Podsakoff et al. (2003, p. 879) defined CMB, "… *Common method bias (CMB) is the bias that is attributable to the measurement method rather than to the constructs the measures represent*". There exists rich debate on how to reduce biases resulting from a single source (see, MacKenzie and Podsakoff, 2012). The biases could be further classified into two parts: *procedural remedies* and *statistical remedies* (Podsakoff et al., 2003; MacKenzie and Podsakoff, 2012). Different procedural remedies may include obtaining explanatory and outcome variables from multiple sources, eliminating common scale properties, rewording the questions so that they are less ambiguous and socially desirable, and using mixed worded questions (MacKenzie and Podsakoff, 2012).

The split-sample method and marker technique are among the popular statistical methods used for examining the effects of common method bias (Jakobsen and Jensen, 2015). We adopted the marker technique to assess the effect of CMB in our study (see, Lindell and Whitney, 2001). The unrelated variables were used to separate the correlations caused by CMB. Following Lindell and Whitney's (2001) recommendations, we determined the significance of the correlations. The significance of the correlations did not change. We therefore can conclude that the CMB cannot be eliminated due to the nature of the study (Ketokivi and Schroeder, 2004). However, we can assure you that the CMB is not a serious issue in the current study.

Next, we checked the endogeneity issue before testing our research hypotheses (Guide and Ketokivi, 2015). Following the work of Kock

Table 5
Discriminant validity (N = 203).

	Scale Range	Means	DADAP	DAGL	GOVE	SCR
DADAP	*1–7*	*5.60*	***0.85***			
DAGL	1–7	5.67	0.48	***0.88***		
GOVE	1–7	4.01	0.64	0.68	***0.78***	
SCR	1–7	5.68	−0.08	−0.04	−0.09	***0.91***

Notes: DADP-digital adaptability; DAGL-digital agility; GOVE-government effectiveness; SCR-supply chain resilience; N = sample size **(The shaded portion represent square root of the AVEs).**

(2019), using WarPLS 7.0 we determined the nonlinear bivariate causality direction ratio (NLBCDR). The acceptable cut off value is ≥ 0.7. In our case, we found NLBCDR = 0.92 (approximately), which suggests that 92 percent of the path related instances follow that suggested in the theoretical framework (see Fig. 2), the likelihood of reversed hypothesized direction of causality is weak or in simple words the possibility of bi-directional associations between the theoretical constructs is not statistically significant (Kock, 2021).

4.3. Hypotheses testing

Unlike in co-variance-based SEM, the PLS SEM does not rely upon the normality criteria of the data distribution (Peng and Lai, 2012). Hence, unlike traditional regression the PLS SEM is far more flexible and convenient to use (Hair et al., 2020). We have reported the beta coefficients (β) and corresponding p-values (Table 6). For example, we observed that H1 (DADAP→DAGL) is supported ($\beta = 0.88$, $p < 0.01$). The beta coefficient and the p-value indicate that the DADAP is a strong determinant of the DAGL. Similarly, we observed that H2 (DAGL→SCR) ($\beta = 0.30$, $p < 0.01$) and H3 (DADAP→SCR) ($\beta = 0.57$, $p < 0.01$) are equally supported.

In totality, we can argue that the DADAP and DAGL are strong determinants of the SCR, which support the previous claim of several scholars (see, Ivanov et al., 2019; Balakrishnan and Ramanathan, 2021). However, whilst these previous studies examined the effects of digital technologies on improving supply chain resilience, we specifically examined the influence of digital adaptability and digital agility on supply chain resilience. This is one of the few attempts which try to extend theoretical debates interrelating supply chain management and information management literatures together (see, Kumar et al., 2018).

Hypotheses H4a and H4b are tested for the moderating relationship between government effectiveness and the paths joining DAGL/DADAP and SCR. We observed that H4a ($\beta = 0.31$, $p < 0.01$) and H4b ($\beta = 0.13$, $p < 0.01$) are also supported. However, if we compare the beta coefficients with the direct and moderated relationships, the difference is significant. Thus, we can conclude that government measure effectiveness has a key role to play in enhancing supply chain resilience with the help of digital capabilities.

We have explained to what extent our theoretical framework explains supply chain resilience using the coefficient of determination (R^2). The reported values of R^2 indicates that DADP is a strong determinant of DAGL (i.e., 0.78). Further, DADP and DAGL under the moderating effect of government effectiveness explains nearly 83% (i.e., $R^2 = 0.83$), of the total variation in supply chain resilience. We therefore conclude that our proposed theoretical model is strong (see, Chin, 1998) (Table 7). The β coefficients do not help understand the extent to which the explanatory variable explains the outcome variable, it is important to report the f^2 values (Cohen, 1988). The Cohen f^2 value is increasingly gaining popularity in social science investigations involving multiple regression. Although, we admit that the assessment based on the values vary largely and it depends on the context. However, we found that in our case the f^2 values are quite strong (see Table 7). Furthermore, we also reported the predictability (Q^2) of the explanatory variables which is increasingly gaining importance with PLS-SEM techniques (Chin, 1998; Peng and Lai, 2012). We noted Q^2 values are much greater than 0.00 which indicates that the DADP is a strong predictor of DAGL (0.78). Similarly, the DADP and DAGL are strong predictors of SCR (0.83).

Table 6
Hypothesis testing (N = 203).

Hypothesis	Explanatory	Outcome	Beta coefficient (β)	p-value	Supported/ Not supported
H1	DADAP	DAGL	0.88	<0.01	supported
H2	DAGL	SCR	0.30	<0.01	supported
H3	DADAP	SCR	0.57	<0.01	supported
H4a	DAGL*GOVE	SCR	0.31	<0.01	supported
H4b	DADAP*GOVE	SCR	0.13	<0.02	supported

Notes: DADP-digital adaptability; DAGL-digital agility; GOVE-government effectiveness; SCR-supply chain resilience.

Table 7
Coefficient of variation (R^2), predictability (Q^2) and effect size (f^2).

Construct	R^2	Q^2	f^2 in relation to	
			DAGL	DADAP
DAGL	0.78	0.78		0.78
SCR	0.83	0.80	0.254	0.51

Notes: DADP-digital adaptability; DAGL-digital agility; GOVE-government effectiveness; SCR-supply chain resilience.

5. Discussion

Both the information management and operations management literature repeatedly show that agility and adaptability are important sources of competitive advantage, in fact agility and adaptability continue to play an important role in building resilience (Aslam et al., 2020). The objective of our study was to extend our understanding of digital adaptability and digital agility and its implications, principally in resolving the puzzle of whether digital adaptability influences digital agility or vice versa. To broaden our understanding, we firmly grounded digital adaptability and digital agility in a nomological network leading to supply chain resilience. We also investigate the context in which digital adaptability and digital agility might help enhance supply chain resilience by examining the moderating effect of government measure effectiveness on the paths joining digital adaptability/digital agility with supply chain resilience.

In their totality, our research findings show that digital adaptability has a positive and significant influence on digital agility. This observation furthers our understanding of digital capabilities which have been conceptualized as dynamic capabilities of the organization (Warner and Wäger, 2019). Furthermore, it establishes that digital adaptability positively enhances digital agility which in turn influences supply chain resilience. This help establishes digital adaptability and digital agility in the hierarchical view of dynamic capabilities. In previous studies, scholars have either conceptualized adaptability or alignment as two dynamic capabilities which are complementary to each other (see, Aslam et al., 2018). No matter if it may be well-established that dynamic capabilities have a positive influence on supply chain resilience (Aslam et al., 2020), this work further recognizes that contextual factors *may further alter the value of dynamic capabilities* (Schilke, 2014; Fainshmidt et al., 2016).

Building on this notion we explicate additional moderating factors (in our case government policy measure effectiveness) that may generate substantive heterogeneity in supply chain resilience. By addressing two relevant yet less developed areas of the dynamic capabilities view (DCV) we believe our study makes significant contribution to the literature. Firstly, considering the hierarchical view of dynamic capabilities (see, Fainshmidt et al., 2016), we explained the less understood mechanisms of how dynamic digital capabilities affects supply chain resilience, and secondly, how the higher-order capabilities and the lower order capabilities are embedded in the nomological network to explain supply chain resilience (Erol et al., 2010). Hence, based on our findings *we argue for adaptability as a higher-order capability and digital agility as a lower-order capability*.

The information management literature has focused on agility and alignment (Tallon and Pinsonneault, 2011). However, adaptability is a relatively less studied area. Thus, our study establishes *the role of digital adaptability as a dynamic capability that influences digital agility which in turn improves supply chain resilience*.

Previous studies have examined the direct effects of agility and adaptability on organizational performance (Eckstein et al., 2015), but the literature examining the effects of adaptability and agility on resilience is limited (Aslam et al., 2020). Aslam et al. (2020) examined the effects of supply chain ambidexterity (adaptability and alignment) on resilience under the mediating effect of agility. Informed by the dynamic capability view, Aslam et al. (2020) considered the moderating role of environmental uncertainty on the path joining supply chain ambidexterity together with supply chain resilience. Building on this notion we considered how government measure effectiveness further moderates the paths joining digital adaptability/digital agility and supply chain resilience. This contributes to our understanding of: *how digital adaptability and digital agility can enhance resilience under the* support *of government agencies and their policy measures, thereby providing a significant contribution to the field of information and operation management interface.*

5.1. Implications for research

In the present study, we examined how the cement industry in response to the COVID-19 crisis has developed dynamic capabilities for digital transformation. Our findings of the study have several theoretical implications for the operations management and information systems interface. Firstly, one of the main contributions of the study is the examination of the digital capabilities of the organization and its effects on supply chain resilience. The COVID-19 pandemic has triggered the traditional manufacturing sector such as cement to be resilient as it relies on domestic consumption. However, despite ongoing digital transformation in the last few years, the COVID-19 pandemic has created new opportunities to for manufacturers to embrace digital technologies to tackle uncertainties in demand and supply.

Hence, we have conceptualized digital adaptability and digital agility constructs as part of supply chain resilience which is our main contribution to the operations management and information systems interface. The terms digital adaptability and digital agility carry inconsistent meanings in operations management and the information systems field. In the absence of any operational definition, we grounded our arguments in the dynamic capability view to explain digital capabilities. Therefore, in this study, we further provide an operational definition of digital adaptability and digital agility as two distinct constructs as higher-order and lower-order dynamic capabilities.

In this way, we make some useful contributions to the digital capability definition by drawing and synthesizing literature drawn from operations management and information management. By addressing RQ1, we extend the dynamic capability view by introducing higher-order and lower-order dynamic capabilities. Moreover, we further provide clarity in the existing operations management literature where scholars have remained silent on nomological networks, since the existing literature has treated these two dynamic capabilities at the same level. Thus, our findings contribute to our understanding of the hierarchical ordering of dynamic capabilities.

Secondly, by addressing RQ2 our study offers a nuanced understanding of the role of external factors in the dynamic capabilities-performance link by including the role of government policy measure effectiveness. Most of the studies have neither considered technological dynamism or environmental dynamism. This often limits the scope of the DCV. The context, in which capabilities generate competitive advantage must be clearly understood (Barney, 2001). Thus, our results help expand the debate that dynamic capabilities assist in enhancing supply chain resilience, depending on the environment in which the organization operates.

The moderating effect of government effectiveness on the paths joining digital adaptability/digital agility and supply chain resilience indicates that organizations having similar capabilities might perform differently owing to differences in government policies and institutional environments. To an extent, our results support the proposition that technological innovation is closely related to the institutional environment. Wen et al. (2021) argue that political connection and government intervention have often acted as strong drivers of technological innovation behaviour. Especially during uncertain times, organizations seek political help to have access to scarce technological resources. *Our results further extend the theoretical understanding of the role of government in building digital capabilities in an uncertain time to improve supply chain resilience.* To our understanding, this is our main contribution to the operations management literature.

In this way, we attempted to tackle the pressing challenge that management scholars often face in how to bridge the gap between macro and micro theory. Over the years, a section within the management community has emphasized the need for research that helps bridge the gaps between the micro and macro disciplines (Hitt et al., 2007; Cowen et al., 2022). Cowen et al. (2022) argue that due to COVID-19 pandemic the organizational response to tackle such challenges is often a mix of macro and micro perspectives.

Macro investigations typically tackle questions related to how the economic or social environment shapes the organization's strategy to deal with it—for example, how government policy effectiveness or market pressures shape the firms' choices regarding digital transformation (Peng et al., 2008). At the micro-level, research questions focus on the individual firm or organization's response to tackling such crisis-for example a change in organizational structure. Our study to an extent tries to address the research calls that help bridge the gaps that exist between macro and micro theory, which is a relatively less researched area within the operations management field.

5.2. Implications for managers

The study is an attempt to understand the initiatives adopted by cement industries in India to build dynamic capabilities to enhance their supply chain resilience. The empirical findings of our study have several implications for managers working in the cement industry in India as well as in other parts of the world or policymakers. Cement companies in recent times are facing enormous challenges resulting from government policies to restrict carbon emissions and the recent pandemic which has forced the industry to invest in their dynamic capabilities to build resilience. To date the cement industry has relied heavily on the "pipeline" based model. However, our analysis, based on semi-structured qualitative interviews and survey-based cross-sectional data, suggests that the cement industry like other competitive sectors, such as automobiles and mobile-phone manufacturing organizations, are slowly shifting from a traditional "*pipeline*" business model to a far more competitive "*platform*" based one. Digitization facilitates the scaling up of platforms that allows the participation of consumers and producers, which further improves collaboration, enhancing the ability to capture, analyse, and exchange huge amounts of data. This improves the platform's value for every stakeholder. Hence, we believe that digital platforms provide the ability to respond to opportunities more cost effectively.

Currently, cement companies face an enormous task to reduce their carbon footprints for long-term viability. On average the cement sector contributes seven to eight percent of global greenhouse gas emissions. Hence pressure from government agencies is constantly building upon cement companies to achieve zero carbon emissions (Schlorke et al., 2020). Therefore, the use of artificial driven big data analytics capability may help managers to monitor and then tackle their carbon emission issues more effectively. During the pandemic the cement companies continued to operate as cement is considered an essential commodity in most countries. However, due to health and safety regulations and standards set by governments in response to the pandemic some cement companies exploited digital technologies to minimize disruptions (i.e., staff absences) in their supply chain due to COVID-19. Thus, it is recommended that cement manufacturing organizations should design and configure their supply chains concurrently and efficiently through data collection and analysis. For instance, their supplier sourcing and development processes. The real challenge often lies between "sensing" and "dynamic responding" which could be strategically tackled using

AI-powered data analytics capability. Hence, the extent to which these organizations can build the capability to extract, process, and analyse data efficiently becomes key to demonstrating adaptability and agility.

It is well understood that companies that have relied on digital technologies and their proper utilization are more resilient in comparison to those companies that are relatively in the early stage of their adoption of digital technologies. In some states in India, cement companies could benefit from government policies, aimed at creating demand for low-price housing schemes or soft loans or by offering rebates on taxes. Whether governments introduce such interventions will depend on the broader challenges facing each country and the importance of the cement sector to the economy. Hence, in totality, our study may provide motivation for managers or policymakers who are contemplating investing in dynamic digital capabilities to improve their supply chain resilience and adapt their strategies according to government policies.

We have developed a digital capability and supply chain resilience framework for managers (see Fig. 3). The core of the framework is a digital transformation strategy. To support the digital transformation strategy, we found that cement manufacturing firms needs to migrate from the traditional pipeline model to the platform-based model, to achieve better adaptability and agility. However, unless the organization embraces a data-driven culture, the benefits of a platform-based business model or digital transformation strategy might not be realised. Grover (2022) argues that the biggest challenge for most companies, particularly the more traditional ones, is to change their digital mindset. Our study found that cement manufacturing organizations are quite slow in terms of embracing a data-driven culture. However, interviews with the participants highlighted the importance and the potential benefits of a data-driven culture in contemporaneous organizational contexts. To further support the development of such cultures, organizations need to shift from having a resource-controlling strategy to a resource orchestration one. This facilitates interaction with their partners and stakeholders, to improve the dynamic sensing capability, continuous performance evaluation of the IT vendors and flexible manufacturing strategies. This in turn helps organizations improve their adaptability and agility.

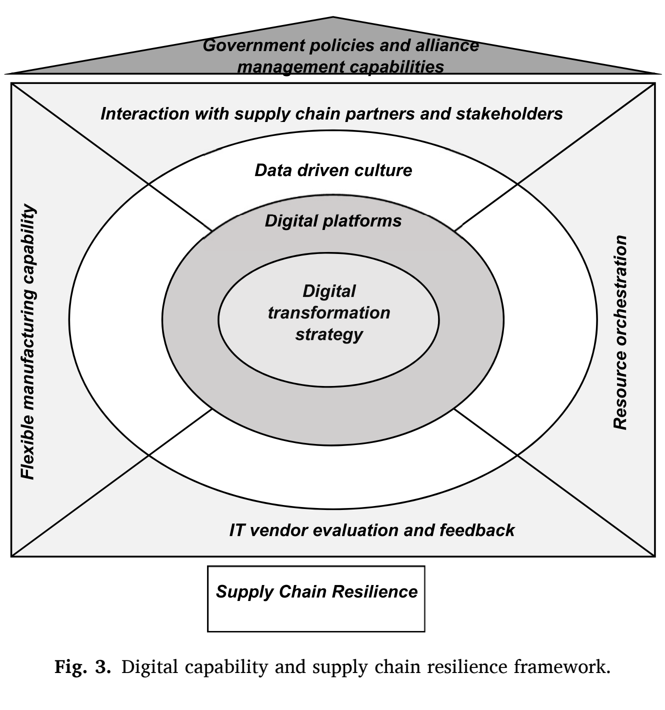

Fig. 3. Digital capability and supply chain resilience framework.

5.3. Limitations and further research direction

We caution our readers that the contribution of our study should be evaluated considering its limitations. Despite extensive efforts, our study has its limitations that can be addressed by future studies. Firstly, we have grounded our arguments in the dynamic capability view. However, we understand that the dynamic capability's view relies on assumptions that may not hold relevance in any other crisis or pandemic. In such a case we believe that an alternative theory (i.e., practice-based view) proposed by Bromiley and Rau (2014, 2016), might help tackle the need for bridging the wide gaps that exist between macro and micro aspects of cement companies or any other traditional industry.

Secondly, we agree with Flynn et al. (1990) and Boyer and Swink (2008), that an empirical study utilizing a survey-based approach is probably one of the best methods to address our research questions. However, we also note that despite significant popularity among the operations and information systems management community, survey-based research has several limitations. The most common problem with survey-based research resides with perceptual measures and measurement errors stemming from subjectivity and bias (Boyer and Swink, 2008).

In our research design and data analysis sections we took the utmost care to minimize the non-response bias or the common method bias. However, we still believe that a longitudinal study may enhance the confidence in the validity of the research findings. The other concerns that Boyer and Swink (2008, p. 340) noted related to survey research is, "*… the difficulties with respondents' interpretations of measures, a potential lack of knowledge, and representations of the unit of analysis*". Although we took the utmost care to identify the right respondents, we still believe that in future research a random call to some of these respondents to understand their views on digital technologies and their implications on supply chain resilience may enhance the validity of the research findings.

Thirdly, a future study could utilize multiple case-based approach to build a holistic understanding of operations and information systems phenomena. Fourthly, samples from one industry may limit the generalizability of our study findings. Often industry differences create confusion, we therefore purposely chose to study one industry. Moreover, to minimize the variations caused by personal background differences, we chose respondents with similar backgrounds. However, our methodological choice might have had a positive impact on the internal validity of the study, this might have come at the price of external validity. Still, generalizability is one of the main pressing concerns of survey-based research, we believe that future studies could tackle this concern by adopting multi-level studies conducted at different times, in different locations, and in different industries.

Fourthly, we agree that the national culture has an important role to play in shaping government policies. In a future study, it would be interesting to investigate how national cultural dimensions influence a government's policy effectiveness, cyber-physical infrastructural investments, and societal levels of digitalization to improve resilience is worth investigating.

Finally, emerging technologies (such as the Metaverse) are projected to positively impact manufacturing, purchasing, supply chain and warehouse management by enhancing their agility and collaboration (Dwivedi et al., 2022b). However, the impact of such technology is yet to be seen and measured. Future research should examine the role of new technology such as the Metaverse on agility adaptability and supply chain resilience.

6. Conclusion

Digital transformation is an ongoing process that involves both macro and micro perspectives. In this study, we explored how digital adaptability and digital agility constitute the digital capabilities of the organization. That help enhance its supply chain resilience during an unprecedented crisis. We further explored how government effectiveness further moderates the paths of joining digital adaptability/digital agility and supply chain resilience. Our study contributes to the DCV in two ways. Firstly, our study provides empirical support for the two important theoretical tenets of dynamic capabilities. In our study, we have found that digital adaptability under the mediating effect of digital agility has a positive and significant effect on supply chain resilience. The second tenet we have proven is the moderating role of government policy effectiveness.

Prior studies have assumed technological dynamism of environmental dynamism as a moderating construct. However, in our case, we extended the second theoretical tenet by examining the moderating effect of government policy effectiveness. In doing so, we have attempted to tackle the long pending research calls of some management scholars who believe in cross-boundary public-private research to bridge the gap between macro and micro theories to understand and solve the complex management issues that societies face. Overall, we believe that our research findings and the limitations of the study will open new avenues of research.

Data availability

Data will be made available on request.

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Appendix 1. Interview Protocol

Research Question: Our research question is focused on understanding how digital capabilities are important in the present situation of disruption and supply chain shocks. We seek to understand how digital capabilities help improve resilience. Furthermore, we also wanted to understand how the role of government effectiveness enhances the effects of digital capabilities on supply chain resilience.

Thank you for participating in the study. The study is all about understanding how the cement industry embraces digital technologies and further invests in building digital technologies to improve their supply chain resilience. The COVID-19 crisis has caused immense challenges and the government restriction on human mobility has further worsened the situation. We assure you that the data or the information shared will be treated anonymously and confidentially. Before, we start could you provide me with some information about yourself?

Respondent details

- *What is your name, age, and education?*
- *What is your position in the current organization?*
- *What was your previous role(s) and for how many years have you worked in this industry (Years, roles etc.)?*
- *Could you share your information for me to contact you for follow-up interviews?*

Digital capabilities

- *What are the factors that triggered your organization to adopt digital technologies?*
- *What was the scope of the digital transformation?*
- *What are the main dynamic capabilities discussed:*
  Sensing:
  Seizing:
  Transformation:
  - *What are the benefits so far?*

Thank you for your precious time and useful insights. So, far all my questions have been answered. Is there anything else you would like to share with me that will help to strengthen my study?

Appendix 2. Sample for expert interviews

Participant	Gender	Tenure (years)	Position	Qualification
P1	Male	15	Vice President	B.E, M.B. A
P2	Male	20	Vice President	B.E, M.B. A
P3	Female	18	B&I Head	B. E
P4	Male	20	Logistics Head	M.A, M.B. A
P5	Male	16	Procurement Head	B.E, M.B. A
P6	Male	17	Regional Head	B.E, M.B.A, Ph.D.
P7	Male	22	Plant Head	B. E
P8	Male	19	Plant Head	B.E, M.B. A
P9	Male	23	Logistics Head	B. E
P10	Female	13	Chief Information Officer	B.E, M.B.A, Ph.D.
P11	Male	16	Procurement Head	B.E, M.B. A
P12	Male	17	Ready Mix Concrete Unit Head	B.E, M.B. A
P13	Female	9	Business Analyst	B.E, M.B. A

B.E (Bachelor in Engineering), M.B.A (Master in Business Administration), Ph.D. (Doctor of Philosophy).

Appendix 3. Following excerpts from interviews and aggregate dimensions

Participant	Excerpt from interviews	Aggregate dimensions
P1, P10, P12, P13	*P1: "We need to shift our business model from a traditional pipeline to platform".* *P10: "Our organization is now shifting from a resource control strategy to a resource orchestration strategy".* *P12: "We rely on data, artificial intelligence and data analytics techniques to respond effectively".* *P13: "We are now shifting from an internal optimization mindset to a continuous engagement approach through interaction with our supply chain partners and their stakeholders".*	The characteristics of the agile organization powered by digitization: *Digital agility*.
P4, P11	*P4: "We need to be prepared for supply chain disruptions. For the last few years, the cement industry has faced severe disruptions due to demonetization and now the pandemic has caused severe disruption".* *P11: "Transportation plays an important role in the cost of the finished good as well as helping to enhance customer satisfaction. We are using GPS tracking devices to monitor the movement of the fleets to reduce the lead time and improve the OTD (on time delivery of the finished product or materials at customer sites)".*	
P2	*P2: "We work closely with our partners and their stakeholders to adapt our business models to tackle climate change and resource constraint challenges. The chief raw materials are obtained from local limestone mines. However, we are facing constant pressure from the ministry of environment and forest (MOEF) to reduce the consumption of limestone-based clinker. Hence, we are utilizing digital capabilities to innovate and develop alternative materials to reduce the pressure on the environment and reduce our carbon emissions".*	The characteristics of the adaptable organizations in the digital age: *Digital adaptability.*
P9	*P9: "We are relying on a digital weighing machine to prevent the overloading of trucks. In the recent past, most of the industry due to the overloading of trucks was severely penalized. We are very much concerned about our image and the overloading of trucks is one of the major issues in the cement industry".*	
P6	*P5: "During COVID-19 the demand from the real-estate sector has reduced significantly. We closed our ready mixed concrete plants to match up with supply. During that time, we invested in training our staff to learn new technologies so that they can work efficiently and effectively during the post-pandemic era".*	
P5	*P5: "The central government has relaxed its duties on the import of certain raw materials".*	The tenets of government support in the time of crisis: *Government effectiveness.*
P10	*P10: "The central government has invested significantly in roads, bridges, and government buildings. It has generated huge opportunities for cement manufacturing firms".*	
P7	*P7: "The government of India's through its e-procurement strategy has motivated us to embrace digital technologies to improve the efficiency of our operations".*	
P8	*P8: "The government banks' soft housing loan scheme has increased the demand for building materials. With the help of various digital platforms, we are trying to improve our efficiency.*	

Appendix 4. Measurement Scales

Construct	Item	Statement	Source
Digital Adaptability (DADAP)	DADAP1	We closely work with our partners to adapt our business models according to government policies related to the environment.	Adapted from Alfalla-Luque et al. (2018); Puckett (2022)
	DADAP2	We use artificial-driven big data analytics capability to tackle the carbon emissions issue.	
	DADAP3	We use virtual sensory devices to track the overloading of trucks.	
	DADAP4	We use artificial driven big data analytics capability to recycle and reuse waste concretes to reduce the consumption of limestone.	
	DADAP5	We are flexible enough to respond to sudden changes in market demands by adjusting the configuration of production capability.	
Digital Agility (DAGL)	DAGL1	We use artificial intelligence-driven big data analytics capability to sense any changes in customer needs.	Adapted from Roberts and Grover (2012); Grover (2022)
	DAGL2	We closely work with our partners to identify any potential threats that could disrupt the supply of blending raw materials.	
	DAGL3	We use a GPS tracking device to monitor the movement of concrete trucks or trucks carrying cement bags.	
	DAGL4	We rapidly respond to disruption in the supply of raw materials to avoid any production delay.	
	DAGL5	We rapidly respond to sudden changes in demand.	
Government Effectiveness (GOVE)	GOVE1	During the COVID-19 crisis, the government has provided financial support in the form of credit or deferral of interest for some time.	Adapted from Kumar et al. (2020)
	GOVE2	During the COVID-19 crisis, the government has deferred the tax payment.	
	GOVE3	The national banks offered soft loans to invest in digital capabilities to tackle the challenges resulting from the COVID-19 crisis.	
	GOVE4	The government has offered a rebate on the demurrage expenses or wharfage charges on the cement companies due to shortages of labour resulting from the social distancing norms and lockdown during the COVID-19 crisis.	
Supply chain Resilience (SCR)	SCR1	We were able to tackle the supply disruptions caused by the COVID-19 crisis.	El Baz and Ruel (2021) and Brandon-Jones et al. (2014)
	SCR2	We were able to adjust our production capabilities due to sudden changes in demand patterns.	
	SCR2	We were able to provide a quick response to supply chain disruptions resulting from the COVID-19 crisis.	
	SCR4	We had backup plans to mitigate any kind of demand or supply risks resulting from sudden changes in government policies in response to the COVID-19 crisis.	
	SCR5	We expect our company to quickly recover to its original state.	

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