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Synergizing Managerial and Organisational Capabilities for Resilient Manufacturing: Integrated NCA and fsQCA Approaches

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ABSTRACT

Growing instability in the global business environment has made organizational resilience an increasingly critical concern for manufacturing firms. While previous research has recognised a range of managerial and organizational capabilities that may contribute to resilience, relatively little is known about the way these capabilities operate collectively within manufacturing settings. Grounded in the dynamic capability view and the three-stage decisional perspective, this study examines how managerial and organizational dynamic capabilities jointly contribute to organizational resilience. The analysis considers human capital, social capital, and knowledge management as managerial-level antecedents, while digital transformation, visibility, and redundancy represent organizational-level antecedents. Data were obtained through a survey of 310 senior professionals employed in manufacturing organizations in Bangladesh and examined using SmartPLS 4, necessary condition analysis (NCA), and fuzzy-set qualitative comparative analysis (fsQCA). The results indicate that human capital, social capital, and knowledge management constitute necessary managerial conditions for achieving greater organizational resilience, while each of the examined organizational antecedents also fulfils a necessary role. Furthermore, the fsQCA findings show that high organizational resilience can be attained through several alternative capability configurations, among which social capital, knowledge management, and visibility appear particularly influential as sufficient conditions. By integrating managerial and organizational capabilities within a configurational framework, this study extends existing research on organizational resilience and clarifies how different capabilities can work together to strengthen firms' capacity to withstand turbulent conditions. The findings additionally provide practical and policy-oriented implications by highlighting specific combinations of capabilities that managers and decision-makers can develop to enhance resilience in manufacturing organizations.

1. Introduction

Manufacturing organizations operate under increasingly complex competitive conditions shaped by climate-related threats, technological change, geopolitical instability, and economic constraints

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[1], [2], [3]. According to Bednarski et al. [3], the uncertainty generated by these pressures can restrict manufacturing development and, consequently, undermine firms' capacity to maintain long-term sustainability. Major disruptive events, including global economic crises and the COVID-19 pandemic, further demonstrated how vulnerable manufacturing operations can become when firms lack the capacity to respond effectively to unexpected shocks [3], [4]. Such disruptions have consequently strengthened scholarly interest in organizational resilience as a means of developing capabilities that allow firms to absorb disturbances, adjust to changing circumstances, and continue operating under volatile conditions. In manufacturing settings, resilience generally reflects a firm's capacity to anticipate external disturbances, withstand their immediate effects, and adapt its operations in response to changing environmental conditions [1], [5].

Building resilience, however, depends on strengthening a combination of interconnected capabilities rather than relying on a single organizational attribute. Existing research commonly conceptualizes resilience as an outcome arising from the interaction and deployment of dynamic capabilities [6], [7]. Within manufacturing organizations, managerial and organizational capabilities are particularly important because they can collectively support adaptive capacity and improve responses to environmental disruptions [8], [9]. Managerial capabilities associated with managerial role-playing include HCA, KMA, and SCA. These dynamic managerial capabilities can contribute to resilience by developing a competent and adaptable workforce, facilitating interpersonal collaboration, and establishing conditions that encourage continuous learning [10], [11], [12]. At the organizational level, capabilities such as digital transformation, visibility, and redundancy can strengthen technological responsiveness, improve the anticipation of potential disruptions, and ensure the availability of alternative resources when normal operations are interrupted. Together, these capabilities provide important foundations for absorbing shocks and adjusting to disruption, thereby supporting organizational resilience [13], [14], [15], [16].

Nevertheless, although existing studies have established links between individual capabilities and organizational resilience [17] insufficient attention has been devoted to examining how different dynamic capabilities interact and combine to produce resilient outcomes. This limitation points to the need for a more integrated examination of the relationships among capabilities and the configurations through which they collectively generate organizational resilience. For instance, the effectiveness of an organizational capability such as digital transformation may depend partly on the presence of a complementary managerial capability such as KMA, which can facilitate the effective acquisition, dissemination, and application of knowledge required to translate technological investments into resilient outcomes [18].

Similarly, Gubbins and Dooley [19] suggested that the integration of multiple capabilities can strengthen workforce adaptability. Satar et al. [20] further highlighted the need to investigate how combinations of capabilities, particularly KMA and SCA, can collectively contribute to resilience. Despite these observations, important questions remain regarding which capabilities represent essential conditions and which combinations or configurations are most likely to produce high levels of organizational resilience in manufacturing contexts [21]. To address these gaps, our study aims to answer several research questions, including:

RQ1: How do synergistic effects on organizational and managerial resilience capabilities enhance resilience in manufacturing firms?

RQ2: What combinations of organizational and managerial resilience capabilities lead to greater organizational resilience?

By addressing these unresolved issues, this study advances the existing literature by examining the complex relationship between managerial and organizational capabilities and their collective contribution to manufacturing resilience within an emerging-country setting. Rather than treating individual capabilities as independent sources of resilience, the study develops a more integrated perspective in which interconnected dynamic capabilities jointly contribute to resilient outcomes. From a theoretical perspective, the study extends the dynamic capability view by demonstrating how combinations of capabilities can collectively support organizational resilience. Whereas previous studies have predominantly examined individual capability dimensions in isolation [13], [15], [17], this research shifts attention towards capability combinations and their collective potential to achieve high resilience. From a practical standpoint, the findings provide managers with guidance on how managerial and organizational capabilities can be configured and integrated to strengthen firms' resilience.

To examine these complex capability relationships, the study adopts a dual-method analytical approach combining NCA and fsQCA. This methodological integration provides a decision-support perspective for resilience development. NCA determines the indispensable capabilities that firms need to possess, while fsQCA identifies alternative sufficient configurations through which high organizational resilience can be achieved and highlights potential capability gaps. Consequently, the combined approach extends beyond examining capabilities independently and provides managers with a clearer basis for understanding their interdependencies and prioritizing strategic interventions. By conceptualizing resilience as a managerial decision-making challenge, the proposed decision-support logic enables managers to distinguish between capabilities that are indispensable and combinations that can provide sufficient conditions for resilience. This can help firms address capability deficiencies systematically rather than relying on isolated initiatives when developing their resilience.

The study is organized into six main sections. The first section introduces the research background, identifies the existing gaps, and outlines the study's contributions. The second section reviews the relevant literature in detail. The third section develops the research hypotheses. The fourth section explains the research methodology and analytical procedures. The fifth section presents and analyses the empirical results obtained through the applied methods. The sixth and final section discusses the findings in relation to the proposed hypotheses and presents the theoretical and practical implications of the study.

2. Literature Review

2.1. Dynamic Capability View (DCV) and Decision-Oriented View

In earlier research, DCV developed as a theoretical extension of the traditional RBV, moving beyond the assumption that competitive advantage can be sustained primarily through the possession of firm-specific resources [22], [23]. The conventional RBV argues that organizations can obtain sustained advantages from resources that are valuable, rare, inimitable, and non-substitutable (VRINs). However, these resources are often treated as relatively stable, which creates limitations when firms must respond to rapidly changing environmental conditions [22], [23]. DCV addresses this limitation by shifting attention from the possession of resources towards the firm's capacity to renew, integrate, and reconfigure them in response to environmental change [102], [103]. In this respect, Khan et al. [26] conceptualised DCV around the processes of integrating, developing, and reconfiguring capabilities to respond effectively to changing environmental circumstances. From this perspective, merely possessing VRIN resources may not enable manufacturing organizations to cope effectively with disruptions or maintain adaptability [23], [24].

Instead, continuous renewal, adaptation, and reconfiguration allow firms to modify their resource base and respond more effectively to internal and external changes [102]. Ostadi et al. [103] further identified sensing, seizing, and transforming as three fundamental dimensions of dynamic capabilities. These dimensions enable firms to recognise relevant opportunities and threats, mobilise available resources, and modify organisational processes accordingly. Thus, DCV provides a useful theoretical explanation of how manufacturing organizations can remain viable, adaptable, and responsive when operating under complex, uncertain, and disruptive conditions.

Although DCV has been applied extensively across different organizational contexts [27], [28], its application in resource-constrained settings and under evolving organizational conditions remains comparatively underexplored [29]. This issue is particularly relevant to the manufacturing sector in Bangladesh, including industries such as garments and leather, where firms operate within resource-intensive environments and face constraints in developing and deploying dynamic capabilities [30]. Although prior research has applied and operationalised DCV, particularly within technologically advanced industries [31], traditional manufacturing environments provide an important setting for examining how firms can develop and integrate dynamic capabilities despite resource constraints and established operational structures [30].

Existing research has examined several consequences of dynamic capabilities, including operational excellence, financial performance, competitive advantage, and innovation in manufacturing [32], [33]. However, relatively limited attention has been directed towards understanding how manufacturing firms in Bangladesh use dynamic capabilities to maintain resilience under prolonged environmental uncertainty and disruption. Accordingly, scholars have called for greater investigation into organizational resilience in the Bangladeshi manufacturing sector to clarify how firms can proactively absorb disturbances, adapt their operations, and reconfigure resources as environmental conditions evolve [29], [30].

Consistent with these research directions, DCV offers a suitable theoretical foundation for explaining how manufacturing firms can develop resilience by converting relatively static resource arrangements into more adaptive capability systems. Previous research has similarly argued that resilience involves the development of capabilities through which firms can sense emerging disruptions, mobilise available resources, and reconfigure organisational processes [25], [34]. Accordingly, organizations can employ dynamic capabilities to respond to evolving challenges, particularly when they operate within volatile and resource-intensive environments [28]. The requirements of resilience, including organizational survival, adaptation, and continuous evolution, are therefore closely aligned with the central logic of DCV [6], [35]. Both perspectives move away from a static conception of organizational behaviour and instead emphasise renewal, transformation, adaptation, and learning. In this sense, DCV closely reflects the underlying resilience cycle. For instance, sensing opportunities and threats, seizing appropriate responses, and transforming organizational routines under DCV correspond closely with anticipating risks, responding rapidly to disruptions, and transforming operations within the resilience perspective [36]. Manufacturing firms can establish this dynamic foundation through managerial capabilities such as human capital, social capital, and knowledge management, together with organizational capabilities including digital transformation, redundancy, and visibility. The interaction of these capabilities can provide the basis for developing and sustaining resilient performance.

From a decision-oriented perspective, however, OR cannot be understood solely as the result of a firm's capability-development processes. Its effectiveness also depends on managerial choices concerning which resilience strategies and capabilities should be prioritised and implemented . This consideration is particularly important for firms operating in resource-intensive and uncertain environments, where managers must make capability-related decisions according to the availability of backup resources, knowledge networks, digital infrastructure, workforce capabilities, and supply-chain visibility [37]. Accordingly, this study conceptualises resilience as a decision-oriented outcome shaped by managerial choices regarding the strategic prioritisation of DCs. This perspective complements DCV by explaining not only how firms develop dynamic capabilities but also how managers can prioritise and combine available DCs when designing resilience-building strategies. In addition to identifying necessary conditions, the decision-oriented perspective recognises that high resilience may be achieved through several alternative capability configurations, depending on the firm's existing resources and circumstances.

This decision logic is structured around three stages. In the first stage, managers determine the minimum capability conditions that must be established to support OR. The second stage draws on NCA to identify indispensable DCs and reveal the bottlenecks that may constrain resilience development. Managers can then use these findings to assess which essential capabilities require priority attention. The second stage also incorporates fsQCA, which enables managers to identify alternative capability configurations capable of producing high OR according to their existing capability and resource conditions. In the third stage, managers examine capability deficiencies by considering the low-performance configurations identified through fsQCA. This final stage helps determine which missing capabilities or unfavourable combinations may contribute to low resilience. Consequently, managers can make more informed decisions about which capabilities must be maintained and which combinations should be developed, recognising that the absence of particular capabilities within a configuration may substantially weaken organizational resilience.

2.2. Organizational Resilience (OR)

OR has become an increasingly significant construct in sustainability and management research because manufacturing firms must remain capable of responding to economic crises, climate-related events, natural disasters, and other forms of external disruption [4]. Early conceptualisations largely associated resilience with an organisation's capacity to recover rapidly following an unexpected disturbance and restore its operations to a relatively stable condition [38]. However, this recovery-oriented interpretation places considerable emphasis on short-term crisis response and provides less consideration to the continuous learning and capability development required to address evolving challenges [39].

The conceptualisation of resilience has consequently progressed towards a broader and more strategic understanding. Contemporary research views resilience as a combination of recovery, adaptation, agility, alertness, and transformation capabilities [1], [40]. From this broader perspective, resilience enables firms to respond proactively to emerging threats while continuously adjusting their operations to changing conditions. It is therefore increasingly regarded as a strategic capability through which firms can tolerate disruption, absorb uncertainty, adapt to environmental changes, and potentially emerge stronger from adverse conditions [7]. These requirements are particularly relevant in today's uncertain global economy, where organizations must continuously withstand disruptions, absorb shocks, adapt their activities, and transform their operations. Consequently, OR has become an important strategic determinant of competitiveness, particularly for firms operating in highly volatile industries [41]. It should therefore be understood not simply as an organisational outcome but as an outcome that develops through the deployment and integration of multiple organizational capabilities.

A substantial body of research conceptualises resilience as a strategic outcome arising from multilevel DCs [6], [28], [35]. The principal attributes of resilience, such as anticipating threats, absorbing disturbances, and adapting to changing conditions, closely correspond with the core processes of DCV, namely sensing risks and opportunities, seizing appropriate responses, and reconfiguring organizational structures and processes [6], [35]. This correspondence positions resilience as a dynamic organizational outcome rather than a fixed organizational characteristic. Although RBV highlights the importance of possessing valuable and rare resources, the mere existence of relatively static resources or capabilities may not be sufficient to ensure resilience [6], [35]. Instead, resilience depends on how firms orchestrate and deploy their DCs to anticipate disruptions, cope with their effects, and adapt to changing environmental circumstances [28], [35]. Moreover, resilience cannot be attributed to a single capability in isolation. It can emerge from the combined influence of different managerial and organizational capabilities [42]. Accordingly, this study conceptualises OR as being influenced by managerial capabilities, namely HCA, SCA, and KMA, together with organizational capabilities represented by digital transformation, redundancy, and visibility.

Despite the recognition that managerial and organizational capabilities contribute to resilience, existing research has devoted comparatively limited attention to the ways in which these capabilities interact and collectively produce resilient outcomes [16], [17], [21]. Although capability interactions have received attention in developed-country settings, substantially less is known about their configurational and conditional effects within developing economies such as Bangladesh, where manufacturing firms operate amid considerable uncertainty, volatility, and resource constraints. This limitation leaves an important gap in understanding how different DCs operate collectively in such environments. Studies including [16], [40] have examined resilience through specific individual dynamic enablers or capabilities, but have generally not explored how multiple capabilities can be integrated to produce resilience within manufacturing organizations. Similarly, much of the existing literature implicitly treats resilience as a relatively linear outcome, giving insufficient consideration to how managerial antecedents, including HCA, SCA, and KMA, may interact with organizational antecedents such as digital transformation, redundancy, and visibility to generate resilient outcomes [10], [38]. This limitation creates a conceptual gap and reinforces the need for an integrated perspective that treats resilience as a holistic outcome emerging from the interaction and configuration of managerial and organizational capabilities.

3. Hypothesis Development

3.1. Human Capital (HCA)

HCA encompasses the knowledge, competencies, educational background, and professional experience embodied within an organization's workforce [43]. These attributes constitute important intellectual resources that can strengthen a manufacturing firm's capacity to adapt to changing conditions and foster innovation [44]. Existing empirical evidence has established a relationship between HCA and efforts to develop organizational resilience. For instance, Eriksson et al. [45] examined the relationship between HCA and innovation in the context of improving economic performance, while Li and Lin [11] reported a positive association between human capital and OR.

Furthermore, Zhou et al. [10] argued that high-performance work systems may not independently constitute an effective internal mechanism for developing OR unless they are supported by strong HCA, which can contribute to both recovery-oriented and forward-looking forms of resilience. Drawing on these findings, this study posits that HCA represents an important necessary condition for developing resilience. At the same time, its contribution may depend on its interaction with complementary capabilities and practices that collectively support high-resilience outcomes. Nevertheless, previous research has paid limited attention to these configurational relationships, particularly to the ways in which HCA may operate jointly with KMA and other organizational capabilities in producing resilience. Therefore, beyond examining the necessity of KMA, this study also investigates how KMA combines with other organizational practices to generate high OR.

P1: HCA is a necessary condition for achieving OR.

3.2. Social Capital (SCA)

SCA represents the relationships, trust, shared norms, and common values embedded within organizational and interorganizational networks that facilitate cooperation for collective benefit. OR, in contrast, reflects an organization's capacity to anticipate, prepare for, respond to, and adapt to internal and external disruptions. The importance of SCA in resilience development has been highlighted by Reniati et al. [17], who argued that networks, trust, and collaborative relationships enable firms to coordinate activities, share risks and resources, and exploit opportunities arising from changing manufacturing environments. These social mechanisms therefore have implications not only for organizational performance but also for the development of resilience. Kuşcu Karatepe et al. [46] further established a psychological link between SCA and psychological resilience, suggesting that stronger social connections can support employee performance and psychological well-being while contributing to a more adaptive working environment capable of responding to external challenges. Similarly, Bernados and Ocampo [47] highlighted the role of SCA in strengthening trust and collaboration, facilitating conflict resolution, and reinforcing social bonds.

Based on this evidence, SCA is expected to constitute a necessary condition for achieving OR. However, its contribution is unlikely to operate independently, as the effectiveness of SCA may depend on complementary managerial and organizational capabilities that collectively support stronger resilience outcomes. Despite this potential interdependence, existing research on manufacturing firms in Bangladesh provides limited evidence regarding the alternative capability configurations through which SCA can contribute to high resilience. Considering the complementary nature of SCA and the identified research gap, this study therefore examines multiple configurational pathways through which SCA can interact with other capabilities to strengthen firms' OR.

P2: SCA is a necessary condition to achieve OR.

3.3. Knowledge Management (KMA)

KMA can be understood as the systematic process through which firms generate, acquire, organise, disseminate, and utilise knowledge and information resources. A growing body of research suggests that effective KMA is an important foundation for developing organizational resilience [12], [48], [49]. For instance, some researchers demonstrated that KMA supports supply-chain reengineering while strengthening collaboration, agility, and risk-management capabilities within manufacturing environments. Nevertheless, the contribution of KMA to resilience may not occur independently, as its effectiveness can be influenced by the presence of complementary organizational capabilities [12], [50], [51]. In this regard, Singh et al. [48] found that the generation, transfer, and acquisition of knowledge can be strengthened through digital transformation, thereby supporting greater firm resilience. Similarly, Rehman et al. [12] identified KMA as an important contributor to organizational agility and flexibility but emphasised that its effectiveness is enhanced when combined with other organizational capabilities. Supporting this configurational perspective, Mata et al. [49] found in the Portuguese context that KMA can serve as a necessary foundation for developing absorptive capability and strategic agility, while higher resilience is achieved when KMA is integrated with other DCs.

The importance of KMA is particularly relevant to Bangladeshi manufacturing firms, where frequent internal and environmental changes require organizations to continuously acquire, transfer, and apply knowledge. Although KMA may provide an essential foundation for resilience, its contribution can be strengthened through interaction with other organizational capabilities. However, empirical evidence concerning manufacturing firms in Bangladesh remains limited, particularly regarding how KMA combines with other DCs to produce stronger resilience outcomes. This limitation highlights the need to examine not only whether KMA is necessary for OR but also how its interaction with complementary capabilities can generate alternative pathways towards high resilience.

P3: KMA is a necessary condition to achieve OR.

3.4. Digital Transformation (DTR)

DTR facilitates the incorporation of advanced digital technologies into manufacturing operations, thereby improving production efficiency, controlling costs, and increasing operational flexibility. These attributes have positioned DTR as an important enabler of OR in recent research [13], [14], [52]. Zhang et al. [52] emphasised that digital transformation is increasingly necessary for manufacturing organizations because, without it, firms may struggle to establish digital capabilities that support adaptability and effective responses to emerging challenges. Similarly, Browder et al. [16] identified DTR as a critical condition for recovering from the disruptions caused by COVID-19, demonstrating its importance in enabling firms to adjust their operations during periods of crisis.

Nevertheless, the resilience contribution of DTR may not be sufficiently explained by technological adoption alone. Previous studies indicate that its effectiveness can depend on the extent to which digital resources are integrated with complementary managerial and organizational capabilities [53],[54]. For example, DTR can strengthen employee empowerment and improve financial efficiency while enabling manufacturers to enhance operational processes, allocate resources more effectively, and respond to environmental pressures [13]. These effects suggest that the value of DTR for resilience may arise not simply from implementing digital technologies but from combining digital resources with other DCs. Accordingly, this study proposes that DTR constitutes a necessary condition for OR while also examining whether its integration with other DCs can form sufficient configurations capable of producing high OR.

P4: DTR is a necessary condition for achieving OR.

3.5. Redundancy (RED)

The importance of redundancy as a resilience-enabling condition has been supported across several studies [55]. Their findings indicate that redundancy can contribute to adaptability through both linear and nonlinear relationships, suggesting that its effectiveness may depend on how redundant resources interact with other DCs within manufacturing organizations. Azadegan et al. [56] described redundancy as the deliberate provision of additional or backup resources that allows firms to maintain operations when unexpected disruptions occur. Similarly, Azadegan et al. [56] demonstrated that redundant resources can be particularly valuable for preserving competitive advantage during disruptive events. They emphasized the importance of RED in supply-chain resilience, noting that mechanisms such as safety stock and alternative supply channels provide firms with additional capacity to absorb disruptions. Ivanov, D. [57] further identified dynamic redundancy, involving the redeployment or relocation of resources, as an important mechanism for supporting both organizational performance and resilience. Redundancy can also facilitate rapid responses to unexpected changes by reducing the time, effort, and financial resources required to restore or adjust operations. In manufacturing contexts, Praharsi et al. [16] similarly identified contingency plans, alternative suppliers, emergency inventories, backup facilities, operational reserves, and additional workforce capacity as important mechanisms for strengthening resilience.

Despite these benefits, redundancy can also involve considerable financial and operational costs. Blackhurst et al. [58] argued that maintaining excess or backup resources may require substantial investment, while ineffective strategic deployment can prevent firms from realizing their intended benefits. therefore, cautioned that decisions concerning redundant-resource investments should be based on careful strategic assessment of whether such resources are genuinely required. Despite these limitations, this study proposes that RED represents a necessary condition for achieving OR when supported by an appropriate strategic framework. At the same time, existing research suggests that redundant resources contribute most effectively to resilience when managerial and organizational capabilities enable firms to convert backup capacity into practical flexibility and adaptability. Although previous literature has established the importance of redundancy, much of this work has examined its contribution through relatively linear relationships. This study therefore extends the discussion by considering whether RED can operate through alternative capability configurations to strengthen resilience, particularly among Bangladeshi manufacturing firms, where the potential of combining backup resources with other DCs to create alternative resilience pathways remains insufficiently explored.

P5: RED is a necessary condition to achieve OR.

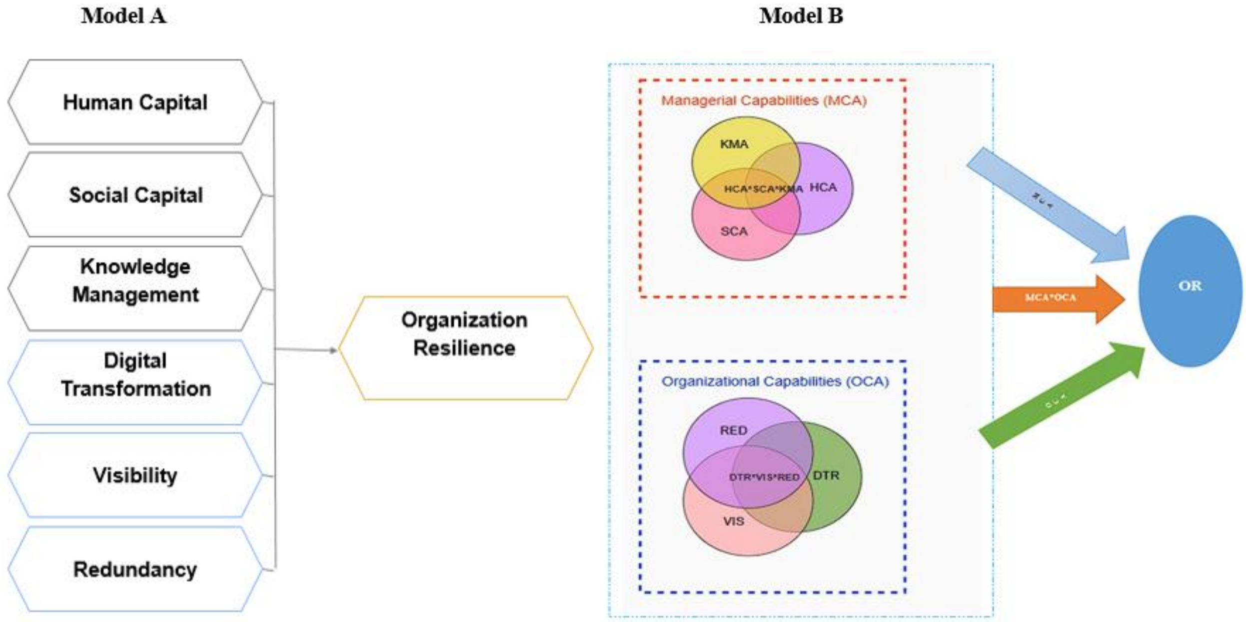
3.6. Visibility (VIS)

The authors in Pertheban et al. [59] conceptualised visibility as the timely communication and availability of information, particularly real-time information, and identified it as a proactive mechanism for strengthening OR. However, the authors also emphasised that such protective mechanisms are more effective when integrated with DCs that enable firms to translate information availability into effective resilience responses [59]. Similarly, Sunmola et al. [15] identified visibility as an influential factor within manufacturing supply chains. Although visibility provides firms with greater awareness of emerging conditions, its contribution to disruption management depends on how effectively the available information is operationalised and incorporated into organizational responses. Wycislak and Akhtar [60] further demonstrated that real-time visibility is necessary for developing adaptive resilience in manufacturing supply chains and identified three mechanisms underlying this relationship: information velocity, system-wide transparency, and predictive capability. Evidence from Malaysian manufacturing sectors provided by Mubarik et al. [61] also supports the positive contribution of visibility to supply-chain resilience. Nevertheless, the findings suggest that its effectiveness can be strengthened when supported by complementary managerial and organizational DCs.

The interdependence between VIS and other capabilities is further supported by Dey [62], who found that real-time information processing and effective information flows enhance visibility while contributing to a more connected, agile, and collaborative supply-chain system capable of responding adaptively to global disruptions. Collectively, these findings provide a strong basis for proposing VIS as a necessary condition for achieving OR. At the same time, the existing evidence indicates that visibility is unlikely to generate its full resilience potential independently. Rather, its contribution may be amplified when it operates alongside complementary managerial and organizational capabilities. Accordingly, this study examines not only the necessity of VIS for OR but also the alternative capability configurations through which VIS can contribute to stronger resilience outcomes.

P6: VIS is a necessary condition for achieving OR.

This study develops a theoretical framework in which OR is conceptualised as an integrated outcome emerging from the interaction of managerial and organizational DCs (Fig. 1). The managerial dimension comprises HCA, SCA, and KMA, whereas the organizational dimension incorporates DTR, RED, and VIS. Model A illustrates the effects of individual capabilities as necessary conditions for achieving OR, while Model B depicts the alternative configurations through which managerial and organizational capabilities can combine to produce a specific resilience outcome. Within the proposed framework, these capabilities are treated as antecedent variables, with OR serving as the outcome variable. The model therefore assumes that HCA, SCA, KMA, DTR, RED, and VIS constitute important antecedents of OR, while the configurational perspective explains how different combinations of these capabilities can interact to generate alternative pathways towards higher levels of OR.



Organizational Resilience (OR): Managerial Capabilities: Human Capital (HCA), Social Capital (SCA), and Knowledge Management (KMA); Organizational Capabilities: Digital Transformation (DTR), Visibility (VIS), and Redundancy (RED)

Fig.1: Conceptual Framework

4. Research Methodology

4.1 Participants, Procedures, and Data Collection

The effective performance of manufacturing firms depends substantially on the reliable functioning of their logistics chains, particularly the efficient coordination and management of raw materials and other essential resources [63]. Recent evidence indicates that 78% of manufacturing organizations have been significantly affected by disruptive events, including the Russia-Ukraine geopolitical crisis and the COVID-19 pandemic, highlighting the particular importance of developing OR within the manufacturing sector [64]. To empirically examine the proposed relationships and address the study objectives, this research adopted a survey-based approach for statistical analysis. The survey was designed in accordance with the established literature and used to assess the proposed relationships within the research framework. This approach provides empirical insight into how manufacturing firms in Bangladesh can develop and deploy managerial and organizational capabilities to strengthen OR when confronted with disruptive events.

As an emerging economy, Bangladesh provides a relevant setting for examining how manufacturing organizations utilise developing resources and capabilities to establish competitive advantages within increasingly complex business environments. Data were collected through a structured questionnaire developed for the statistical assessment of the proposed research framework. The study was conducted among manufacturing organizations operating in Bangladesh, with senior-level professionals selected as the target respondents because of their involvement in organizational and managerial decision-making. Initially, 360 senior professionals were invited to participate in the survey, of whom 310 completed and returned the questionnaire, providing the final sample for analysis. Participants were informed that their responses would be used exclusively for academic research and that the confidentiality and anonymity of the information they provided would be maintained. To strengthen the relevance and validity of the survey instrument, the research objectives were also discussed with professionals representing different functional departments within the participating manufacturing organizations. Detailed information concerning the participants is presented in Table 1.

4.2 Measures

The survey instrument was operationalised using measurement items adapted from established literature. The items were derived from previous empirical studies and further reviewed in consultation with management professionals to enhance their content validity and contextual suitability (Appendix A). Respondents evaluated all items using a 5-point Likert scale. HCA was measured using five items adapted from Bergkvist et al. [65], while six items from Al-Omoush et al. [66] were used to assess SCA. KMA was operationalised through four items adopted from Wu and Chen [67]. Four items adapted from He et al. [68] were used to measure DTR, and RED was assessed using four items derived from Chowdhury and Quaddus [69]. VIS was measured using six items adapted from Kurniawan et al. [70], Swafford et al. [71], and Blome et al. [72]. Finally, OR, which served as the dependent variable, was assessed using four items adopted from Ambulkar et al. [73].

Table 1

Demographic Information

Respondents	Constructs	Frequency	Percent
	Female	127	41.0
	Male	183	59.0
	Total	310	
Age	Less than 23	2	0.6
	24-30 Years	74	23.9
	31- 37 Years	220	71.0
	38-45 Years	10	3.2
	More than 45 Years	4	1.3
	Total	310	
Education	SSC	3	1.0
	HSC	12	3.9
	Bachelor Degree	198	63.9
	Master Degree	94	30.3
	PhD or Above	3	1.0
	Total	310	
	Senior Executive	31	10.0
Position	Manager	23	7.4
	Senior Manager	124	40.0
	Director	81	26.1
	CEO/Owner	51	16.5
	Total	310	
Industry Type	Telecommunications	23	7.4
	Construction	124	40.0
	Health	51	16.5
	Transpiration	81	26.1
	Others	31	10.0
	Total	310	

4.3 Analytical Approach

NCA is an innovative analytical approach introduced by Dul [91] for examining whether a particular condition X is necessary for achieving an outcome Y. According to Dul et al. [74], NCA evaluates the necessity effect of a prerequisite condition and determines whether that condition constrains the attainment of a desired outcome. Thus, NCA serves two related purposes: identifying whether a condition is necessary and assessing the extent to which that condition creates a constraint or bottleneck for achieving the outcome. Unlike conventional regression models, where deficiencies in one predictor may be offset by higher values of other predictors, NCA follows a nocompensatory logic. A required outcome cannot be attained when an indispensable condition remains below its necessary level, regardless of the levels achieved by other variables. This feature makes NCA particularly useful for identifying capability-related barriers that may prevent manufacturing firms from attaining high OR.

In contrast, fsQCA investigates how combinations of conditions relate to a particular outcome through configurational analysis [75]. Its sufficient-condition analysis identifies combinations of relevant conditions that can produce the desired outcome [76]. This approach provides several advantages over conventional regression techniques. Whereas traditional correlational approaches generally rely on a net-effect logic in which individual predictors are assumed to exert relatively stable effects on a dependent variable, fsQCA examines how conditions operate collectively and how different combinations can generate an outcome [77]. It can also distinguish between core and peripheral conditions within particular configurations, thereby revealing which elements play more central roles in producing specific outcomes [78].

This study integrates NCA and fsQCA to examine OR from complementary causal perspectives. NCA identifies the conditions that are indispensable for achieving the outcome, whereas fsQCA identifies alternative configurations through which managers can attain high OR. The theoretical rationale for combining these approaches arises from the nonlinear and configurational nature of OR, particularly within resource-intensive manufacturing environments. From a managerial decision-making perspective, understanding whether individual capabilities are indispensable is insufficient; managers must also know which alternative combinations of capabilities can produce high resilience under different organizational circumstances. Accordingly, this study treats OR as a decision-oriented outcome in which managerial and organizational capabilities operate interdependently rather than as isolated predictors.

The methodological integration addresses two distinct forms of causal reasoning. NCA provides necessity logic by determining whether individual constructs represent indispensable conditions and by identifying their noncompensatory bottlenecks [74]. fsQCA, by contrast, examines sufficiency by identifying alternative combinations of these constructs that can lead to high OR [85]. Combining the two approaches is particularly valuable for managerial decision-making because NCA establishes the minimum capability requirements that firms need to secure, while fsQCA captures equifinality, whereby different combinations of capabilities can produce the same resilience outcome [79]. This distinction is especially relevant to manufacturing firms in Bangladesh because organizations may differ considerably in their resource availability, managerial capabilities, and operational constraints. The integrated approach therefore moves beyond conventional linear net-effect analysis by revealing both indispensable capability requirements and alternative configurational pathways, thereby providing a more comprehensive basis for resilience-related decision-making.

The application of NCA alongside fsQCA is particularly important because the two methods answer different questions. fsQCA can reveal sufficient configurations or alternative pathways through which firms may achieve high OR, but it cannot establish whether any individual condition is indispensable for attaining that outcome. NCA addresses this limitation by determining whether a particular construct constitutes a noncompensatory bottleneck. In practical terms, a capability may need to reach a minimum level before high resilience becomes possible, even when other capabilities are already highly developed. Identifying such indispensable conditions allows managers to determine the minimum capability requirements that should be secured before selecting among alternative resilience-building strategies.

Overall, the combined application of NCA and fsQCA establishes a three-stage decision logic. In the first stage, NCA identifies indispensable capabilities and their associated bottlenecks. In the second stage, fsQCA identifies multiple sufficient pathways towards high OR, enabling managers to select configurations that correspond to their available capabilities and resources. In the third stage, the low-outcome configurations generated by fsQCA provide insight into potential capability gaps that should be avoided. The integration of NCA and fsQCA therefore converts the empirical analysis into a decision-support framework by identifying indispensable capabilities, revealing alternative high-resilience configurations, and highlighting capability deficiencies that may undermine resilience development in Bangladeshi manufacturing firms.

5. Data Analysis and Results

5.1 NCA Results

NCA is applied not only to examine associations between the characteristics of the explanatory constructs and the outcome, but also to determine whether specific conditions are indispensable for achieving the desired result. The analysis follows three principal requirements when establishing a necessary condition. First, the relationship between the condition and the outcome must be theoretically and empirically supported. Second, the necessity effect size must be greater than zero to indicate the presence of a meaningful necessity effect. Third, the observed necessity effect must be evaluated against the null hypothesis to minimise the risk of Type I errors and misleading conclusions. To support this assessment, bootstrapping with a permutation procedure is employed to test the observed necessity effects and determine their statistical significance.

Given the distinct structure and hierarchical characteristics of the data, the ceiling regression-free disposal hull (CR-FDH) technique was selected as the appropriate analytical approach. NCA was initially conducted by representing the scores of the hypothetical constructs within a Cartesian coordinate system. The CR-FDH ceiling line was then established to identify the upper boundary of the observed data distribution (Fig. 2). This approach is particularly suitable for analysing continuous and discrete variables measured at multiple levels, allowing the necessary-condition effect to be evaluated without imposing a conventional regression-based functional form.

The measurement model was assessed within the proposed research framework to establish the reliability and validity of the constructs. PLS was employed to evaluate the measurement properties, with Table 2 presenting the outer loadings, Cronbach's alpha (CA), composite reliability (CR), and average variance extracted (AVE) values. CA and CR were used to assess the internal consistency and reliability of the measurement scales, as recommended by Hair et al. [80]. A CA value above 0.70 is generally considered indicative of satisfactory reliability. As all constructs in the model exceed this recommended threshold, the measurement scales demonstrate adequate internal consistency and reliability.

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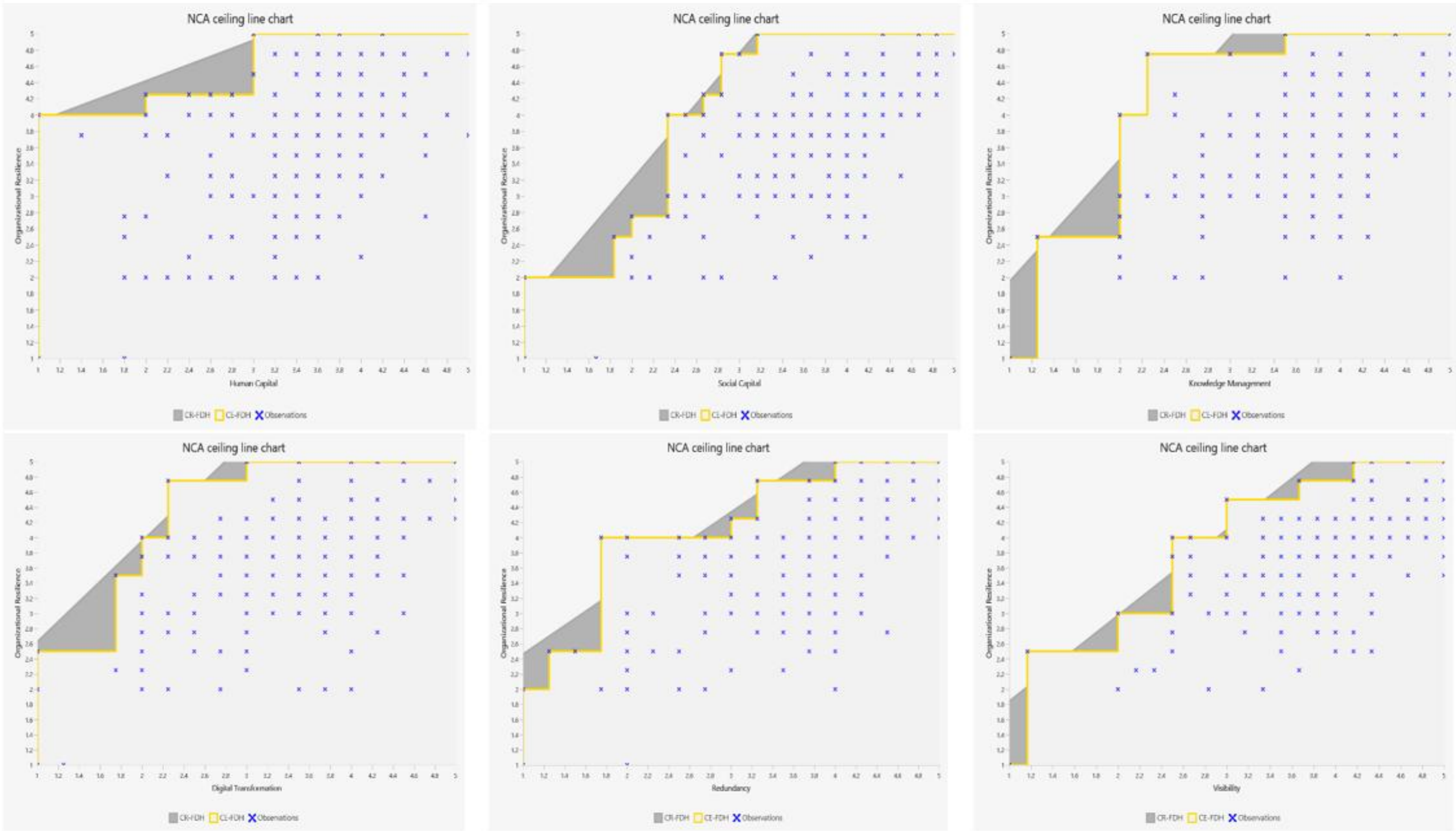

Fig.2: NCA Ceiling Plots

CR was further examined to assess the reliability and convergent validity of the constructs. As reported in Table 2, the CR values range from 0.869 to 0.942, substantially exceeding the recommended minimum value of 0.70 and thereby confirming satisfactory construct reliability Fornell and Larcker [81]. Convergent validity was additionally assessed using AVE. All constructs produced AVE values above the recommended threshold of 0.50, indicating that the constructs explain a sufficient proportion of the variance in their respective indicators [81]. Discriminant validity was subsequently assessed by comparing the square root of the AVE for each construct with its correlations with the other constructs. As presented in Table 3, the square root of each construct's AVE exceeds its corresponding inter-construct correlations, providing evidence that the constructs are empirically distinct [81].

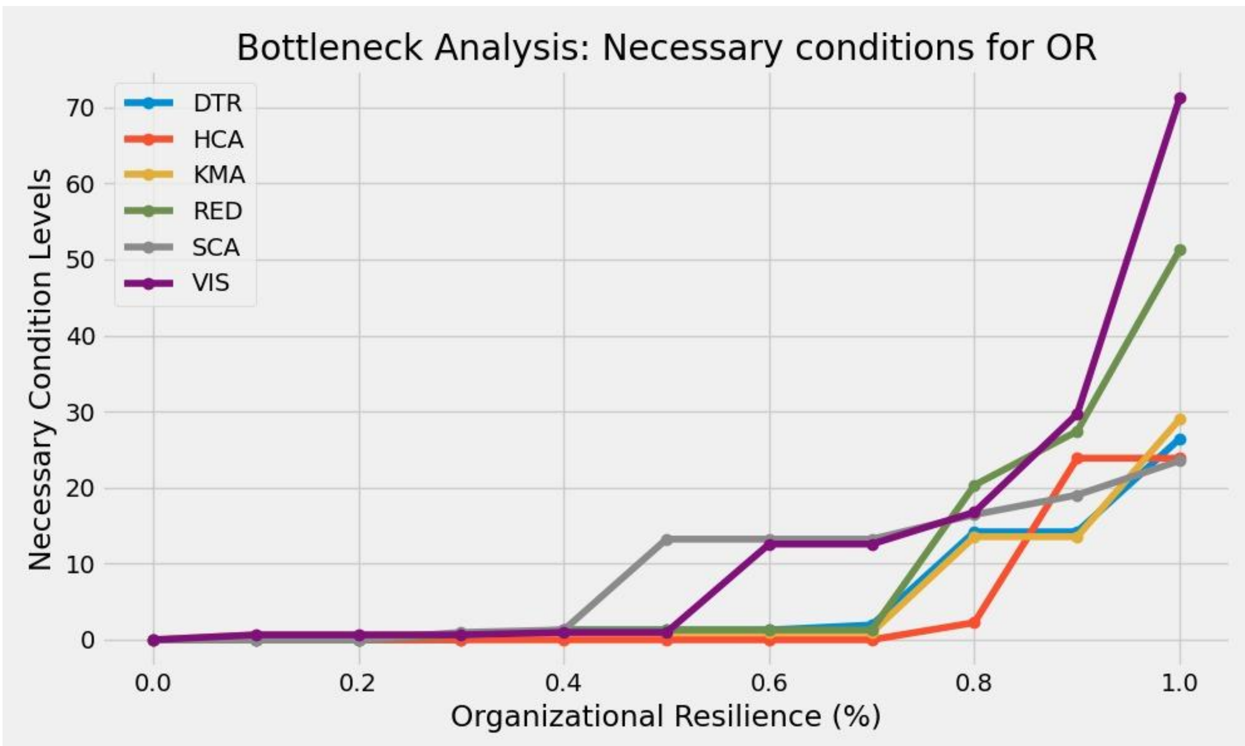

Fig.3: Line Graphs of the Assessment of the Bottleneck Results

The effect sizes (d) of the latent constructs were examined using NCA, with their statistical validity assessed through the recommended randomisation procedure [74]. Following the criteria proposed by Dul et al. [75], a condition can be considered necessary only when three requirements are satisfied: (i) a sound theoretical rationale supports its necessity, (ii) the effect size is greater than zero ($d > 0$), and (iii) the associated p-value is statistically significant ($p < .05$) (Fig. 2). As reported in Table 4 and illustrated in Fig. 2, the NCA findings show that DTR ($d = 0.168$, 0.133), KMA ($d = 0.215$, 0.194), RED ($d = 0.227$, 0.215), SCA ($d = 0.263$, 0.226), and VIS ($d = 0.294$, 0.276) demonstrate medium-sized necessity effects. By comparison, HCA produces a negligible effect ($d = 0.109$, 0.073), with the reported results showing 100% accuracy and statistically significant p-values ($p < 0.05$). Overall, the findings provide evidence that DTR, KMA, RED, SCA, and VIS constitute important necessary conditions for achieving OR, with their medium-sized necessity effects statistically significant at $p < 0.01$.

Table 2
Measurements

	CA	CR	AVE
Digital Transformation	0.872	0.913	0.723
Human Capital	0.774	0.869	0.69
Knowledge Management	0.889	0.924	0.752
Social Capital	0.901	0.924	0.67
Organizational Resilience	0.903	0.932	0.775
Redundancy	0.895	0.927	0.761
Visibility	0.925	0.942	0.729

Table 3
Correlational Matrix (FLC)

	Digital Transformation	Human Capital	Knowledge Management	Social Capital	Organizational Resilience	Redundancy	Visibility
Digital Transformation	0.851						
Human Capital	0.541	0.83					
Knowledge Management	0.772	0.599	0.867				
Social Capital	0.658	0.577	0.804	0.819			
Organizational Resilience	0.692	0.556	0.736	0.748	0.88		
Redundancy	0.692	0.532	0.75	0.785	0.763	0.872	
Visibility	0.652	0.57	0.757	0.811	0.817	0.787	0.854

Table 4
NCA Results

Causal Condition	Method	Accuracy	Original Effect Size	Permutation *P Value*
Digital Transformation	CE-FDH	100%	0.168	0.000
	CR-FDH	100%	0.133	
Human Capital	CE-FDH	100%	0.109	0.040
	CR-FDH	100%	0.073	
Knowledge Management	CE-FDH	100%	0.215	0.000
	CR-FDH	100%	0.194	
Redundancy	CE-FDH	100%	0.227	0.000
	CR-FDH	100%	0.215	
Social Capital	CE-FDH	100%	0.263	0.000
	CR-FDH	100%	0.226	
Visibility	CE-FDH	100%	0.294	0.000
	CR-FDH	100%	0.276	

Table 5
Bottleneck Analysis of Organizational Resilience

OR	DTR	HCA	KMA	RED	SCA	VIS
0.00%	NN	NN	NN	NN	NN	NN
10.00%	NN	NN	0.645	NN	NN	0.645
20.00%	NN	NN	0.645	NN	NN	0.645
30.00%	NN	NN	0.645	0.645	0.968	0.645
40.00%	1.29	NN	0.968	1.29	1.29	0.968
50.00%	1.29	NN	0.968	1.29	13.226	0.968
60.00%	1.29	NN	0.968	1.29	13.226	12.581
70.00%	1.935	NN	0.968	1.29	13.226	12.581
80.00%	14.194	2.258	13.548	20.323	16.452	16.774
90.00%	14.194	23.871	13.548	27.419	19.032	29.677
100.00%	26.452	23.871	29.032	51.29	23.548	71.29

5.1.1 Bottleneck Analysis

Bottleneck analysis determines the minimum level of each necessary condition required to attain a specified level of the outcome, as reported in Table 5. Within NCA, this analysis extends the assessment of multiple necessary conditions by examining the minimum level of each condition X required to achieve successive levels of the outcome Y. The results presented in Table 5 and Fig. 3 therefore illustrate the extent to which individual conditions constrain the attainment of a desired level of OR. A value of "0" in the bottleneck table indicates that the corresponding condition does not impose a constraint on Y at that outcome level and is therefore not necessary.

The findings indicate that a low level of OR, below 30%, can be achieved with only RED and VIS, each requiring a minimum level of 0.645%. Reaching a moderate level of OR, up to 50%, requires a broader combination of capabilities, although HCA does not constitute a bottleneck at this level. Specifically, the required minimum levels are 1.29% for DTR, 0.968% for KMA, 1.29% for RED, 13.226% for SCA, and 12.581% for VIS. At the highest level of OR, all six capabilities become necessary. The corresponding minimum requirements are 26.452% for DTR, 23.871% for HCA, 29.032% for KMA, 51.29% for RED, 23.548% for SCA, and 71.29% for VIS. These results demonstrate that the minimum capability requirements increase as firms seek progressively higher levels of OR, with VIS and RED imposing particularly substantial bottlenecks at the highest outcome level. The bottleneck analysis therefore provides a precise assessment of the capability levels required along the ceiling line and complements the NCA effect-size results by translating necessity effects into actionable capability requirements.

5.2 fsQCA Results

This study employed fsQCA alongside the statistical analysis to provide a more comprehensive understanding of how different combinations of conditions can contribute to OR. The method is particularly appropriate because it enables the identification of multiple causal configurations in which distinct combinations of constructs can produce comparable outcomes [82]. Unlike conventional regression-based approaches that primarily estimate the net effect of individual predictors, fsQCA adopts a configurational perspective based on conjunctural causation, recognising that the contribution of one condition may depend on the presence or absence of other conditions within a particular configuration. This approach therefore provides greater insight into how capabilities operate collectively to generate desired organizational outcomes.

The fsQCA findings identified multiple equifinal configurations through calibration and set-theoretic analysis, demonstrating that high OR can be achieved through more than one combination of conditions. The configurations further indicate that capabilities such as DTR and KMA play important roles within particular high-resilience pathways, while OR represents the resulting outcome across the identified configurations. These findings reinforce the argument that resilience should not be understood solely through the independent contribution of individual capabilities, but rather through the alternative combinations in which managerial and organizational capabilities jointly operate.

5.2.1 Calibration

A calibration scale is essential in fsQCA because it transforms raw observations into meaningful set-membership scores, enabling the method to represent different degrees of membership rather than treating variables as purely binary [82]. Previous studies have commonly used the 5th, 50th, and 95th percentiles as reference points for establishing the calibration structure, allowing clear distinctions among full nonmembership, crossover membership, and full membership [77]. This procedure supports theoretical consistency while facilitating comparability with previous research. Following Ragin [82], this study applied the direct calibration approach, which requires the appropriate identification of crossover points. Accordingly, each variable was converted into a fuzzy set using three cutoff values: the 5th percentile represented full nonmembership, the 50th percentile served as the crossover point, and the 95th percentile represented full membership [83]. Furthermore, the truth table analysis indicates that different combinations of HCA, SCA, KMA, DTR, RED, and VIS can collectively contribute to high OR (Appendix B). Most of the identified solutions demonstrate consistency values above 0.96, indicating that resilience is not dependent on a single component. Rather, it results from the interaction and mutual reinforcement of multiple important capabilities, thereby complementing both configurational and resource-based perspectives [84].

Table 6
Data Calibration for Fuzzy Set Membership Levels

Causal Construct	Mean	Std.Dev.	Minimum	Maximum	N Cases	Full Membership (95%)	Cross Over Membership (50%)	Non-Membership (5%)
Digital Transformation	0.495	0.321	1.000	5.000	310	2.000	3.500	4.500
Human Capital	0.5136	0.292	1.000	5.000	310	2.000	3.600	4.400
Knowledge Management	0.509	0.276	2.000	5.000	310	2.000	3.750	4.750
Social Capital	0.517	0.281	1.000	5.000	310	2.000	3.833	4.666
Organizational Resilience	0.582	0.246	2.000	5.000	310	2.000	4.000	4.750
Redundancy	0.484	0.304	1.000	5.000	310	2.000	3.750	4.500
Visibility	0.532	0.264	3.000	5.000	310	2.000	4.000	4.833

5.2.2 Analysis of Necessary Conditions

The sufficient condition analysis results from fsQCA identify the main variables associated with high and low OR, as presented in Table 7. In fsQCA, coverage indicates the practical relevance of a condition and the extent of the outcome explained by it, whereas consistency reflects the degree to which a condition is associated with the outcome. Consistency and coverage values above 0.90 and 0.75, respectively, are regarded as acceptable thresholds according to established guidelines [82]. A condition is considered “almost always necessary” when its consistency exceeds 0.80 to 0.90 and its coverage is above 0.75 [85]. As shown in Table 7, all constructs for high OR exceed the specified threshold values. For low OR, only VIS exceeds the required threshold to be classified as an almost always necessary condition.

Table 7
NCA Results for High and Low Resilience via fsQCA

Constructs	High Organizational Resilience		~Low Organizational Resilience	
	Consistency	Coverage	Consistency	Coverage
Human Capital	0.744023	0.844197	0.808150	0.693222

~ Human Capital	0.584736	0.700783	0.651175	0.528825
Social Capital	0.789407	0.888494	0.861584	0.745435
~ Social Capital	0.588776	0.711715	0.666795	0.537158
Knowledge Management	0.781326	0.893650	0.870090	0.740118
~ Knowledge Management	0.595640	0.707887	0.656588	0.537507
Digital Transformation	0.733950	0.864191	0.838850	0.692942
~ Digital Transformation	0.565033	0.652123	0.578873	0.487847
Redundancy	0.747952	0.900333	0.884318	0.715197
~Redundancy	0.584792	0.660788	0.580575	0.500200
Visibility	0.847963	0.928320	0.908521	0.810500
~Visibility	0.586563	0.731098	0.698577	0.547383

5.2.3 Sufficient configurations

The sufficient configurations for high and low OR identified through fsQCA are presented in Table 8. In this analysis, raw coverage indicates the proportion of the outcome explained by a particular configuration and therefore reflects its empirical relevance. In contrast, unique coverage represents the proportion of the outcome attributable exclusively to that configuration, without overlap with other configurations [85]. Similar to reliability assessment in regression-based analysis, consistency indicates the extent to which cases exhibiting a particular configuration also display the corresponding outcome. Established guidelines generally consider a consistency value above 0.80 as sufficient, while solution coverage above 0.50 indicates substantial explanatory relevance.

For high OR, the overall solution coverage is 0.914, while the consistency value is 0.793, indicating strong explanatory relevance and acceptable reliability. For low OR, the solution coverage and consistency values are 0.939 and 0.725, respectively. Both sets of results meet the suggested standards. These findings indicate that the identified configurations account for a substantial proportion of variation in OR and provide evidence of equifinality, whereby different combinations of HCA, SCA, KMA, DTR, RED, and VIS can produce either high or low resilience outcomes (Fig. 4).

Model 1 shows that the combination of SCA, KMA, and VIS leads to high OR. This configuration has a raw coverage of 0.658, unique coverage of 0.029, and consistency of 0.958, accounting for 65.8% of the instances. These values indicate substantial empirical relevance and strong reliability. The findings therefore show that SCA, KMA, and VIS form a suitable configuration for achieving OR, whereas DTR, HCA, and RED do not contribute to this configuration. Model 3 indicates that the combination of HCA, RED, and VIS substantially contributes to OR. The configuration records raw coverage of 0.579, unique coverage of 0.010, and consistency of 0.967, covering 57.9% of the cases with high reliability. HCA, RED, and VIS represent the core conditions in this configuration and, collectively, are sufficient for achieving OR. DTR, KMA, and SCA play secondary roles in this configuration.

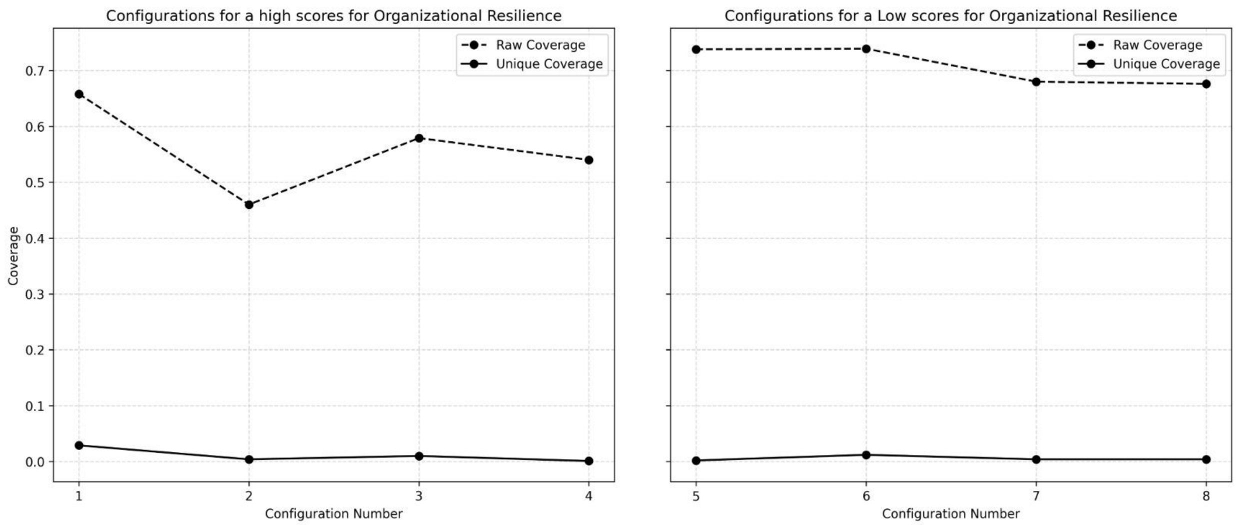

Fig.4: Ceiling Lines for Predicting High and Low ORs

Model 4 demonstrates that the combination of HCA, KMA, DTR, and VIS contributes to the development of OR. This configuration produces raw coverage of 0.612, unique coverage of 0.015, and consistency of 0.951, accounting for 61.2% of the cases with high reliability. The results indicate that HCA, KMA, DTR, and VIS constitute the core and sufficient conditions for achieving OR within this configuration. SCA and RED are insignificant in this model. Model 5 indicates that the absence of KMA, DTR, and RED is associated with low OR. The configuration records raw coverage of 0.738, unique coverage of 0.002, and consistency of 0.843, accounting for 73.8% of low-resilience cases. Here, the absence of KMA, DTR, and RED represents the core conditions of the configuration. Their presence and absence therefore constitute sufficient conditions associated with OR. SCA, VIS, and HCA are irrelevant in this configuration. Model 6 demonstrates that the absence of SCA, KMA, and DTR contributes to low OR. This configuration has a raw coverage of 0.739, unique coverage of 0.012, and consistency of 0.854, accounting for 73.9% of low-resilience cases with reasonable precision. The presence and absence of SCA, KMA, and DTR constitute relevant combinations associated with OR. HCA, RED, and VIS are extraneous in this solution.

Table 8
Sufficient Configurations for High and Low ORs

Category	Model	Configuration	Raw Coverage	Unique Coverage	Consistency
High Scores for Organizational Resilience	Model 1	SCA*KMA*VIS	0.658	0.029	0.958
	Model 2	~SCA*~KMA*~DTR	0.460	0.004	0.743
	Model 3	HCA*RED*VIS	0.579	0.010	0.967
	Model 4	HCA*KMA*DTR*VIS	0.540	0.001	0.976
	Solution Coverage:	0.914		Solution Consistency:	0.793
Low Scores for Organizational Resilience	Model 5	~KMA*~DTR*~RED	0.738	0.002	0.843
	Model 6	~SCA*~KMA*~DTR	0.739	0.012	0.854
	Model 7	~HCA*~KMA*~RED*~VIS	0.680	0.004	0.931
	Model 8	~HCA*~SCA*~KMA*~RED	0.676	0.004	0.882
	Solution Coverage:	0.939		Solution Consistency:	0.725

6. Discussion

This section examines the necessary and sufficient roles of managerial and organizational capabilities in strengthening OR. The combined application of NCA and fsQCA identifies both the necessity of individual capabilities and the configurations associated with high or low OR. The findings are discussed below to determine whether the proposed hypotheses are supported.

For H1, NCA shows that HCA has a small but statistically significant necessity effect. The fsQCA results further identify HCA as a core condition, thereby supporting the hypothesis. Models 3 and 4 identify HCA as a core condition in multiple high-performance configurations. This finding indicates that the contribution of HCA to resilience becomes stronger when it forms part of a configurational pathway. Accordingly, managerial decisions should prioritise HCA within a combined capability strategy. HCA may not be sufficient independently; instead, managers should strengthen its contribution to resilience through appropriate capability combinations [69]. Shatila et al. [87] similarly suggested that investment in KMA and digital literacy can strengthen the contribution of HCA to resilience development.

SCA demonstrates a medium-sized effect in the NCA results and appears as a core condition in high-performance fsQCA configurations, supporting H2. These findings highlight the importance of incorporating SCA into combined strategies for strengthening OR and supporting managerial decision-making regarding the integration of HCA within configurational strategies. This result is consistent with Ben-Hador and Yitshaki [88], who found that SCA represents not only a useful resource but also a fundamental mechanism for addressing disruptions, particularly during crises, while high performance depends on its support from other mechanisms for preventing and managing disruptions. Schobert et al. [89] likewise recommended that firms prioritise the development of strong SCA because it can contribute to cooperative resilience, collaboration, organizational flexibility, and responsiveness.

For H3, both NCA and fsQCA provide strong support. KMA demonstrates a medium-sized necessity effect in NCA and appears as a central condition across multiple fsQCA configurations, indicating that KMA functions as both a necessary and conditional capability for strengthening resilience. This finding suggests that managers should prioritise KMA as part of a configurational strategy, particularly in firms that already possess a structured KMA capability. The result is consistent with Ding et al. [90], who found that dynamic KMA, when combined with digital innovation, can sufficiently enhance OR. Similarly, Tukamuhabwa et al. [91] identified KMA as a necessary instrument for supply-chain resilience and as a conditional mechanism supporting resilience, recommending its use to facilitate both innovation capability and supply-chain resilience.

DTR also demonstrates a medium-sized necessity effect in NCA. Furthermore, fsQCA identifies DTR as a core capability in multiple configurations, although resilience can also be achieved without DTR in Model 2, demonstrating equifinality. These findings provide an important decision-making insight: DTR can strengthen resilience but does not guarantee it, as firms possessing strong social and knowledge capabilities may remain resilient without advanced digital infrastructure. This finding is consistent with Chi et al. [92], who reported a positive influence of DTR on recovery and resilience. However, firms should exercise caution when investing broadly in digital technologies and instead prioritise the digital resources that are necessary, particularly where resource constraints exist. RED demonstrates medium-sized necessity in NCA and functions as a configurational condition in fsQCA, supporting H5. The findings suggest that managers should integrate RED with other capabilities to strengthen its contribution to resilience.

VIS produces the strongest NCA effects and is present in every high-resilience fsQCA configuration, making it one of the most important capabilities for OR. Its presence within different configurations indicates that VIS can contribute sufficiently to resilience when combined with other conditions. From a managerial perspective, the findings suggest that VIS should receive the highest priority as an indispensable capability for resilience development. Managers can also incorporate VIS into alternative configurations by combining it with other managerial and organizational DCs. Wycislak and Akhtar [60] found that real-time VIS is necessary for strengthening adaptive resilience in manufacturing supply chains. Similarly, Mubarik et al. [61] reported that VIS can improve resilience through approaches such as supply-chain mapping.

6.1. Theoretical and Methodological Implications

The study makes several theoretical contributions to organizational resilience, dynamic capabilities, and strategic management, particularly within the manufacturing context. First, it advances the theoretical understanding of OR by extending DCV and proposing that resilience is not developed solely through isolated managerial and organizational capabilities but can also emerge from strategic combinations of these capabilities. Although previous research has largely examined resilience in relation to individual capabilities [13], [15], [17], this study demonstrates how different configurations of managerial and organizational capabilities can collectively produce resilient outcomes. The findings also support the principle of equifinality, whereby different combinations of capabilities can lead to the same outcome [93]. In doing so, the study responds to the increasing emphasis on configurational perspectives within resilience research.

Regarding managerial and organizational capabilities, the study conceptualises KMA as an essential adaptive learning mechanism for developing OR. Whereas previous research has primarily considered KMA as a supportive process [42], [49], the findings position KMA as an integrated DC. The study also provides theoretical clarification regarding SCA as a DC. Although previous research has established the role of social capital in developing trust and collaboration [47], [88], [89], the present findings position SCA as a necessary condition within resilience research. Similarly, the study clarifies the theoretical relevance of HCA to OR by highlighting its contribution to resilience development. The findings further extend research on DTR and resilience by demonstrating that DTR can be combined with human-centred capabilities to strengthen OR [75]. In addition, the findings challenge the conventional assumption that RED is inherently beneficial, instead suggesting that its contribution to resilience depends on its combination with complementary capabilities.

A further theoretical contribution lies in the configurational explanation of how OR can be achieved through different causal pathways. The fsQCA findings identify several configurations associated with high OR. In Model 1, the combination of SCA, KMA, and VIS is sufficient for high OR, supporting trust and collaboration, improving transparency, and facilitating effective information sharing, which are important for achieving high resilience [19], [43]. Another pathway combines HCA, RED, and VIS, providing skill integration for adaptive capability, situational awareness for timely intervention, and redundant resources for absorbing sudden shocks [87], [60]. Model 4 combines HCA, KMA, DTR, and VIS and contributes to high OR through innovation, learning, operational agility, and informed decision-making [43], [60]. Collectively, these configurations extend DCV by shifting attention from isolated capabilities towards configurational outcomes through which high OR can be achieved.

The study also makes a methodological contribution. While previous studies in emerging economies have frequently focused on the linear and direct effects of individual DCs on firm resilience [12], [28], [94], this research combines the analysis of necessary conditions with the examination of nonlinear relationships among antecedents and OR through NCA and fsQCA. This methodological integration enables fsQCA to identify sufficient configurational pathways for strengthening OR, while NCA determines whether individual capabilities constitute non-compensatory bottlenecks. The combined application therefore identifies both alternative capability combinations and indispensable capabilities that managers should secure when developing OR. Furthermore, integrating the two methods supports the proposed three-stage decision logic, which cannot be fully addressed through either method independently. This framework uses the findings of both approaches to support managerial choices, establish empirically sufficient capability combinations according to organizational priorities, and identify capability gaps that should be avoided.

6.2. Managerial Implications

Our study provides practical implications for managers, entrepreneurs, leaders, and policymakers seeking to strengthen OR in the manufacturing sector. The findings identify configurational pathways and necessary conditions that can guide practical implementation. SCA appears in several configurations, indicating that managers should prioritise coordination, trust, and communication when making resilience-related decisions. Given Bangladesh’s weak and limited enforcement, trust, coordination, and communication are particularly important for establishing responsive and adaptive connections [95]. Managers in resource-intensive firms can also utilise SCA to support cross-border and interorganizational collaboration during crises [96]. Personal and community ties can further be leveraged to develop collaborative networks [97]. Policymakers can also promote interfirm partnerships. Moreover, combining SCA with KMA and VIS can support high OR by fostering trust and collaboration, facilitating information sharing, and improving transparency, thereby supporting collaborative adaptability, workforce resilience, and proactive responses to challenges [47], [88], [98].

Although HCA is not a strong driver, it is necessary and appears in several configurations. This finding suggests that managers should consider HCA in combination with other constructs when seeking high-resilience performance. HCA can strengthen a firm’s adaptability and capacity to absorb shocks and respond to changing circumstances [54]. For Bangladeshi managers, prioritising low-cost training, skill development, and employee empowerment may be a strategic approach in environments characterised by unskilled or less-skilled employees [98]. Managers can introduce vocational training and leadership development to strengthen HCA. HCA can also be combined with RED and VIS to sufficiently support OR. HCA provides the skills required for adaptive capacity, VIS supports situational awareness and timely intervention, while RED provides additional capacity to address and adapt to external challenges [87], [60].

According to the findings, KMA is a necessary and core condition for two outcomes and has a significant influence on resilience. This finding suggests that managers in Bangladesh can institutionalise simple and effective KMA practices, including informal and nondigital approaches, to support resource-constrained environments [99]. Conversely, in technologyintensive manufacturing environments such as the UK and USA, formal KMA supported by technology-tool assessment may be more effective because these contexts provide greater support for technology-driven knowledge management [99]. KMA can also be combined with SCA and VIS to achieve high OR. Managers can implement this reliable configuration, in which SCA promotes collaboration and organizational adaptability, KMA facilitates effective information sharing, and VIS enhances transparency and supports proactive responses [43], [60], [92].

DTR does not independently guarantee OR and should be complemented by other constructs, including HCA, KMA, and VIS [92]. DTR can provide technological adaptability and support responsiveness, while managers can integrate it with KMA and HCA to avoid fragmented implementation [11]. VIS appears as a consistently necessary condition across configurations, supporting adaptive capability and sensing ability. However, firms operating in Bangladesh's low-technology environment can strengthen VIS through nondigital measures that improve situational awareness [100]. In high-technology environments, firms can instead utilise digital tools to strengthen VIS and combine it with other constructs, such as DTR, to achieve stronger resilience outcomes [99]. VIS appears in almost all high-OR configurations, indicating that managers and policymakers should prioritise its integration within firms. Among the examined constructs, RED is important but is not universally required for achieving OR. Although redundant resources provide buffers and backup capacity against shocks, investment in RED should be selective in Bangladesh because of the associated costs and limited access to capital. Managers should therefore prioritise targeted and selective redundancy to strengthen firms' capacity to withstand external disruptions.

6.2.1. Decision-Making Implications of Configurational Pathways

The findings can be translated into a decisional perspective to support managers in strengthening OR. In the first stage, NCA findings can assist managers in identifying essential capabilities and their bottlenecks for improving resilience. In the second stage, fsQCA findings can guide decisions among sufficient alternative configurations for enhancing resilience performance. The results from both methods provide several important decisional insights. First, VIS should be considered a foundational capability for resilience because it demonstrates significant necessity effects and appears in several high-resilience configurations. Managers should therefore strengthen visibility across the supply chain, as limited visibility may hinder disruption anticipation, risk detection, and the coordination of rapid responses. Accordingly, VIS should be prioritised as a baseline condition before firms make substantial investments in other resilience capabilities.

In the second stage, firms should consider their organizational context and available resources when selecting capability pathways. For example, Model 1 indicates that firms can sufficiently enhance resilience by combining SCA, KMA, and VIS. This configuration is particularly relevant for firms that depend on trust, information management, and visibility while having limited digital maturity and resources. Another configuration may be suitable for firms that frequently experience operational disruptions. The combination of HCA, RED, and VIS indicates that firms can use skilled employees, backup resources, and visibility to absorb shocks. This pathway suggests that firms can strengthen resilience without relying on advanced digital infrastructure by combining skilled human resources, backup capacity, and situational awareness. Another pathway may be appropriate for firms with broader technological infrastructure and greater technological readiness. Model 4 combines HCA, KMA, DTR, and VIS, demonstrating the importance of integrating these capabilities to strengthen manufacturing firms' resilience. This pathway is particularly suitable for firms seeking to integrate human resources, organizational learning, digital tools, and resources with strong process transparency.

In the third stage, managers should identify and address capability gaps revealed by the low-resilience configurations. For example, the absence of KMA, DTR, and RED in Model 5 may weaken firms' ability to adapt to and absorb external disruptions. Similarly, the absence of SCA, KMA, and DTR in Model 6 may reduce firms' ability to address disruptions. Models 7 and 8, which also involve the absence of several capability constructs, indicate lower adaptability and a reduced capacity to absorb shocks and strengthen resilience. However, these low-performance configurations suggest that resilience-building failure may not result from the absence of a single capability. Instead, failure may occur when several complementary resilience capabilities are simultaneously absent. Managers should therefore proactively identify capability gaps and strengthen combinations of capabilities before disruptions occur. Accordingly, policy and managerial decisions should consider not only successful configurations but also the strategic presence of complementary capabilities according to the firm's specific conditions.

6.3 Limitations and Future Research

Despite providing insights into the necessary and sufficient configurations of DCs that contribute to OR, this study has several limitations. First, the research adopted a cross-sectional design and collected data at a single point in time, limiting the assessment of resilience to its state during that period. Future studies could adopt longitudinal designs to examine how DCs contribute to the development of OR across different stages of disruption over time. Second, the study relied on self-reported perceptual data, which may be subject to subjective bias because individual interpretations can influence responses. Future research could therefore combine multisource data, including operational measures and perceptual assessments, within longitudinal designs. Triangulating different data sources could provide a more comprehensive understanding of resilience development across different types of disruptions.

The study also employed fsQCA and NCA to examine configurational pathways and necessary conditions associated with OR development. However, these methods do not capture the causal sequence through which different DC pathways contribute to resilience over time. Although fsQCA establishes equifinality, it does not reveal the processual depth of the identified outcomes. Future research could employ process tracing and event history analysis to examine the sequence of interactions among DCs and their contribution to resilience development. Finally, the study's focus on the Bangladesh manufacturing industry may limit the generalisability of its findings to other industries and national contexts. The developing-country setting may also restrict generalisation to developed economies and other country contexts. Future researchers could examine comparative industry settings and investigate the dynamic interplay of capabilities in resilience development across diverse regions.

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Appendix A.

-The adapted items of previous literature
-Kindly evaluate your level of consent with the following questions (5 presented strongly agree and 1 strongly disagree):

Human capital (HCA) was assessed through the prior literature of Dumont et al. [119].
HCA 1: My organization sets green goals for its employees.
HCA 2: My organization provides employees with green training to promote green values.
HCA 3: My organization provides employees with green training to develop the employees' knowledge and skills required for green management.
HCA 4: My organization considers employees' green workplace behavior in performance appraisals.
HCA 5: My organization relates employees' green workplace behaviors to rewards and compensation.

Social capital (SCA) was assessed through the prior literature on Bergkvist et al. [65].
SCA 1: My firm is well connected to its business partners.
SCA 2: My firm obtains the required resources and capabilities via its business networks
SCA 3: My firm has close relationships and collaborative activities with other firms.
SCA 4: My firm has strong ties with business partners, including a high degree of trust and commitment.
SCA 5: My firm acquires and leverages value-added knowledge from its business networks
SCA 6: My firm social network influences its strategy, decisions, process, and activities.

Knowledge management (**KMA**) was assessed through the prior literature on Al-Omoush et al. [66].
KMA 1: My firm can codify acquired knowledge into accessible and useable formats
KMA 2: My firm can distribute relevant knowledge throughout the organization
KMA 3: My firm can integrate different sources and types of knowledge
KMA 4: My firm can apply knowledge to solve new problems. Organizational learning capability

Digital transformation (**DTR**) was assessed through prior studies by He et al. [68].
DTR 1: We are using digital technologies (such as analytics, social media, and mobile and embedded devices) to understand our customers better
DTR 2: We sell our products and services through digital channels
DTR 3: An integrated system to support key operational and customer information
DTR 4: We use digital technologies to increase the performance or added value of our existing products and services.

Redundancy (**RED**) was assessed through prior studies by Chowdhury, M. M. H., & Quaddus, M. [69].
RED 1: We maintain reserve capacity for machinery, parts, and logistical support of the firm
RED 2: We have a backup energy/utility source
RED 3: We have a buffer stock for the raw material of the firm
RED 4: Redundant aid supplies covered by several actors with similar products.

Visibility (**VIS**) was assessed through prior studies by Kurniawan et al. [70], Swafford et al. [71], Blome et al. [72].
VIS 1: We are always aware who the firms engaged in our supply chain
VIS 2: We are well aware where our supply chain members are located
VIS 3: We always have complete information such as inventory availability, lead times and delivery dates in our supply chain
VIS 4: The location and status of our main product is always visible throughout the distribution network (e.g., distribution centers, transportation).
VIS 5: My organization informs our partners in advance about changing customer needs
VIS 6: My organization communicates "future strategic needs" with our partners

Organizational resilience (**OR**) was assessed on the basis of prior studies Ambulkar et al. [73]
OR 1: The firm where I work can cope with changes caused by project disruption.
OR 2: Our teams are able to adapt to the organizational disruption easily.
OR 3: We are able to provide a quick response to supply chain disruption.
OR 4: Our firm is able to maintain high situational awareness at all times.

Appendix B:
Truth Table Algorithm

Appendix: Truth Table analysis (Fuzzy-sets-95, 50, 5%)

HCA	SCA	KMA	DTR	RED	VIS	OR	Number	raw consists.	PRI consists.	SYM consist
1	1	1	1	1	1	1	52	0.978462	0.958324	0.966885
0	1	1	1	1	1	1	2	0.975727	0.875458	0.882734
1	0	1	1	1	1	1	3	0.975271	0.807326	0.807326
1	0	1	1	0	1	1	2	0.974633	0.78087	0.780871
1	1	0	1	1	0	1	1	0.973244	0.700001	0.700002
0	1	0	1	1	0	1	2	0.973238	0.691037	0.694313
0	0	1	0	1	1	1	1	0.970308	0.703911	0.703911
1	1	0	1	1	1	1	1	0.97003	0.789941	0.789942
1	1	1	1	0	1	1	3	0.969801	0.779087	0.791917
0	1	1	1	0	1	1	1	0.969282	0.738334	0.745791
1	0	1	0	1	1	1	1	0.969215	0.705535	0.705535
0	1	1	0	1	1	1	1	0.968101	0.744526	0.752213
1	0	0	0	1	1	1	2	0.968096	0.708561	0.708562
1	0	0	1	1	1	1	2	0.967497	0.705545	0.736528
1	1	1	1	1	0	1	2	0.966081	0.71134	0.748645