INTERNATIONAL JOURNAL OF ACADEMIC RESEARCH IN BUSINESS & SOCIAL SCIENCES

Vol 15, Issue 12, (2025) E-ISSN: 2222-6990

The Role of Big Data Analytics Capability in Enhancing Supply Chain Risk Management, Resilience, and Performance

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DOI Link: http://dx.doi.org/10.6007/IJARBSS/v15-i12/27274

Published Date: 20 December 2025

Abstract

The increasing complexity and competition within modern supply chains have heightened the need for technological integration to ensure both survival and strategic advantage. As supply chains span multiple stakeholders and complex logistics networks, the associated risks demand the effective, efficient, and timely acquisition, processing, and analysis of information. Big Data Analytics Capability (BDAC) has thus emerged as a critical enabler, empowering organizations to enhance risk management, build resilience, and improve performance. For clarity, Big Data Analytics (BDA) refers to the use of tools and techniques to analyze large datasets for decision-making, whereas BDAC reflects an organization's ability to effectively apply these technologies to create value and achieve strategic goals. However, traditional supply chain risk management (SCRM) approaches largely focus on proactive activities, overlooking the reactive capabilities essential for achieving resilience. This study proposes a holistic conceptual framework that integrates both proactive and reactive activities, conceptualizes supply chain resilience (SCR) as a mediator and BDAC as a moderator that strengthens the impact of SCRM on SCR. Grounded in the Dynamic Capability View (DCV) and syntheses from literature, the framework addresses key theoretical gaps and offers actionable insights for practice. Future research should empirically validate the framework across varied industry contexts.

Keywords: Big Data Analytics Capability, Supply Chain Risk Management, Supply Chain Resilience, Organizational Performance, Dynamic Capability Theory

Introduction

Supply chains play a central role in ensuring the movement of goods and services from point of origin to point of consumption. However, they are inherently vulnerable to a variety of risks

that can adversely affect its efficiency and reliability. According to Olsen and Wu (2014), supply chain risk is not a new phenomenon, as doing business requires the acceptance of some level of risk. Moreover, Blom and Niemen (2022) opine that supply chain disruption is a matter of when, not if they will occur. The inevitability of supply chain disruptions has led scholars to emphasize the critical need for robust supply chain risk management practices. Traditional SCRM approaches have primarily focused on proactive activities such as risk identification, assessment, mitigation, and monitoring. However, authors like Ho et al. (2015) and Munir et al. (2020) have called for a more comprehensive approach that includes reactive components such as risk recovery to enable the supply chain to return to its original state post-disruption. Supply Chain Resilience (SCR) is a critical capability that enables supply chains to absorb the shock of a disruptive event, respond effectively, and recover either to their original state or a more optimal operational condition (Zhao et al., 2023). It helps reduce vulnerability and supports firms in coping with disruptions to restore or improve their performance. As Chowdhury and Quaddus (2016) explain, SCR involves the ability to prevent disruptions and minimize their impact through adequate readiness, rapid response, and recovery capacity. In modern times, to achieve such resilience capabilities, firms increasingly leverage advanced information technologies such as Big Data Analytics (BDA) which enables more accurate forecasting, better risk assessment, and enhanced decision-making under uncertainty. However, the ability of a firm to effectively deploy technology and talent to capture, store and analyze data, toward the generation of insight is referred to as Big Data Analytics Capability (Mikalef et al., 2020).

Therefore, this paper proposes a holistic conceptual framework that links Supply Chain Risk Management (SCRM) to Organizational Performance (OP) through the mediating role of Supply Chain Resilience (SCR), moderated by Big Data Analytics Capability (BDAC). In an era characterized by disruptions and supply chain fragility, this framework responds directly to these challenges and offers a timely and strategic contribution to academic theory and managerial practice.

Literature Review and Conceptual Clarifications

Supply Chain Risk Management (SCRM)

Supply Chain Risk Management (SCRM) refers to the identification, assessment, mitigation, and monitoring of supply chain risks through the internal implementation of tools, techniques, and strategies, as well as external collaboration with supply chain partners, aimed at reducing vulnerability, increasing robustness and resilience, and ensuring continuity and profitability (Fan & Stevenson, 2018; Baryannis et al., 2018). Literature has focused on four primary stages of SCRM: risk identification, risk assessment, risk mitigation, and risk monitoring (for example; Pham et.al 2023; chin and min, 2021; Hohenstein, 2021; Fan et.al 2018). These stages represent proactive approaches that aim to prevent disruptions before they occur. However, scholars such as Munir et al. (2020) and DuHadway (2019) notes that risk detection, mitigation, and recovery form the three key elements of managing supply chain risks. Similarly, Ho et al. (2015) advocated for integrating recovery into SCRM to ensure supply chains swiftly regain stability following disruptions. this study adopts a holistic view of SCRM that incorporates both proactive and reactive components to ensure robust and adaptive supply chain risk management.

Essentially, the risk management process in supply chains typically follows five key stages. The first is risk identification, which involves recognizing events or activities that may directly or indirectly impair supply chain performance (Ho et al., 2015; Kern et al., 2012). Next is risk assessment, which focuses on evaluating the likelihood and potential impact of these risks, identifying their sources, assessing urgency, and classifying them for prioritization. Risk mitigation follows as a proactive step, where organizations implement measures to reduce the likelihood or impact of potential disruptions before they occur (Kirilmaz & Erol, 2017). The fourth stage, risk monitoring, involves the continuous updating of risk-related data, supporting the refinement of risk planning and enabling timely corrective actions (Duong & Ha, 2021). Finally, risk recovery (reactive SCRM) entails executing response strategies aimed at counteracting the adverse effects of disruption and returning the supply chain to a stable or original state (Ivanov et al., 2017; Duhadway, 2019).

Supply Chain Resilience (SCR)

Scholars have frequently positioned supply chain resilience (SCR) as a direct outcome of SCRM practices (Baryannis et al., 2018; Foli et al., 2022; Fan & Stevenson, 2018). In recent literature, SCR is increasingly conceptualized as a capability, the ability of a supply chain to absorb the shock of a disruptive event, respond effectively, and recover either to its original state or to a more adaptive, improved operational condition (Zhao et al., 2023; Chowdhury & Quaddus, 2016). Literature reveals diverse conceptualizations of SCR. First is a unidimensional conceptualization (Rashid et al., 2024; AlAyed & Al Tib, 2023; Bahrami & Shokouhyar, 2021; Al Naimi et al., 2020), followed by a multidimensional conceptualization (Abeysekera & Wang, 2019; Chowdhury et al., 2019; Liu et al., 2018). Within this multidimensional camp, two distinct approaches emerge. The first, which could be referred to as the "proxy approach," identifies resilience based on specific enabling attributes like flexibility, agility, redundancy, and visibility (Abeysekera & Wang, 2019; Chowdhury et al., 2019). The second, more holistic view defines resilience in terms of core dynamic capabilities encompassing absorptive, response, and recovery capabilities (Chowdhury & Quaddus, 2018; Chowdhury & Quaddus, 2016; Hohenstein et al., 2015). The latter approach is more aligned with a comprehensive view of SCRM, as it reflects both proactive and reactive outcomes of SCRM into resilience capability development.

Organizational Performance (OP)

Organizational performance is the strategic goal of SCRM as noted by authors such as Fan and Stevenson (2018) and Baryannis et al. (2018). Primarily SCRM aims to reduce supply chain vulnerability, ensure continuity, increase supply chain robustness and resilience, coupled with profitability. According to Turi et al., (2023), organizational performance also referred to as firm performance or business performance has been defined different ways largely framed around economy, efficiency and effectiveness or merely as the ability to attain set goals and objectives. Several dimension of organizational performance has been reported in extant literature across sustainable performance and traditional performance dimensions. These include economic, social, environmental performance dimensions (Nugrahani and Atrtanto, 2022), financial, operational, social, environmental, interorganizationl, and customer performance (Dahinine et.al 2024; Menhat et.al 2022; Kruger et.al 2022; Shou et.al 2018). However, operational and financial performances are particularly relevant in strategic frameworks like SCRM, which emphasize supply chain resilience, business continuity, and profitability. Operational performance reflects an organization’s ability to transform

capabilities into competitive advantage through productivity, quality, cost, delivery, flexibility, and customer satisfaction (Kareem & Kummitha, 2020). In contrast, financial performance refers to the efficient use of resources to generate economic value and expand market share (Orozco et al., 2018).

Big Data Analytics Capability (BDAC)

Evidenced from extant literature, Big Data Analytics (BDA) and Big Data Analytics Capability (BDAC) are closely related but conceptually distinct. BDA refers to the tools, techniques, and methods deployed to analyze large, complex datasets to generate insights that support decision-making (Wamba et al., 2017; Wang et al., 2016). It focuses on the act of processing big data through various analytical techniques such as predictive analytics, data mining, and visualization. In contrast, BDAC refers to the organizational ability to effectively deploy, manage, and leverage BDA technologies to create value and achieve strategic objectives (Mikalef et al., 2020; Dubey et al., 2022; Bahrami & Shokouhyar, 2021). It embodies not just the use of big data tools, but the presence of the required tangible resources, human skills, and intangible assets necessary for effective big data exploitation. This study focuses on BDAC, given its strategic orientation and its alignment with dynamic capability perspectives which underpins this study. Empirical studies operationalize BDAC as a unidimensional construct (Dubey et al., 2018; Balci & Ali, 2024; Bahrami & Shokouhyar, 2021; Wamba et al., 2019) and as a multidimensional construct (Bag et al., 2020; Rialti et al., 2019; Mikalef et al., 2020). Within the multidimensional conceptualizations, a further distinction is made between reflective and formative models. This study adopts a formative perspective, following the logic that a capability is constituted by the aggregation of distinct resources and abilities, where the absence of any component diminishes the overall capability. In this view, tangible resources, human skills, and intangible assets are formative dimensions that collectively build BDAC, as operationalized by Mikalef et al. (2020).

Research Gaps and Conceptual Framework Rationale

It has been observed that existing studies in SCRM offer very few holistic approaches encompassing all the major phases of the risk management process (Ganesh and Kalpana, 2022). Additionally, of the few holistic approaches, reactive component (recovery) is often excluded as a critical part of the SCRM process. Moreover, Norman and Wieland (2020) assert that proactivity alone is not sufficient for SCRM but reactivity is also needed in the form of actions required after a risk event. This underscores a conceptual gap in SCRM as such this study proposes a more holistic framework in which SCRM is conceptualized to include both proactive and reactive elements. Furthermore, increasingly emphasized is the role of Supply Chain Risk Management (SCRM) in building Supply Chain Resilience (SCR), yet conceptual and empirical inconsistencies remain regarding their relationship, the mediating role of SCR between SCRM and organizational performance, and the integration of technological capabilities such as Big Data Analytics Capability (BDAC).

Mediating Role of Supply Chain Resilience

Several studies substantiate the critical role of SCR as a mediator in supply chain research. Al-Ayed and Al-Tit (2023) found that SCRM has a significant direct effect on SCR, with IoT enhancing this relationship. Elbaz and Ruel (2021) showed that SCRM mediates the relationship between disruption impact and SCR during the COVID-19 pandemic. Their findings reinforce the view that SCR emerges from structured risk management efforts.

Rashid et al. (2024) similarly reported that SCRM mediates the relationship between Information Processing Capability, Digital Supply Chains, and SCR. Zhang et al. (2024) demonstrated that SCRM mediates the relationship between Supply Chain Integration (SCI) and SCR. Although these studies formally treat SCRM as a mediator, they nonetheless provide empirical support for the influence of SCRM on SCR. Further empirical evidence establishes that SCR significantly influences organizational performance. Alkhatib and Almomani (2023) found that SCR capabilities such as agility, flexibility, and collaboration enhance operational performance, particularly when enabled by digital technologies. Likewise, Abeysekera and Wang (2019) demonstrated that resilience capabilities mediate the relationship between supply chain risk management culture and competitive advantage. Together, these findings suggest a plausible and underexplored pathway that SCR mediates the relationship between SCRM and organizational performance. However, few studies have directly modeled SCR as the mediator linking comprehensive risk management practices to performance outcomes.

Moderating Role of Big Data Analytics Capability

Studies have shown that technological integration such as IoT, BDAC, and IT infrastructure enhances supply chain resilience (SCR) and performance outcomes (Bahrami & Shokouhyar, 2021; Turi et al., 2023; Singh, 2020; Liu et al., 2024). Bahrami and Shokouhyar (2021) found that BDAC improves SCR, with SCR mediating its effect on performance. Turi et al. (2023) examined the moderating role of BDAC in the relationship between customer knowledge management and organizational performance. Similarly, Singh (2020) showed that BDAC moderates the impact of IT infrastructure capability on business risk resilience, while Liu et al. (2024) found that BDA-enabled agility moderates the relationship between supply chain integration and SCR a role conceptually consistent with BDAC's function in enabling responsiveness under uncertainty. These findings support the view that BDAC facilitates the transformation of strategic initiatives into resilience and performance outcomes. However, few studies explicitly examine BDAC as a moderator between structured risk management and resilience. From an information processing perspective, SCRM generates critical risk intelligence, but the extent to which this intelligence translates into resilience depends on the organization's ability to process, interpret, and act on it which are functions enabled by BDAC. As such, BDAC acts as a factor that strengthens the effect of SCRM on SCR, depending on its maturity and integration within the firm. Therefore, this study addresses the identified gap by conceptualizing BDAC as a critical moderating capability that amplifies the impact of holistic SCRM, encompassing both proactive and reactive components on supply chain resilience.

Theoretical Underpinning: Dynamic Capability Theory

The Dynamic Capability Theory (DCT) posits that a firm's ability to integrate, build, and reconfigure internal and external resources in response to environmental changes and uncertainties enables it to create new value and improve performance (Teece et al., 1997; Chowdhury and Quaddus (2017). Dynamic capabilities are typically expressed through three dimensions: sensing, seizing, and transforming or reconfiguring capabilities (Bahrami & Shokouhyar, 2021). This theoretical lens underpins the conceptualizations and relationships of the variables in this study. SCRM is viewed as a dynamic process that equips firms to respond to uncertainty through risk identification, assessment, mitigation, monitoring, and recovery. Within the DCT framework, identification and assessment reflect sensing capabilities, mitigation aligns with seizing, and monitoring and recovery represent

reconfiguring capabilities. The outcomes of these processes are absorptive, response, and recovery capabilities which constitute SCR, as a dynamic capability that enables firms to maintain operations or adapt during disruptions (Zhang et al., 2024), aligning with DCT's focus on flexibility and resource reconfiguration. As a dynamic capability, BDAC involves the integration of big data technologies, human expertise, and organizational systems to support timely and informed action under uncertainty (Bahrami & Shokouhyar, 2021), while, organizational performance is framed as the strategic outcome of dynamic capabilities. Essentially, this study positions SCRM as the dynamic process, SCR as the resulting capability, BDAC as the facilitating resource, and OP as the performance outcome which is consistent with the tenets of the Dynamic Capability View.

Proposed Conceptual Framework

Figure 1 presents the proposed conceptual framework, which establishes the relationships between supply chain risk management (SCRM), supply chain resilience (SCR), organizational performance (OP), and big data analytics capability (BDAC).

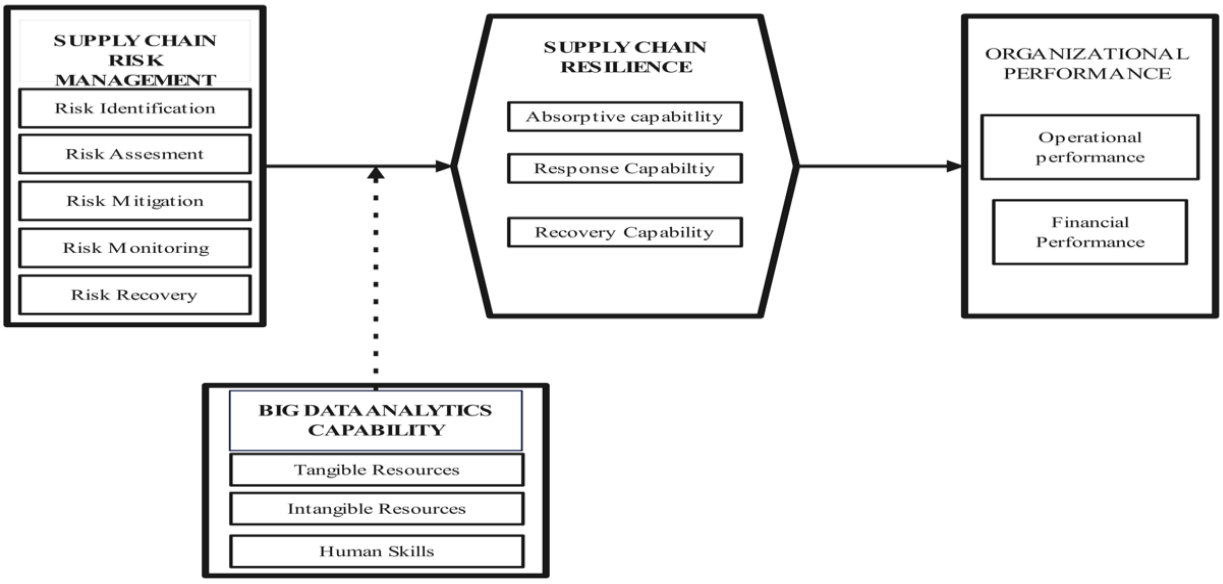

Figure 1. Conceptual Framework of SCRM, SCR, OP, and BDAC Relationship

SCRM is positioned as the independent variable and conceptualized holistically to capture both proactive and reactive risk management activities. This better aligns with the multidimensional view of SCR, wherein the proactive components of SCRM contribute to the development of absorptive and response capabilities, while the reactive component (risk recovery) contributes to the development of recovery capability. SCR is positioned as a mediating variable between SCRM and OP, implying that resilience serves as the mechanism through which the benefits of SCRM practices are transmitted to organizational performance, the ultimate strategic goal of risk management efforts. Finally, BDAC is introduced as a moderating variable that strengthens the effect of SCRM on SCR.

Implications for Theory and Practice

The proposed conceptual framework in Figure 1 offers critical implications for both theory and practice by reconfiguring existing conceptualizations and integrating emerging technological capabilities into SCRM. This study also provides a timely contribution to the

evolving discourse on SCR and organizational performance in this modern era of advancements in information and digital technologies.

Implications for Theory

This study advances the theoretical development of SCRM addressing critical gaps in traditional models. In addition, the study enriches the alignment of SCRM and SCR by adopting a multidimensional view of SCR comprising absorptive, response, and recovery capabilities, thereby offering a more nuanced understanding of resilience building along with how SCRM efforts account for resilience outcomes. Additionally, positioning of BDAC as a moderating dynamic capability expands its theoretical relevance in the context of SCRM and SCR. By drawing on the Dynamic Capability View, the study logically connects organizational sensing, seizing, and reconfiguration capabilities to SCRM, SCR, BDAC and OP.

Implications for Practice

This framework underscores the importance of adopting a comprehensive risk management approach that incorporates both proactive and reactive SCRM practices. The study notes that organizations must recognize that SCR cannot be achieved through prevention alone but requires the ability to recover and adapt post disruptions. Moreover, BDAC should be viewed not as an operational tool but as a strategic resource that enables organizations to convert SCRM practices into robust supply chain resilience capabilities. Investing in BDAC can significantly enhance the effectiveness of SCRM in building SCR, maintaining operational continuity and performance in these uncertain environments.

Conclusion

This study proposed a holistic conceptual framework that integrates proactive and reactive risk management practices; positions supply chain resilience (SCR) as a multidimensional mediator, and introduce big data analytics capability (BDAC) as a moderating dynamic capability, as a means to address critical gaps in the supply chain risk management literature. By building on the Dynamic Capability View, this approach offers a more comprehensive and actionable framework for enhancing organizational performance. It is important to note that this conceptual framework forms part of an ongoing doctoral research project, in which it will be subjected to empirical validation. The findings from the empirical phase are expected to yield further insights that enrich the theoretical and practical understanding of supply chain risk management, supply chain resilience, organizational performance, and the role of big data analytics capability.

Acknowledgment

The first author gratefully acknowledges the sponsorship support received from the Petroleum Technology Development Fund (PTDF), Nigeria, under the Overseas Scholarship Scheme (OSS) for Ph.D. studies.

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