Annals of Operations Research (2024) 340:723–755
https://doi.org/10.1007/s10479-024-06092-4

ORIGINAL RESEARCH

Developing operational resilience to navigate transportation disruptions: the role and boundaries of efficiency priority

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Received: 22 February 2023 / Accepted: 31 May 2024 / Published online: 21 June 2024

Abstract

Operational resilience is crucial for navigating the increasing transportation disruption challenges, but building this capability can be expensive and sometimes result in inefficiencies. Meanwhile, firms must prioritize efficiency to remain competitive and profitable. However, it is unclear how and when firms' pursuit of efficiency priority hinders or helps their resilience to specific disruptions. This research uses the theory of constraints to propose that while efficiency priority limits opportunities for improving operational resilience, buffering and bridging strategies lessen this constraint by enabling firms to align efficiency priority with operational resilience objectives. The study hypothesizes that these strategies positively moderate the negative effect of efficiency priority on operational resilience to transportation disruptions. These arguments are tested on primary data from a sample of 199 firms in Ghana using moderated regression analysis and the Johnson-Neyman technique. The results reveal that efficiency priority is negatively related to the disruption absorption dimension of operational resilience but unrelated to its recoverability dimension. Additionally, the study finds that under low conditions of buffering and bridging strategies, efficiency priority has stronger negative associations with both dimensions of operational resilience. In contrast, these relationships are positive under the high conditions of either strategy. These findings contribute to resolving existing debates on the efficiency-resilience link and have important implications for supply chain and business executives, as discussed in this article.

Keywords Supply chain disruption · Resilience capabilities · Competitive priorities · Theory of constraints · Transportation · Developing country

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1 Introduction

Transportation disruption is a crucial aspect of supply chain disruptions that concerns firms today (Albertzeth et al., 2020; Azad et al., 2013). The Business Continuity Institute's (2021) recent survey reveals that 84.0%, 70.0%, 65%, and 63.0% of companies encounter cross-border land, domestic land, sea, and air transportation disruptions. Transportation disruption refers to unexpected interruptions, delays, or stoppages in transporting materials and products from supply sources to points of demand (Paul et al., 2019; Wilson, 2007). Transportation disruption can cause considerable costs to businesses and societies (Kurth et al., 2020; Safitri & Chikaraishi, 2022; Zhen et al., 2016). For instance, the strike action-induced UK rail transportation disruption cost the country's hospitality sector £1.5bn in December 2022 alone (Kiely, 2022; Kollewe, 2022). Moreover, the Suez Canal disrupted several supply chain operations in Europe (Leonard, 2021) and cost global trade about $6 billion to $10 billion a week (Reuters, 2021). In effect, transportation disruption can break down supply chain operations, resulting in inefficiencies, lost sales revenue, and reduced market share and profitability (Albertzeth et al., 2020; Wong et al., 2020). Thus, it is strategically imperative for firms to develop operational resilience to transportation disruption (Albertzeth et al., 2020; Laguir et al., 2022).

Operational resilience, the capability of firms' operations to absorb and recover quickly from disruptions, is crucial for business survival and growth (Jiang et al., 2023; Li et al., 2022). Accordingly, supply chain scholars and practitioners have developed a keen interest in this resilience capability (Xi et al., 2024; Essuman et al., 2023; Business Continuity Institute, 2022). As detailed in Table 1, past studies have focused on understanding the antecedents of operational resilience in different contexts. Despite these advances in knowledge, there is a lack of understanding of the operational resilience construct in transportation disruption settings. More importantly, despite the growing controversies about the efficiency implication of resilience-building (see Table 2), previous studies do not answer how and when efficiency priority affects operational resilience to specific disruptions (Aldrighetti et al., 2023; de Arquer et al., 2022; Chopra et al., 2021; Essuman et al., 2020).

Despite its economic value, building operational resilience can be expensive and associated with inefficiencies (Essuman et al., 2020; Katsaliaki et al., 2021). This conflicting situation is a significant concern for business executives (Chopra & Sodhi, 2014) and takes on added importance in developing economies for several reasons. First, developing countries' limited and poor transportation network infrastructure can amplify transportation disruption-induced inefficiencies. Second, significant barriers to accessing finance in developing countries restrict firms' ability to expand resilience investment to navigate transportation disruption and other disruptions. Lastly, low-income consumer populations and underdeveloped financial and capital markets in developing countries require firms to prioritize operational efficiency to stay competitive and profitable. These challenging task environment issues in developing countries complicate the controversies about the efficiency priority-resilience link (Essuman et al., 2020; Katsaliaki et al., 2021; Tukamuhabwa et al., 2015).

This research analyzes the relationship between efficiency priority and operational resilience to transportation disruptions and the boundary conditions of this relationship in a developing country. Efficiency priority, the extent to which firms emphasize cost and inefficiency reduction in business processes, underlies low-cost and low-price competitive strategies (Vachon et al., 2009). Using the theory of constraints (TOC) (Goldratt, 1990), we

Table 1 Related empirical studies on operational resilience

Authors (year)	Independent variable	Dependent variable	Mediator (a)/ Moderator (b)	Theoretical foundation	Data type and empirical setting	Key findings
Xi et al. (2024)	Intelligent manufacturing	Operational resilience	Ambidextrous capability [a] Managerial myopia [b]	Dynamic capabilities theory	Secondary data from Chinese firms during the Covid-19 pandemic	o Intelligent manufacturing positively affects operational resilience. o Ambidextrous capability mediates the relationship between intelligent manufacturing and operational resilience. o Managerial myopia moderates the effect of intelligent manufacturing on operational resilience.
Essuman et al. (2023)	Organizational improvisation: creative improvisation and spontaneous improvisation	Operational resilience: disruption absorption and recoverability	Supply chain disruption [b]	Conservation of resources theory	Survey data from firms in Ghana	o Creative improvisation positively relates both dimensions of operational resilience; spontaneous improvisation is unrelated to these operational resilience dimensions. o Supply chain disruption positively moderates the relationships between creative improvisation and operational resilience dimensions; spontaneous improvisation does not moderate these relationships.
Liu et al. (2023)	Supply chain learning	Operational resilience	Digital-technological diversity [b] Customer concentration [b] Pilot program [b]	Organizational information processing theory	Secondary data from Chinese firms	o Supply chain learning positively affects operational resilience. o Digital-technological diversity negatively moderates this effect o Customer concentration and pilot program positively moderate this effect

Table 1 (continued)

Authors (year)	Independent variable	Dependent variable	Mediator (a)/ Moderator (b)	Theoretical foundation	Data type and empirical setting	Key findings
Esuman et al. (2022)	Resource slack	Operational resilience: disruption absorption and recoverability	Organizational attention [a] Strategic mission rigidity [b]	Resource-based view and attention-based view	Survey data from firms in Ghana	o Resource slack does not relate to any dimension of operational resilience. o Organizational attention mediates the relationships between resource slack and operational resilience dimensions. o Strategic mission rigidity negatively moderates these mediation relationships.
Esuman et al. (2021)	Operational resilience: disruption absorption and recoverability	Operational efficiency	Operational disruption [b]	Contingent-resource based view	Survey data from firms in Ghana	o Compared to disruption absorption, recoverability has a stronger positive association with operational resilience. o In high operational disruption situation, disruption absorption has a stronger positive relationship with operational efficiency. o In low operational disruption situation, recoverability has a stronger positive relationship with operational efficiency.

Table 1 (continued)

Authors (year)	Independent variable	Dependent variable	Mediator (a)/ Moderator (b)	Theoretical foundation	Data type and empirical setting	Key findings
Li et al. (2022)	Internal Flexibility (product diversity) Internal stability (operational efficiency) External flexibility (structural holes) External stability (network centrality)	Operational resilience		Matching theory	Secondary data from Chinese firms	o Product diversity does not affect operational resilience. o Operational efficiency positively affects operational resilience. o Product diversity, network centrality, and structural holes do not affect operational resilience. o The interaction between product diversity and network centrality positively affects operational resilience. o The interaction between product diversity and structural holes negatively affects operational resilience. o The interaction between operational efficiency and network centrality negatively affects operational resilience. o The interaction between operational efficiency and structural holes positively affects operational resilience.

conceptualize efficiency priority as a constraint to operational resilience improvement. In encouraging firms to design supply chains and operations to exploit economic and market opportunities, efficiency priority shifts firms' attention and resources from disruption management. Specifically, efficiency-priority firms tend to eliminate waste and reduce expenses on initiatives that do not have direct economic benefits (Baştuğ & Yercan, 2021; Chopra & Sodhi, 2014; Sáenz et al., 2018). Thus, we argue that efficiency priority can undermine firms' effectiveness in achieving operational resilience objectives (Rajesh, 2021).

Notwithstanding, competitive priorities literature suggests that the effects of efficiency priority depend on how firms pursue it (Qi et al., 2017). We argue that to be operationally resilient, efficiency-priority firms must expand their capacities to reduce vulnerability cost-effectively (Chopra & Sodhi, 2014; Sáenz et al., 2018; Chopra et al., 2021). Extending resilience literature to the TOC perspective, we propose that buffering and bridging strategies can enable firms to pursue efficiency priority in ways that align with operational resilience

Table 2 Indicative controversies on the efficiency-resilience link

Study	Study type	Perspective/conclusion on the efficiency-resilience link
Van der Vegt et al. (2015)	Conceptual	Trends show that increases in supply chain efficiency have not only reduced costs but have also increased vulnerability to disruptions. Resilience (often in the form of redundancy and slack) indicates inefficiency and comes at a cost.
Ivanov and Dolgui (2019)	Conceptual	Resilience and efficiency are opposing concepts. Efficiency and resilience can be integrated using low-certainty-need practices, such as structural complexity reduction, process and resource utilization flexibility, and non-expensive parametric redundancy.
Essuman et al. (2020)	Empirical	Resilience building may generate sunk costs, contributing to inefficiencies. How operational resilience affects operational efficiency depends on disruption intensity and the type of resilience capability.
Golgeci et al. (2020)	Conceptual	Efficiency is necessary under scenes of fierce competitiveness, whereas resilience is crucial to minimize supply chain vulnerability. While efficiency and resilience in global value chains may be at odds with each other in the short term, they are not necessarily mutually exclusive in the long run.
Chopra et al. (2021)	Conceptual	Firms can access commons (i.e., pooled resources for the flow of information, funds, and products within a firm, across firms, and across industries) to foster both resilience and efficiency. Companies that used multiple channels to improve efficiency when facing day-to-day demand-and-supply variations found that the structure also offered resilience without additional cost when COVID-19 struck; and that technology plays a vital role.
de Arquer et al. (2021)	Analytical	While efficiency and resilience may present as trade-offs, they are strongly interrelated, and it is possible to improve both simultaneously. Optimizing efficiency may be problematic in terms of resilience to demand shocks; thus, a trade-off exists that needs to be carefully considered by supply chain managers.
Belhadi et al. (2022)	Empirical	Resilience is often built at the expense of operational efficiency; however, achieving both efficiency and resiliency is no longer a choice but a necessity in the post-COVID-19 era. Additive manufacturing presents the potential to develop an ambidextrous supply chain, leading to reconciling resilience and efficiency.
Aldrighetti et al. (2023)	Analytical	It is possible to increase resilience at minimal cost by determining an optimal combination of preparedness (i.e., redundant backup suppliers) and recovery investments (i.e., flexible capacity). The optimal solution of their resilience model increases supply chain efficiency even in business-as-usual scenarios.

objectives (Manhart et al., 2020; Mishra et al., 2016). Buffering strategy refers to the degree to which firms rely on multiple, alternative, and redundant supply chain resources and processes to insulate them from their task environment. In contrast, bridging strategy reflects the degree to which firms engage in collaborative relationships with supply chain actors (Bode et al., 2011; Manhart et al., 2020). We develop and test the argument that greater conditions of these strategies can afford firms to operate more efficiently, mitigating the adverse effect of efficiency priority on operational resilience.

This study advances the operations and supply chain literature in three ways. First, by focusing on operational resilience to transportation disruption, this research broadens the scope of the empirical literature on supply chain/operational resilience to supply chain disruptions. Despite transportation disruption being a critical aspect of supply chain disruption and a significant issue today, particularly in developing countries, it is under-considered in the supply chain management literature. With few studies using mathematical modeling and simulations to study transportation disruption issues (Albertzeth et al., 2020; Paul et al., 2019; Tao et al., 2020; Zhen et al., 2016), this research takes a step further to advance empirical knowledge of the determinants of firms' ability to absorb and recover from transportation disruptions quickly. Second, the study's findings enrich the conceptual literature on the link between efficiency priority and resilience constructs (e.g., Baştuğ & Yercan, 2021; Chopra & Sodhi, 2014; Sáenz et al., 2018). Related empirical studies focus on operational resilience and efficiency performance indicators (e.g., Li et al., 2022; Essuman et al., 2020). However, unlike efficiency performance, efficiency priority has long-term implications and determines how firms design and manage their operations and supply chains (Fisher, 1997; Vachon et al., 2009). This study reveals how efficiency priority affects operational resilience differently as levels of buffering and bridging strategies vary. Finally, we contribute to TOC literature and existing theoretical perspectives on firm/supply chain resilience capabilities by theorizing how efficiency priority affects operational resilience differently as levels of buffering and bridging strategies change.

2 Literature review

Extant supply chain literature suggests that it takes the resilience of individual firms or nodes, for the most part, to achieve supply chain resilience (de Sá et al., 2019; Sáenz & Revilla, 2014). Accordingly, firms' operational resilience has recently gained significant interest among supply chain scholars and practitioners (Essuman et al., 2022; Li et al., 2022). However, supply chain researchers disagree on how the resilience concept manifests at various levels of analysis (Jiang et al., 2023; Wieland & Durach, 2021). In analyzing the literature, Essuman et al. (2020) identified two broad approaches to conceptualizing and measuring resilience: input- and output-based resilience perspectives. The former captures what some scholars call resilience-enhancers, drivers, or formative indicators, such as visibility, agility, slack resources, collaboration, integration, and information sharing. In contrast, the latter approach captures immediate resilience outcomes, which firms manifest during disruptions. Recent scholarly developments in the supply chain literature identify four resilience manifestations: disruption absorption, recoverability, adaptability, and transformability (Cui et al., 2022; Essuman et al., 2020; Wieland & Durach, 2021).

The supply chain resilience literature suggests that disruption absorption and recoverability are the defining elements of resilience at the operations level of the firm (e.g., Essuman et al., 2020; Jiang et al., 2023; Li et al., 2022). These dimensions of resilience, functioning as ordinary capabilities, aim at preserving how firms create and deliver market value presently. In contrast, adaptive and transformative resilience dimensions function as dynamic capabilities, enabling firms to change the structure and configuration of operations post-disruption (Wieland & Durach, 2021; Essuman et al., 2020). Accordingly, in focusing on the operations level of the firm, this research defines operational resilience as the ability of firms' operations to absorb and recover from disruptions quickly (Essuman et al., 2020; Jiang et al., 2023). The disruption absorption dimension of the construct captures the ability of a firm's operations to contain, cushion, or minimize the impacts of disruptions while maintaining its structure. On the other hand, recoverability reflects the ability of a firm to resume operations quickly to prior-disruption performance levels (Brandon-Jones et al., 2014; Jiang et al., 2023).

Prior studies have contributed to our understanding of the antecedents of operational resilience (see Table 1). These studies are grounded in different theoretical lenses, including dynamic capabilities theory, conservation of resources theory (Essuman et al., 2023), organizational information processing theory (Liu et al., 2023), resource-based view, attention-based view (Essuman et al., 2022), and matching theory (Li et al., 2022). Drawing on different methodologies (e.g., survey and secondary data) and empirical settings (e.g., China and Ghana), these studies identified several determinants of operational resilience: intelligent manufacturing (Xi et al., 2024), creative improvisation (Essuman et al., 2023), supply chain learning (Liu et al., 2023), organizational attention (Essuman et al., 2022), and alignment between internal organizational factors and external ones (Li et al., 2022). A significant conclusion from these studies is that contingency models offer a better understanding of why firms differ in operational resilience (e.g., Xi et al., 2024; Essuman et al., 2022; Li et al., 2022).

The literature further highlights efficiency priority and performance as central to resilience thinking and application (Essuman et al., 2020). While some scholars underscore the tension between efficiency and resilience (de Arquer et al., 2022; Ivanov & Dolgui, 2019; van der Vegt et al., 2015), others believe the two variables can coexist (e.g., Aldrighetti et al., 2023; Chopra et al., 2021; Ivanov & Dolgui, 2019) and that both are imperative for driving business success (Golgeci et al., 2020; Belhadi et al., 2022) (see Table 2 for details). However, these perspectives lack an empirical foundation. This research contributes to this conversation by applying the TOC principles to develop a contingency model to explain the relationship between efficiency priority and operational resilience to transportation disruptions under varying conditions of buffering and bridging strategies in a developing country (see Fig. 1).

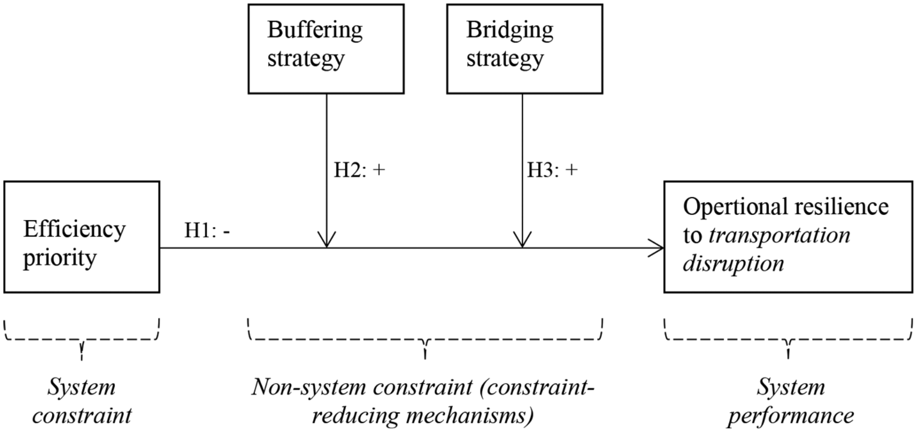

Fig. 1 Research model

3 Theoretical foundation and hypothesis development

3.1 A TOC perspective on operational resilience

We use the TOC to organize and theorize the relationships between the study's variables, as illustrated in Fig. 1. The TOC emerged in operations management and has been applied in many management and organizational settings (de Jesus Pacheco et al., 2021; Ikeziri et al., 2019) due to its suitability for identifying performance-related variables and theorizing their relationships (Naor et al., 2013). The TOC is concerned with the performance of systems (e.g., firms, supply chains) or subsystems (e.g., operations systems), the factors limiting system performance, and how firms can manage such constraining factors to improve system performance (Ikeziri et al., 2019; Naor et al., 2013). This study's unit of resilience analysis is firms' operations systems (Essuman et al., 2023). We follow extant resilience literature to conceptualize operational resilience as a performance indicator of firms' operations systems during disruptions (Brandon-Jones et al., 2014; Bruneau et al., 2003). During disruptions, resilient operations systems maintain or quickly recover normal performance levels (Li et al., 2022; Essuman et al., 2020).

The TOC suggests that every system has at least one constraint, defined as "anything that limits a system from achieving higher performance versus its goals" (Goldratt, 1988, p. 453). We propose efficiency priority as a constraint to operational resilience as it can suppress the effectiveness of firms achieving operational resilience-enhancing objectives (Essuman et al., 2020; van der Vegt et al., 2015). As with other competitive priorities, efficiency priority underlies firms' supply chain design and operations configuration for achieving specific economic and market outcomes (Chenhall, 2005; Vachon et al., 2009). For example, while efficiency priority encourages managers to design and implement lean supply chains and operations, its emphasis crowds out contingencies necessary for managing unpredictable events (Chopra & Sodhi, 2014; Sáenz et al., 2018). In doing so, however, efficiency priority creates structures that limit firms' capacity to absorb disruption impacts and the capability to quickly recover from disruptions (Chopra & Sodhi, 2014). The Covid-19 pandemic generally revealed that the operations systems of efficiency-focused firms are more fragile during disruptions (Baştuğ & Yercan, 2021). The constraint posed by prioritizing efficiency on operational resilience can be particularly noticeable in developing countries, where firms frequently encounter heightened resource scarcity issues. In such contexts, firms must look for ways to build and strengthen operational resilience without jeopardizing efficiency objectives in their supply chain operations.

The TOC's perspective is that firms can mitigate the potential adverse effects of a constraint by either exploiting it, subordinating everything else to it, or elevating its capacity (Naor et al., 2013). As argued above, exploiting or increasing efficiency priority can be counterproductive for operational resilience. We propose that an effective approach to address this problem would involve subordinating non-constraint factors to efficiency priority. That is, deploying mechanisms that align with the needs of efficiency priority while narrowing its conflict with operational resilience goals. We theorize how two such mechanisms, buffering and bridging strategies, attenuate the adverse effect of efficiency priority on operational resilience. We build on and extend prior studies showing buffering and bridging strategies as drivers of resilience capabilities (Manhart et al., 2020; Mishra et al., 2016) to explain how they interact with efficiency priority to determine operational resilience levels.

3.2 Efficiency priority and operational resilience

Efficiency priority is a key competitive priority for firms. As with other competitive priorities (e.g., quality, flexibility, delivery), efficiency priority shapes how a firm configures its internal structure and processes by combining resources and competencies to transform inputs into outputs (Chenhall, 2005). The operational setups of the supply chain (internal and external) can be designed to support efficiency to reflect a cost leadership strategy of the firm (Fisher, 1997; Vachon et al., 2009). Efficiency priority refers to how parsimoniously resources are expended in operations. An efficient operations setup allows firms to achieve significant cost savings in their supply chain (Sáenz et al., 2018). That is, by designing supply chain operations to be efficient, firms acquire the capacity to compete on low-cost leadership and low prices (Vachon et al., 2009).

Consequently, prioritizing efficiency in operations design has been deemed more appropriate for markets where demand is highly predictable, i.e., where there is low customer dynamism and the products tend to have a longer shelf life (Fisher, 1997; Vachon et al., 2009). At the supply chain level, efficiency priority aims to coordinate the flow of materials and services by eliminating non-value-adding processes while optimizing value-adding operations (Parmigiani et al., 2011). Efficiency priority favors predictable supply chain and market conditions, allowing firms to standardize and streamline processes to reduce waste, save cost, and improve capacity utilization across the supply chain (Parmigiani et al., 2011; Vachon et al., 2009).

Since efficiency priority transcends the supply chain design and operations configuration, it has crucial implications for disruption management. For instance, as eliminating waste becomes the focus, efficiency-based supply chains become tightly coupled and lean (Sáenz et al., 2018; Vachon et al., 2009). Whereas such an operational setup will guarantee cost savings, it predisposes the supply chain to high vulnerability to disruptions due to the loss of flexibility and buffer in the face of disruptions (Chopra & Sodhi, 2014; Sáenz et al., 2018; Scheibe & Blackhurst, 2018). Specifically, the TOC suggests that where firms prioritize efficiency, they will have less capacity to absorb disruption impacts. Similarly, the tightly coupled processes and the lack of excess capacity and slack resources may constrain and delay recoverability efforts. Therefore, we test the following hypothesis:

H1 Efficiency priority is negatively related to operational resilience.

3.3 Moderating roles of buffering and bridging strategies

Firms use buffering strategy to ensure their current operations are independent of the task environment by relying on multiple, alternative, and redundant supply chain resources and processes (e.g., suppliers, distribution channels, product lines, inventory, and transportation resources and routes) (Manhart et al., 2020). To this end, buffering strategy reduces uncertainty and ensures operations stability and continuity (Bode et al., 2011). It also helps to prevent and facilitate rapid responses to disruptions (Manhart et al., 2020). Since buffering strategy channels investment into non-value-adding activities, it appears to conflict with the rational and economic goals that underlie efficiency priority. However, the literature suggests that efficiency priority and buffering strategy can complement each other, enabling firms to be resilient (Chopra & Sodhi, 2014). As efficiency priority increases disruption-related uncertainty, greater levels of efficiency priority require firms to emphasize buffering strategy to achieve fit and stability (Bode et al., 2011). It is important to note that efficiency-based supply chains may become vulnerable in disruption situations only when they have completely eliminated buffers (Chopra & Sodhi, 2014).

Buffering strategy is disruption-reduction centered; therefore, high conditions of buffering strategy can allow firms that implement efficiency priority to minimize vulnerability to disruptions. While efficiency priority enables firms to streamline and standardize processes to gain visibility, buffering strategy can help them make appropriate decisions about which portions of the supply chain, where minimum and less costly buffers are required to cushion operations against disruptions (Chopra & Sodhi, 2014). Therefore, the negative consequence of efficiency priority on operational resilience could be attenuated significantly by combining efficiency priority and buffering strategy. Moreover, buffering strategy allows firms to maintain relationships with multiple suppliers, arrange backup transportation capacities, etc. (Gebhardt et al., 2022). In the event of disruption at the primary supplier's or carrier's end, the focal firm can quickly switch to the alternative supplier or carrier whose operations may not have been disrupted. By introducing such flexibility in the upstream supply chain (Gebhardt et al., 2022), efficiency-priority firms can swiftly recover from disruptions. Following these arguments, we test the hypothesis that:

H2 Buffering strategy weakens the negative relationship between efficiency priority and operational resilience, such that the relationship is less negative at high levels of buffering strategy

Bridging strategy involves the firm developing closer and stronger bonds with supply chain partners (Manhart et al., 2020). Through bridging strategy, firms engage in boundary-spanning and boundary-shifting activities to increase the certainty of securing uninterrupted important resources from exchange parties despite disruptions (Bode et al., 2011). Bridging strategy such as collaborative planning, information sharing, and strengthening relationships with suppliers and other stakeholders can afford firms flexibility when needed (Manhart et al., 2020; Bode et al., 2011). In so doing, bridging strategy increases information processing capacity to attenuate uncertainty (Manhart et al., 2020). This benefit is achieved through close ties with exchange partners, which grants the firm access to reliable and timely information from partners to enable quick detection and swiftly mitigate disruptions. Therefore, bridging enables firms to increase control and predictability in their dependence relations (Al-Balushi & Durugbo, 2020). In particular, bridging strategy benefits visibility, quicker detection of disruptions, and coordinated efforts to deal with disruptions (Manhart et al., 2020; Mishra et al., 2016).

Like the efficiency priority, bridging strategy maintains fewer manageable exchange partners but invests heavily in the relationship to minimize uncertainties. The emphasis here is to increase the importance of risk criteria in supplier selection, supply chain integration, supply chain collaboration, and supply chain mapping initiatives (Gebhardt et al., 2022). The vulnerabilities introduced by the leanness of the efficiency-based supply chain can be attenuated by the capacity of bridging strategy to increase visibility and collective action among supply chain members. Also, firms using bridging strategy can be prioritized by their suppliers (Manhart et al., 2020). This means that firms can achieve fair negotiations for shorter and more reliable lead times at the best cost (Manhart et al., 2020; Mishra et al., 2016). Bridging strategy, without detracting from efficiency priority, can improve operational resilience by reducing vulnerabilities associated with an efficiency-based supply chain through quick detection and joint response to disruptions.

In addition, efficiency-priority operations tend to rely on just-in-time inventory management. Accordingly, the visibility of each exchange party's inventory levels and suppliers' commitment to agreed delivery schedules becomes indispensable for the success of operations. A bridging strategy reinforces visibility through seamless information transfer among exchange partners and boosts commitment and trust, which minimizes overall vulnerability in the exchange and fluctuations in lead times (Manhart et al., 2020; Mishra et al., 2016). Impliedly, bridging strategy re-enforces information processing capability between exchange parties and their commitment to maintaining the tightly coupled supply chain while collectively responding to emergent disruptions. Therefore, we contend that bridging strategy complements efficiency priority, enabling efficiency-priority firms to be operationally resilient. Formally stated,

H3 Bridging strategy weakens the negative relationship between efficiency priority and operational resilience, such that the relationship is less negative at high levels of bridging strategy

4 Research methodology

4.1 Sample and data

Given the transportation disruption setting of the study, we constructed a sample that comprises transportation logistics firms, distribution firms, and manufacturing firms that manage their transportation operations in-house. The firms operate in Ghana, a sub-Saharan country with great growth prospects (World Economic Forum, 2019) but underdeveloped transportation and logistics systems (World Bank, 2018; Global, 2022). Our unit of analysis is the firm, and we measured all variables from the firm's perspective. The firms are largely small and medium-sized enterprises (SMEs) (full-time employees = between 5 and 250) that operate in two major commercial and industrial settings in Ghana (i.e., Greater Accra and Ashanti Regions (Ghana Statistical Service, 2016). We used a three-year time window to capture the research variables; therefore, we limited our sample to firms that had operated for at least three years. We relied on the online database of Ghana Business Directory (https://www.ghanayello.com) to generate a sample of 300 firms that meet these sample selection criteria.

We could not obtain secondary data to capture the variables of interest in the study's setting. Thus, we followed examples of related empirical studies on efficiency priority (Amoako-Gyampah & Meredith, 2007; Qi et al., 2017), operational/supply chain resilience (Essuman et al., 2022; Laguir et al., 2022), and buffering and bridging strategies (Mishra et al., 2016; Bode et al., 2011) to collect survey data to test our hypotheses. The data was collected between March 2021 and June 2021, nine months after businesses resumed operations from a three-week Covid-19 lockdown (March 30 - April 20, 2020) (Kenu et al., 2020). Given our SME sample and the fact that the variables of interest are firm-specific (Flynn et al., 2018), we relied on one key informant per firm (i.e., senior managers holding logistics and supply chain-related positions) to gather the data (cf., Cui et al., 2022; Laguir et al., 2022; Qi et al., 2017). Table 3 presents information about the sample and the key informants.

We employed a face-to-face approach and trained fieldworkers to collect the data in 2021, allowing us to overcome the challenges of using mail or electronic surveys in Ghana (Essuman et al., 2022). The survey package included a questionnaire, a cover letter, and a consent form. The questionnaires were delivered to and collected from key informants in firms that agreed to participate in the study. We retrieved 207 questionnaires out of the 281 questionnaires that were administered. Out of the 207 received questionnaires, we retained 199 that had less than 5% item-level missing values for the main analyses. Thus, the study's effective response rate was 66.33%.

We obtained one-hundred and forty-one of the effective sample data within the first two weeks after the questionnaires were delivered (early respondents) and the remaining data within the third and fourth weeks (late respondents). A t-test revealed that the early and late respondents are not statistically different in terms of firm size (mean difference=0.039; t=1.004; p=0.317) and firm age (mean difference=0.007; t=0.196; p=0.845). Accordingly, we merged the two datasets for the study.

4.2 Questionnaire development and common method bias controls

We adapted existing measurement items in the literature to measure the study's constructs. We followed a series of steps to modify the items and refine the questionnaire to ensure they

Table 3 Characteristics of the sample

Items		Frequency	Percentage	Mean	Min	Max	SD
Industry	Manufacturing	63	31.7%				
	Distribution	105	52.8%				
	Third-party logistics	22	11.1%				
	Trucking	9	4.5%				
Scope of operation	Local operations	186	93.5%				
	International operations	13	6.5%				
Informant's education	Up to SHS/A'Level/O'Level	43	21.6%				
	Up to HND / Diploma	55	27.6%				
	Up to First Degree	94	47.2%				
	Post-graduate level (Masters or PhD)	7	3.5%				
Informant's position	Others	13	6.5%				
	Operations Manager	21	10.6%				
	Transport Manager	53	26.6%				
	Logistics Manager	88	44.2%				
	Supply Chain Manager	13	6.5%				
	CEO	11	5.5%				
Firm size (no of full-time employees)				16	5	250	23
Years of operation				12	3	47	7
Years in current position				7	3	30	4

were appropriate for the study's setting and capture the constructs validly. We engaged a team of five supply chain management researchers who understand the operations strategy and resilience literature to review and revise the definitions and indicators of the constructs. We then finalized the items and the questionnaire based on pilot study feedback from 20 MBA students who held logistics/supply chain-related positions in their firms.

In addition to ensuring item brevity and clarity, we incorporated several procedural remedies into the cover letter, the questionnaire, and the fieldwork processes to mitigate common method bias concerns (Podsakoff et al., 2003). For example, we used the cover letter to explain the study's purpose and potential industry impacts while assuring informant anonymity and offering clear guidelines for completing the questionnaire. To minimize illusionary correlation and consistency motif biases, we removed information about the specific variables and the relationships between variables of interest and further placed items for the predictor and the outcome variables wide apart in the questionnaire. Additionally, we used different scale formats to rate the items for the independent, moderating, and dependent variables. Furthermore, we administered the questionnaires to key informants (Cui et al., 2022; Essuman et al., 2022).

4.3 Measurement items

Table 3 presents the final items and scale anchors and their psychometric information. Additional information about how we operationalized the constructs and the measurement sources are presented as follows.

Substantive variables. As discussed in Sect. 2.2, we conceptualized operational resilience as a multi-faceted construct comprising disruption absorption and recoverability (Essuman et al., 2020). We adapted four items from previous studies (e.g., Brandon-Jones et al., 2014; Essuman et al., 2020) to measure each dimension of operational resilience. We used transportation disruptions as a reference to anchor each item to improve measurement validity. Specifically, we asked the firms to indicate unexpected transportation-related events that interrupted their transportation operations in the last three years (see Table 2). Based on this information, they rated the disruption absorption and recoverability items. We used three to measure buffering strategy and and four items to measure bridging strategy. The items were adapted from Bode et al. (2011) with supplementary insights from Manhar et al. (2020). The items required the firms to indicate the degree to which they have pursued each strategy in the last three years. We adapted four items from Boyer and Lewis (2002) and Kroes and Ghosh (2010) to capture efficiency priority. The items reflect the degree to which the firms have emphasized efficiency priority as a strategy for competing in the marketplace in the last three years.

Control variables. The supply chain literature suggests that internal and external environment factors affect firms' resilience capabilities and factors that may contribute to such capabilities (e.g., Manhart et al., 2020). Accordingly, we included several firm-specific and external environment factors that may affect either operational resilience, efficiency priority, or buffering and bridging strategies. In addition to firms' demographic factors (e.g., firm sector, firm size, and firm age (Manhart et al., 2020; Pettit et al., 2019), we controlled for firm's flexibility priority (Baştuğ & Yercan, 2021), transportation disruption (Essuman et al., 2020), environmental dynamism (Manhart et al., 2020). Based on the sample distribution, we created two dummy variables to represent firm sector: *manufacturing* = 1, otherwise = 0;

distributor = 1; otherwise = 0. We operationalized firm size and firm age as the natural logarithm transformation of the number of full-time employees and the number of years of operation, respectively. We adapted three items from Boyer and Lewis (2002) and Kroes and Ghosh (2010) to measure flexibility priority. The items for this construct reflect the degree to which firms emphasized operational flexibility as an important strategy for competing in the marketplace in the last three years. Drawing on the extant literature (e.g., Miles et al., 2000), we measured environmental dynamism with four items that reflect the degree of unpredictable changes in variables in the external environment. Lastly, we identified 14 context-specific unexpected events to capture transportation disruption. The firms indicated how frequently each event interrupted their transportation operations in the last three years.

5 Data analysis strategy and results

We followed a two-step analytical strategy to analyze data. The first step involved validating the measurement indicators and constructing composite scales for testing the hypotheses. In the second stage, we used the constructed scales to test the hypotheses (e.g., Laguir et al., 2022; Srinivasan & Swink, 2018). Before conducting the analyses, we examined the data for normality, missing value, and outlier issues using skewness and Kurtosis indices, missing value analysis, and Mahalanobis distance & Cook's distance indices, respectively (Essuman et al., 2022). Results reveal that the data capturing the measurement items meet univariate normality assumptions, have less than 5% item-level missing values, and do not have outliers. We applied the expectation maximization estimator to replace the few missing values (Hair et al., 2019). Data capturing firm age and firm size exhibited non-normality properties. Accordingly, we used the natural logarithm function to transform these data (Hair et al., 2019).

5.1 Item validation and variable construction

Using Mplus 7.4, we applied covariance-based confirmatory factor analysis (CFA) and maximum likelihood estimator to evaluate the reliability and validity of the study's reflective items (Bagozzi & Yi, 2012). This analytical technique allowed us to account for measurement errors and simultaneously examine the psychometric properties of the items (Bagozzi & Yi, 2012). The results of our multi-CFA model demonstrate acceptable levels of reliability, convergent validity, and discriminant validity. Specifically, the model fit indices exceed the recommended thresholds: normed $\chi^2 = 1.309$ (i.e., χ^2 (332.458)/DF (254), RMSEA = 0.039, NNFI = 0.954, CFI = 0.961, SRMR = 0.056 (Bagozzi & Yi, 2012; Hair et al., 2019). Again, all factor loadings are greater than 0.60 and are statistically significant at 1% (see Table 3).

The congeneric reliability values are greater than 0.70. Moreover, the average variance extracted (AVE) values, except for two cases, are greater than 0.50. Specifically, the AVE values associated with the items tapping buffering strategy and flexibility priority are 0.48 and 0.45, respectively. We retained the items for these constructs to preserve content validity (Srinivasan & Swink, 2018) and because their congeneric reliability values are greater than 0.70 (Fornell & Larcker, 1981). These results and the acceptable model fit indices demonstrate convergent validity (Srinivasan & Swink, 2018). Voorhees et al. (2016) show

Fornell and Lacker's (1981) AVE-shared variance comparison as a robust strategy for testing discriminant validity. In applying this strategy, we found that the highest shared variance between the constructs (=0.32) is less than the AVE values, indicating that the measures exhibit discriminant validity (Voorhees et al., 2016). Accordingly, we used arithmetic mean to construct scales to capture their respective constructs (Srinivasan & Swink, 2018; Bode et al., 2011).

We used 14 items that trigger transportation disruption to capture this construct. Therefore, we followed previous resilience literature to construct a formative index from the items to tap transportation disruption (e.g., Essuman et al., 2020; Bode et al., 2011). We constructed this index using an unweighted linear sum function (Bode et al., 2011). Not only do the items meet theoretical assumptions underlying formative constructs (Diamantopoulos & Winklhofer, 2001), but they also do not violate statistical assumptions underlying the construction of formative indices. That is, the items' variance inflation factors are all below 2.0 (see Table 4), suggesting that they do not violate the assumptions of item multicollinearity and redundancy (Diamantopoulos & Winklhofer, 2001).

5.2 Common method bias assessment

To be sure common method bias does not confound the study's findings, we applied CFA procedures in Mplus 7.4 to examine the extent to which a common factor explains the variances in the reflective items (Craighead et al., 2011). CFA is a robust analytical strategy for examining common method bias issues. It allows researchers to statistically compare a theoretically specified measurement model (Model 1) with alternative models incorporating an unmeasured common latent factor (Craighead et al., 2011). We estimated a method-only model that loads an unmeasured common latent factor on all the items of interest (Model 2). The results show that Model 2 does not explain the data ($\chi^2=1610$, DF=275, RMSEA=0.157, NNFI=0.281, CFI=0.341, SRMR=1.53) and is significantly worse than Model 1 ($\chi^2=332.458$, DF=254, RMSEA=0.039, NNFI=0.954, CFI=0.961, SRMR=0.056), given $\Delta\chi^2=1{,}277.542$, ΔDF=21, $p<0.01$. We probed common method bias further by estimating a method-and-trait model (Model 3) to control for the potential effect of an unmeasured common factor (Podsakoff et al., 2003). This analysis added an unmeasured common factor to Model 1 by specifying it to load equally on the items and setting its correlations with the theoretical constructs to zero (Podsakoff et al., 2003). Model 3 shows a marginal improvement in model fit indices ($\chi^2=327.652$, DF=253, RMSEA=0.039, NNFI=0.956, CFI=0.963, SRMR=0.055) over Model 1, although the difference in χ^2 values between the two models ($\Delta\chi^2=4.806$, DF=1) is significant at 5%. However, further analysis reveals that the correlation between theoretical construct correlation coefficients in Model 3 and those in Model 1 is close to one ($r=0.95$, $p<0.001$) (Bode et al., 2011). These results suggest that common method bias is less likely to explain the study's main findings (Bode et al., 2011).

5.3 Main results and hypothesis evaluation

Table 5 presents the correlations and descriptive statistics for the study's variables. We applied moderated regression analysis and the Johnson-Neyman technique in SPSS PROCESS 3.5 to test the main and moderating effect hypotheses. These analytical tools allowed

Table 4 Details of measurement indicators, descriptive statistics, and validity results

Constructs and indications.	Mean	SD	VIF	Loading	T-value
Transportation disruption. *Indicate the frequency with which your company's transport operations has encountered each of the following over the past three years*:					
- Accidents on the road	3.36	1.41	1.41		
- Faulty vehicles stacked on the road	3.53	1.58	1.34		
- Breakdown of company vehicles	2.78	1.21	1.16		
- Attacks (e.g., armed robbery) on the road	2.57	1.39	1.24		
- Flooding of roads	2.74	1.49	1.78		
- High intensity-rainfalls	2.98	1.49	1.79		
- Extreme fog limiting highway/road visibility	2.44	1.54	1.42		
- Drivers' strike actions	1.36	0.77	1.28		
- Fuel shortage	1.31	0.71	1.41		
- Road infrastructure (e.g., bridges) breakdown	2.57	1.25	1.34		
- Repair of transport infrastructure	2.99	1.30	1.36		
- Roadblocks due to social events (e.g., funerals)	2.82	1.35	1.21		
- Malfunctioning of road traffic controllers	3.64	1.47	1.17		
- Lockdown due to disease outbreaks (e.g., Ebola, COVID-19, etc.), disasters, tribal wars, etc.	2.56	0.82	1.31		
Operational resilience: disruption absorption[1] (CR = 0.87; AVE = 0.64). *When faced with any or some of the transport disruptions above, my company, compared to other companies in the industry, was able to*					
- continue providing uninterrupted deliveries to our customers	4.78	1.39		0.77	Fixed
- complete already dispatched deliveries on-time	4.73	1.45		0.79	10.92
- maintain the same delivery service level for received and incoming orders	4.58	1.35		0.78	11.22
- maintain desired operational throughput/output rates	4.62	1.34		0.85	11.82
Operational resilience: recoverability[1] (CR = 0.86; AVE = 0.61). *Even where such disruptions affect our operations badly, my company was able to*					
- resume normal operation in a cost-effective manner	4.65	1.32		0.74	Fixed
- deal with the disruptions quickly	4.57	1.40		0.76	10.21
- recover normal transport operating performance in the shortest possible time	4.55	1.43		0.81	10.72
- quickly return its transport operations to the original state	4.47	1.34		0.82	10.81
Efficiency priority[3] (CR = 0.82, AVE = 0.53). *How important has each of the following been to your company as a strategy for competing in the marketplace in the last three years?*					
- Reducing volume of inventory	5.24	1.26		0.73	Fixed
- Increasing capacity utilization	5.23	1.21		0.65	8.08
- Reducing transport costs	5.27	1.26		0.80	9.50
- Increasing labour productivity	5.30	1.20		0.72	8.57
Buffering strategy[2] (CR = 0.73; AVE = 0.48). *To what extent has your company pursued each of the following initiatives in the last three years?*					
- Relying on multiple sources of supply for each key input/raw material	3.65	1.18		0.62	Fixed
- Keeping alternative transport routing	4.01	1.20		0.73	6.64
- Maintaining flexible distribution arrangements	4.22	1.15		0.72	6.46

Table 4 (continued)

Constructs and indications.	Mean	SD	VIF	Loading	T-value
Bridging strategy[2] (CR=0.90; AVE=0.76). *To what extent has your company pursued each of the following initiatives in the last three years?*					
- Cooperating intensively with other transport firms (e.g., forming alliances)	3.04	1.64		0.86	Fixed
- Increasing information exchange with other transport firms	2.95	1.70		0.89	15.47
- Improving information exchange with supply chain partners	3.22	1.74		0.86	14.82
Flexibility priority[3] (CR = 0.71; AVE = 0.45). *How important has each of the following been to your company as a strategy for competing in the marketplace in the last three years?*					
- Changing delivery scheduling to fulfill customer requests	4.91	1.30		0.64	Fixed
- Modifying operating routines in response to changes in the marketplace	4.75	1.36		0.73	5.90
- Offering a broader range of services to meet different customers' needs	4.60	1.33		0.63	5.61
Environmental dynamism[1] (CR = 0.81; AVE = 0.51). *To what extent do you agree or disagree with each of the following statements?*					
- Terms and conditions in our supply market change rapidly	4.24	1.45		0.73	Fixed
- Actions of competitors are unpredictable	3.96	1.47		0.73	8.95
- Demand and taste of customers are unpredictable	3.87	1.36		0.65	7.99
- The technologies used in our industry change quickly	3.97	1.41		0.74	8.47

Notes Transportation disruption is captured with formative indicators while the remaining constructs were captured with reflective indicators; [1] Items were anchored on "strongly disagree (=1)" to "strongly agree (=7)". [2] Items were anchored on "not at all (=1)" to "to the largest extent (=7)"; [3] Items were anchored "not important (=1)" to "extremely important (=7)"; All loadings are significant at 1%; CR=congeneric reliability; AVE=average variance extracted

us to examine whether the direction and magnitude of the association between efficiency priority and operational resilience are contingent on buffering and bridging strategies (Hayes, 2018).

Table 5 Descriptive statistics and correlations

Variables	1	2	3	4	5	6	7	8	9	10	11	12
1. Recoverability												
2. Disruption absorption	0.57^{**}											
3. Buffering resource	0.15^{*}	0.19^{**}										
4. Bridging resource	-0.09	0.04	0.23^{**}									
5. Efficiency priority	-0.05	-0.12	0.13	0.17^{*}								

Table 5 Descriptive statistics and correlations

Variables	1	2	3	4	5	6	7	8	9	10	11	12
6. Flexibility priority	0.17*	0.05	-0.02	-0.01	0.05							
7. Transportation distribution	-0.10	-0.05	-0.05	0.23**	0.14	0.02						
8. Environmental dynamism	0.01	0.11	0.01	0.24**	-0.04	0.07	0.08					
9. Firm sector (manufacturing = 1)	0.05	0.03	0. 04	0.09	0.17*	0.11	0.37**	0.12				
10. Firm sector (distributors = 1)	-0.08	-0.13	-0.22**	-0.41**	-0.24**	-0.20**	-0.42**	-0.22**	-0.72**			
11. Firm age (log)	0.08	0.11	0.02	0.11	0.06	0.07	0.09	0.03	0.20**	-0.34**		
12. Firm size (log)	0.08	0.16*	0.16*	0.07	-0.05	0.10	0.01	0.04	0.13	-0.25**	0.40**	
Mean	4.56	4.68	3.96	3.07	5.26	4.75	37.65	4.01	0.32	0.53	1.01	1.09
Standard deviation	1.15	1.17	0.95	1.55	0.99	1.06	8.65	1.13	0.47	0.50	0.23	0.25

Notes $^{*}p<0.05$ (2-tailed), $^{**}p<0.01$ (2-tailed)

To isolate the main and the moderation effects, we estimated two sets of hierarchical models with disruption absorption and recoverability as the dependent variables. The baseline models (Model 1a & Model 1b) test the main effects of efficiency priority on disruption absorption and recoverability while controlling for the effects of buffering and bridging strategies and the covariates (i.e., transportation disruption, environmental dynamism, flexibility priority, firm size, firm age, and firm industry). The other two models, which include the variables in the baseline models, test the unique moderating effects of buffering strategy (Model 2a & Model 2b) and bridging strategy (Model 3a & Model 3b). The last set of models, which includes the variables in the baseline models, tested the relative moderating effects of buffering and bridging strategies (Model 4a & Model 4b). To correctly interpret the main effects of efficiency priority, we mean-centered this variable and the moderating variables before creating the moderation terms using a multiplicative approach (Hayes, 2018). The results for the disruption absorption and recoverability models are given in Table 6a and Table 6b, respectively.

Model 1a shows that efficiency priority has a significant negative relationship with disruption absorption (β = -0.178, $p=0.041$), whereas Model 1b indicates that efficiency priority does not significantly relate to recoverability (β = -0.087, $p=0.308$). These results partially support *H1*, which states that efficiency priority is negatively related to operational resilience. On the other hand, Model 2a and Model 2b indicate that the buffering strategy has significant positive moderating effects on the relationships between efficiency priority and disruption absorption ($\beta = 0.209$, $p = 0.022$) and between efficiency priority and recoverability ($\beta = 0.196$, $p = 0.029$). Similarly, Model 3a and Model 3b show that bridging strategy positively moderates the relationships between efficiency priority and disruption absorption ($\beta = 0.166$, $p = 0.004$) and between efficiency priority and recoverability ($\beta = 0.145$, $p = 0.011$). These results support *H2* and *H3*, which posit that buffering and bridging strategies weaken the negative relationship between efficiency priority and operational resilience. However, Model 4a and Model 4b, which include both moderating terms, suggest that bridging strategy has stronger moderating effects on the efficiency priority-disruption absorption link ($\beta = 0.138$, $p = 0.022$) and the efficiency priority-recoverability link ($\beta = 0.117$, $p = 0.05$) than the moderating effects of buffering strategy on the efficiency priority-disruption absorption link ($\beta = 0.141$, $p = 0.137$) and efficiency priority-recoverability link ($\beta = 0.139$, $p = 0.014$).

To correctly interpret and generate in-depth insights into the nature of the moderating effects of buffering and bridging strategies, we first tested and plotted the slope of the efficiency priority-operational resilience link at + 1 and – 1 standard deviations of the moderating variables (Hayes, 2018). The PROCESS results reveal that efficiency priority has more significant negative relationships with disruption absorption and recoverability at -1 standard deviation of buffering strategy or bridging strategy. However, at + 1 standard deviation of buffering strategy or bridging strategy, efficiency priority has positive relationships with both dimensions of operational resilience, although the relationships are insignificant at 5% (see Table 7a). The graphical representations of these results are given in Figs. 2 and 3.

We probed the moderating effects further using the Johnson-Neyman technique (Hayes, 2018). The results, as shown in Table 7b, indicate that the effect of efficiency priority on operational resilience has positive relationships with buffering and bridging strategies. That is, the negative effect of efficiency priority on operational resilience increases in magnitude under low conditions buffering and bridging strategies. However, this negative effect decreases as buffering and bridging strategies take on high values and even becomes positive when these strategies attain the highest values.

6 Discussion

6.1 Discussion of results

This research examined how and when efficiency priority affects operational resilience to transportation disruptions in a developing country, Ghana. There are two significant findings from the study. Firstly, the study finds that how efficiency priority affects operational resilience to transportation disruptions varies by the dimensions of operational resilience. That is, efficiency priority has a stronger negative effect on disruption absorption than recoverability. The results follow the direction of our hypothesis (H1), although the effect of efficiency priority on recoverability is statistically non-significant. These findings broadly support our TOC-grounded theorization, which suggests that efficiency priority can inhibit operational resilience (Ikeziri et al., 2019; Naor et al., 2013). The findings, however, indicate that the extent to which efficiency priority can function as a constraint to operational

Table 6a Results of moderated regression analysis (*dependent variable: disruption absorption*)

	Model 1a: Main effects			Model 2a: Unique moderating effect of buffering strategy			Model 3a: Unique moderating effect of bridging strategy			Model 4a: Relative moderating effects of buffering and bridging strategy		
Hypothesized paths:	β	SE	*p*	β	SE	*p*	β	SE	*p*	β	SE	*p*
H1: Efficiency priority (EP)	-0.178	0.087	0.041	-0.163	0.086	0.060	-0.150	0.085	0.082	-0.144	0.085	0.093
H2: EP × BFS				0.209	0.091	0.022				0.141	0.094	0.137
H3: EP × BDS							0.166	0.057	0.004	0.138	0.060	0.022
Control paths:												
Buffering strategy (BFS)	0.215	0.093	0.021	0.235	0.092	0.011	0.267	0.093	0.004	0.272	0.092	0.004
Bridging strategy (BDS)	-0.039	0.064	0.537	-0.026	0.063	0.677	-0.074	0.063	0.243	-0.060	0.064	0.352
Flexibility priority	0.024	0.080	0.764	0.022	0.079	0.778	0.016	0.078	0.840	0.016	0.078	0.838
Transportation disruption	-0.008	0.011	0.444	-0.008	0.011	0.461	-0.006	0.010	0.583	-0.006	0.010	0.573
Environmental dynamism	0.089	0.076	0.239	0.084	0.075	0.262	0.079	0.074	0.291	0.077	0.074	0.300
Firm sector (manufacturing)	-0.190	0.272	0.486	-0.143	0.270	0.597	-0.137	0.267	0.609	-0.114	0.267	0.669
Firm sector (distributors)	-0.390	0.303	0.200	-0.371	0.300	0.218	-0.310	0.299	0.301	-0.311	0.298	0.298
Firm age	0.294	0.397	0.460	0.194	0.395	0.624	0.378	0.391	0.334	0.297	0.393	0.451
Firm size	0.322	0.371	0.387	0.331	0.367	0.369	0.217	0.366	0.554			
Constant	4.134	0.907	<0.001	4.188	0.897	<0.001	4.051	0.890	<0.001	4.102	0.888	<0.001
R^2	0.098			0.123			0.137			0.147		
ΔR^2				0.025			0.039			0.049		
F	2.038			2.379			2.699			2.676		
ΔF				5.322			8.493			5.390		
p of F	0.032			0.009			0.003			0.002		
p of ΔF				0.022			0.004			0.005		

Notes β = unstandardized regression coefficients; SE = standard errors

Table 6b Results of moderated regression analysis (*dependent variable: recoverability*)

	Model 1b: Main effects			Model 2b: Unique moderating effect of buffering strategy			Model 3b: Unique moderating effect of bridging strategy			Model 4b: Relative moderating effects of buffering and bridging strategy		
Hypothesized paths:	β	SE	*p*	β	SE	*p*	β	SE	*p*	β	SE	*p*
H1: Efficiency priority (EP)	-0.087	0.085	0.308	-0.073	0.085	0.392	-0.063	0.085	0.462	-0.057	0.085	0.501
H2: EP × BFS				0.196	0.089	0.029				0.139	0.093	0.140
H3: EP × BDS							0.145	0.057	0.011	0.117	0.059	0.050
Control paths:												
Buffering strategy (BFS)	0.205	0.091	0.026	0.224	0.091	0.015	0.251	0.092	0.007	0.255	0.092	0.006
Bridging strategy (BDS)	-0.107	0.063	0.089	-0.095	0.062	0.129	-0.138	0.063	0.030	-0.123	0.064	0.054
Flexibility priority	0.164	0.079	0.039	0.162	0.078	0.039	0.157	0.078	0.045	0.157	0.077	0.044
Transportation disruption	-0.014	0.011	0.189	-0.014	0.010	0.196	-0.012	0.010	0.259	-0.012	0.010	0.252
Environmental dynamism	0.010	0.075	0.892	0.005	0.074	0.942	0.001	0.074	0.990	-0.001	0.073	0.992
Firm sector (manufacturing)	0.000	0.269	0.999	0.045	0.267	0.867	0.047	0.265	0.861	0.069	0.265	0.795
Firm sector (distributors)	-0.260	0.300	0.387	-0.242	0.297	0.416	-0.190	0.297	0.522	-0.191	0.296	0.519
Firm age	0.293	0.392	0.456	0.199	0.391	0.611	0.367	0.388	0.345	0.286	0.390	0.464
Firm size	-0.017	0.367	0.962	-0.009	0.363	0.980	-0.109	0.363	0.764	-0.086	0.362	0.813
Constant	4.121	0.895	<0.001	4.174	0.887	<0.001	4.051	0.883	<0.001	4.101	0.881	<0.001
R^2	0.092			0.114			0.122			0.133		
ΔR^2				0.023			0.031			0.041		
F	1.895			2.195			2.368			2.368		
ΔF				4.819			6.545			4.394		
p of F	0.048			0.016			0.009			0.007		
p of ΔF				0.029			0.011			0.014		

Notes β = unstandardized regression coefficients; SE = standard errors

Table 7 **a** Simple slope analysis of the efficiency priority-operational resilience link

Efficiency priority → disruption absorption relationship								Efficiency priority → recoverability relationship							
Buffering strategy	β	SE	*p*	Bridging strategy	β	SE	*p*	Buffering strategy	β	SE	*p*	Bridging strategy	β	SE	*p*
-1SD	-0.360	0.117	0.002	-1SD	-0.407	0.116	0.001	-1SD	-0.259	0.115	0.026	-1SD	-0.287	0.115	0.013
Mean	-0.163	0.086	0.060	Mean	-0.150	0.085	0.082	Mean	-0.073	0.085	0.392	Mean	-0.063	0.085	0.462
+SD	0.035	0.126	0.780	+SD	0.108	0.130	0.407	+SD	0.113	0.125	0.364	+SD	0.162	0.129	0.211

resilience will depend on resilience-building objectives: whether firms seek to build the capability to absorb or recover from transportation disruption impacts on operations. While there is a lack of empirical research examining the link between efficiency priority and resilience outcomes to compare our results, our findings broadly resonate and offer clarity to the existing debates on the link between efficiency and resilience (de Arquer et al., 2022; Ivanov & Dolgui, 2019; Aldrighetti et al., 2023; Chopra et al., 2021).

The difference in the magnitude of effects of efficiency priority on the dimensions of operational resilience can be explained as follows. Efficiency-priority firms seek to eliminate waste and minimize operations costs by reducing redundancies and slack resources in their supply chains. Redundant and slack resources primarily underlie disruption absorption capability, whereas flexible resources underpin operations' capacity to recover from disruptions (Essuman et al., 2020; Sheffi & Rice, 2005). However, the literature suggests that investment in disruption absorption, relative to investment in recoverability, tends to be associated with greater inefficiency (Essuman et al., 2020; Sheffi & Rice, 2005). Therefore, efficiency-priority firms are likely to substantially reduce investment in disruption absorption capability, particularly in a resource-constrained setting (e.g., a developing country) (Essuman et al., 2020). On the contrary, because inefficiencies associated with investments in flexibility capacities tend to be lower (Sheffi & Rice, 2005), the tendency of efficiency priority to conflict with operations recovery objectives might be lower.

Secondly, the study uncovers buffering and bridging strategies as significant boundary conditions of the relationships between efficiency priority and both dimensions of operational resilience. We found that efficiency priority has stronger negative associations with operational resilience in situations where buffering and bridging strategies are low. However, under high buffering and bridging strategy conditions, efficiency priority tends to be positively associated with both dimensions of operational resilience. These results are consistent with our TOC-based theorizations that buffering and bridging strategies can lessen the degree to which efficiency priority inhibits operational resilience-building (Gebhardt et al., 2022; Chopra & Sodhi, 2014). From the TOC perspective, buffering and bridging strategies serve as resilience constraint-reducing mechanisms, allowing firms to pursue efficient priority without jeopardizing operational resilience. This TOC perspective, along with the study's findings, offers credence to the assertion that it is possible to improve efficiency and resilience simultaneously (Aldrighetti et al., 2023; Arquer et al., 2022; Chopra et al., 2021; Golgeci et al., 2020).

6.2 Implications for resilience research

The study's insights have several theoretical implications for future research. Firstly, the study shows how analyzing the effect of efficiency priority on specific dimensions of operational resilience can unravel the nuances associated with the relationship between these variables. The findings offer a new lens for rethinking the debates about the link between efficiency and resilience. As explained above, the trade-offs between efficiency priority and operational resilience need to be recalibrated to account for differences in resilience objectives (e.g., disruption absorption versus recoverability objectives) and the efficiency problems each resilience objective presents (Essuman et al., 2020; Sheffi & Rice, 2005; Chopra & Sodhi, 2014). Theoretical and empirical analyses incorporating these complexities will

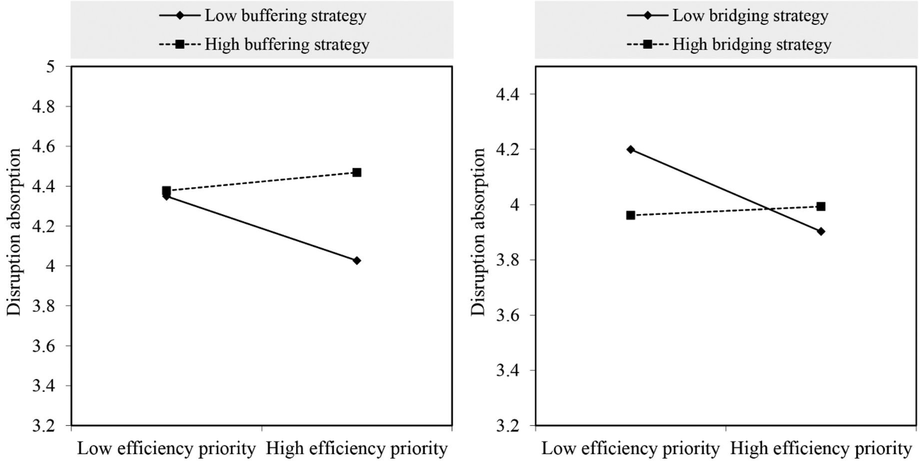

Fig. 2 Surface of the moderating effects of buffering and bridging strategies on the efficiency priority-disruption absorption link. *Note* Low and high levels of the independent and the moderating variables are – 1 and + 1 standard deviation values, respectively

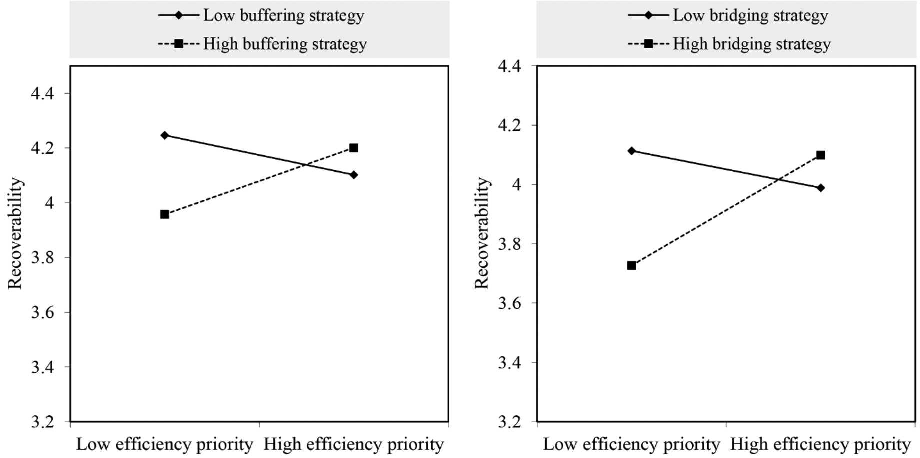

Fig. 3 Surface of the moderating effects of buffering and bridging strategies on the efficiency priority-recoverability link. *Note* Low and high levels of the independent and the moderating variables are – 1 and + 1 standard deviation values, respectively

likely offer a finer understanding of the operational resilience consequences of efficiency priority.

Second, the study's findings about the positive moderating effects of buffering and bridging strategies on the link between efficiency priority and operational resilience dimensions challenge the conventional wisdom that the pursuit of efficiency goals conflicts with resilience objectives (Chopra & Sodhi, 2014; Rajesh, 2021; Sáenz et al., 2018; Scheibe & Blackhurst, 2018). The study demonstrates that the degree to which efficiency priority will inhibit operational resilience depends on the extent to which firms deploy buffering or bridging

Table 7b Johnson-Neyman analysis of the efficiency priority-operational resilience link

Efficiency priority → disruption absorption relationship								Efficiency priority → recoverability relationship							
Buffering strategy	β	SE	*p*	Bridging strategy	β	SE	*p*	Buffering strategy	β	SE	*p*	Bridging strategy	β	SE	*p*
1.00	-0.781	0.275	0.005	1.00	-0.494	0.138	0.000	1.00	-0.654	0.272	0.017	1.00	-0.363	0.137	0.009
1.25	-0.729	0.253	0.005	1.27	-0.450	0.126	0.001	1.25	-0.605	0.251	0.017	1.27	-0.324	0.125	0.010
1.50	-0.676	0.232	0.004	1.53	-0.405	0.115	0.001	1.50	-0.556	0.230	0.016	1.53	-0.285	0.114	0.013
1.75	-0.624	0.211	0.004	1.80	-0.361	0.106	0.001	1.75	-0.507	0.209	0.016	1.80	-0.247	0.105	0.020
2.00	-0.572	0.191	0.003	2.07	-0.317	0.097	0.001	2.00	-0.458	0.189	0.016	2.07	-0.208	0.097	0.032
2.25	-0.520	0.171	0.003	2.33	-0.272	0.091	0.003	2.25	-0.409	0.169	0.017	2.25	-0.181	0.092	0.050
2.50	-0.468	0.152	0.002	2.60	-0.228	0.087	0.009	2.50	-0.360	0.150	0.018	2.33	-0.169	0.090	0.062
2.75	-0.415	0.134	0.002	2.87	-0.183	0.085	0.032	2.75	-0.311	0.132	0.020	2.60	-0.131	0.086	0.130
3.00	-0.363	0.117	0.002	2.96	-0.168	0.085	0.050	3.00	-0.261	0.116	0.025	2.87	-0.092	0.084	0.276
3.25	-0.311	0.103	0.003	3.13	-0.139	0.086	0.107	3.25	-0.212	0.102	0.039	3.13	-0.053	0.085	0.532
3.50	-0.259	0.092	0.006	3.40	-0.095	0.090	0.292	3.36	-0.191	0.097	0.050	3.40	-0.015	0.089	0.869
3.75	-0.206	0.086	0.018	3.67	-0.050	0.096	0.599	3.50	-0.163	0.091	0.076	3.67	0.024	0.095	0.801
3.93	-0.169	0.086	0.050	3.93	-0.006	0.103	0.955	3.75	-0.114	0.085	0.184	3.93	0.063	0.103	0.543
4.00	-0.154	0.086	0.075	4.20	0.039	0.113	0.733	4.00	-0.065	0.085	0.447	4.20	0.101	0.112	0.367
4.25	-0.102	0.092	0.267	4.47	0.083	0.123	0.503	4.25	-0.016	0.091	0.861	4.47	0.140	0.122	0.255
4.50	-0.050	0.102	0.626	4.73	0.127	0.135	0.347	4.50	0.033	0.101	0.742	4.73	0.179	0.134	0.184
4.75	0.002	0.116	0.984	5.00	0.172	0.147	0.244	4.75	0.082	0.115	0.473	5.00	0.217	0.146	0.138
5.00	0.055	0.132	0.680	5.27	0.216	0.160	0.178	5.00	0.132	0.131	0.316	5.27	0.256	0.158	0.108
5.25	0.107	0.150	0.478	5.53	0.261	0.173	0.133	5.25	0.181	0.149	0.226	5.53	0.295	0.171	0.087
5.50	0.159	0.169	0.349	5.80	0.305	0.186	0.103	5.50	0.230	0.167	0.172	5.80	0.333	0.185	0.073
5.75	0.211	0.189	0.266	6.07	0.349	0.200	0.082	5.75	0.279	0.187	0.138	6.07	0.372	0.198	0.062
6.00	0.263	0.210	0.211	6.33	0.394	0.214	0.067	6.00	0.328	0.207	0.115	6.33	0.411	0.212	0.054

strategies. Importantly, the study's findings suggest that efficiency-priority firms can achieve operational resilience gains by deploying greater levels of these strategies. These findings highlight the need for research to delineate the boundaries of the theoretical assumptions that underlie the opposing views on the link between efficiency and resilience (de Arquer et al., 2022; Ivanov & Dolgui, 2019; Aldrighetti et al., 2023; Chopra et al., 2021). More specifically, future research can apply the TOC to explore or theorize other mechanisms (non-constraint factors) that help realign efficiency priority with operational resilience objectives.

Finally, with the TOC central to operations strategy/competitive priority literature (de Jesus Pacheco et al., 2021), this study takes the first step to demonstrate the theory's utility in analyzing the role and boundary conditions of efficiency priority in explaining levels of operational resilience. Study's insights reveal how analyzing the interactions between constraint (efficiency priority) and non-constraint factors (buffering and bridging strategies) better explain why firms differ in their operational resilience. More broadly, we demonstrate how the TOC offers a compelling theoretical perspective for developing and analyzing contingency models to explain the antecedents of resilience capabilities.

6.3 Practical implications

Like other supply chain disruptions, transportation disruption threatens business survival and performance, particularly in developing countries with weaker transportation systems. Accordingly, firms must develop multiple operational resilience capabilities for navigating transportation disruptions successfully, even though building resilience can be expensive. Managers should recognize that while upfront investments in operational resilience capabilities may be substantial, the costs of disruptions can be overwhelming. Therefore, in prioritizing efficiency, they should allocate sufficient organizational attention to strategies necessary for enhancing operational resilience. This research shows that emphasis on efficiency priority alone can limit or reduce the capability of firms' operations to absorb and recover quickly from transportation disruptions. Firms in resource-constrained contexts could prioritize efficiency without hurting their operational resilience if they emphasized buffering or bridging strategies.

Efficient-priority firms should implement a cost-efficiency buffering strategy, such as maintaining and relying on multiple and alternative sources for materials, having a backup transportation route for delivery, and maintaining flexible distribution arrangements. Managers should first map their supply chains to appreciate where and how much buffers may be needed before investing in them. In addition, efficient-priority firms in resource-constrained settings can leverage informal relationship practices and norms to strengthen collaboration and information sharing with their supply chain partners. Collectivist-culture environments, as in the case of Ghana, create a conducive context for efficiency-priority firms to nurture and sustain inter-organizational collaborative initiatives that improve supply chain visibility and access to critical resources for responding to disruptions while minimizing the cost of doing business.

7 Conclusion, limitations, and direction for future studies

The costs of transportation disruptions, in addition to global fuel price surges and economic hardships, make it imperative for firms to concurrently pursue efficiency and operational resilience to survive and compete successfully, especially in developing economies. In extending the conceptual literature and the debates on the link between efficiency and resilience, this research uses the TOC and data from a developing country to shed new light on when efficiency priority and operational resilience may (not) coexist. Two novel insights emerged from the study: (1) the efficiency priority-operational resilience relationship varies across the dimensions of operational resilience; (2) low and high conditions of buffering and bridging strategies determine when efficiency priority undermines and enhances operational resilience, respectively.

The study's findings also have theoretical and methodological limitations, which should motivate and guide future research endeavors. First, we analyzed resilience at the operations level of the firm by focusing on disruption absorption and recoverability dimensions of resilience. Supply chains are more complex systems with additional resilience properties, including adaptability and transformability. Such complexity, however, raises the question of whether and the extent to which firms' efficiency priority determines supply chain-level resilience capabilities. Therefore, scaling up the study at the supply chain level to account for the complex domain of supply chain resilience could yield richer insights.

Second, our operationalization of the moderating variables does not fully tap the conceptual domains of buffering and bridging strategies (see Manhart et al., 2020). Of particular importance, some buffering practices, including excess inventory and spare capacity, may have greater efficiency implications than those that we used to capture the buffering strategy construct. Besides broadening the conceptualization of buffering and bridging strategies, future studies can explore additional contingencies in the efficiency priority-operational resilience link.

Third, we believe that transportation disruption and efficiency concerns are not peculiar to firms operating in developing countries. Resource frugality and economic sustainability motives may also encourage firms in developing countries to prioritize efficiency while responding to transportation disruptions. However, the ease at which firms obtain financial resources to build resilience can vary between developed and developing countries. Moreover, supply chain disruption impacts and firms' ability to manage them can vary by disruption type. The study was conducted in the recovery phases of the Covid-19 pandemic. Though the pandemic had short-lived effects on the business environment in Ghana, its associated economic losses may have contributed to heightened concerns about both operational efficiency and resilience. Thus, we encourage future studies to examine efficiency priority-resilience models in different business contexts and periods.

Lastly, while cross-sectional survey design permits an analysis of the relationship between efficiency priority and operational resilience (Essuman et al., 2022; Laguir et al., 2022), it limits the ability to make causal claims about this relationship. In addition, a cross-sectional survey design does not allow us to analyze the potential reverse causality between efficiency priority and operational resilience. Future studies can utilize longitudinal data to address such methodological limitations of the present study (Manhart et al., 2020).

Acknowledgements The first author received research support from the Africa Centre of Excellence Project, the Africa Centres of Excellence (ACE) Regional Transport Research and Education Centre, Kumasi

(TRECK), funded by the World Bank. The authors express their profound gratitude to the anonymous reviewers for their constructive comments and suggestions that helped strengthen the paper's quality.

Author contributions Conceptualization: Henry Ataburo, Dominic Essuman; Methodology: Getrude Effah Ampong, Dominic Essuman; Formal analysis and investigation: Dominic Essuman, Henry Ataburo; Writing - original draft preparation: Henry Ataburo, Dominic Essuman, Getrude Effah Ampong; Writing - review and editing: Henry Ataburo, Dominic Essuman, Getrude Effah Ampong; Supervision: Dominic Essuman.

Data availability The study's data are available from the corresponding author upon request.

Declarations

Ethical approval The study received ethical approval from the ethics committee at the first author's affiliate institution before data collection.

Conflict of interest The authors have no conflict of interest to disclose.

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