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Overcoming Logistics Challenges in Large-Scale Disruptions: Dynamic Capabilities in Türkiye's Earthquake Response

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Abstract

Dynamic capabilities (DC) play a critical role in addressing logistics challenges during emergency responses to natural disasters. While researchers in logistics operations (LO) acknowledge this importance, the specific context of major earthquakes remains underexplored. This study aims to analyze logistics challenges in emergency responses to major earthquakes, with a focus on the experiences of Türkiye's recent seismic events.

An exploratory mixed-methods approach that combines qualitative and quantitative methodologies. The research includes a systematic review of 23 academic articles published between 1999 and 2023, supplemented by secondary sources (news, websites, reports) and expert interviews. The Best-Worst Multi-Criteria Decision-Making (BWM) method was employed to identify and prioritize key criteria and alternatives for DC and logistics challenges. The Weighted Sum Model (WSM) prioritizes the other options.

The findings highlight the core logistics challenges in earthquake responses, such as responsiveness and agility. Key DCs— organizational learning, visibility, information flow, robustness, delivery reliability and speed—were essential to mitigating risks for affected populations. This research supports and extends the humanitarian logistics literature by offering a DC framework to address logistics challenges in large-scale disasters, providing practical insights for improving response effectiveness during major earthquakes.

Keywords Logistics Operations · Dynamic Capabilities · Logistics Challenges · Humanitarian Response · Major earthquakes

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Overcoming Logistics Challenges in Large-Scale Disruptions: Dynamic Capabilities in Türkiye's Earthquake Response

The frequency and intensity of major earthquakes have significantly impacted the humanitarian sector in recent decades (Joseph, 2022). In 2000, Walker highlighted that major earthquakes are among the most devastating natural disasters, leading to substantial loss of life and prolonged suffering. For instance, the earthquake in Türkiye on August 17, 1999, which measured 7.4 on the Richter scale, resulted in approximately 18,000 deaths and severely affected the industrial city of Izmit and its surrounding areas. Additionally, many poorly constructed buildings in Istanbul collapsed (Walker, 2000, p.72). More recently, on February 6, 2023, a series of powerful earthquakes struck Türkiye and North of Syria. The main quake, with a magnitude of 7.8 on the Richter scale, was followed by three significant aftershocks, each measuring greater than 5.5, within the next 18 minutes (Maletckii et al., 2023).

These major earthquakes reveal failures in disaster response (Yilmaz et al., 2023; Schiffling et al., 2022; Christopher & Peck, 2004). They worsen existing logistics systems for extended periods, leading to urgent shortages of, for example, health equipment. Health workers often lack preparation and coordination, struggling to fulfill essential needs food, heating, and accommodation (Freddi et al., 2021). Improving coordination emerged as the most urgent challenge (Freddi et al., 2021) during disaster operations (Freddi et al., 2021; Comes et al., 2020; Besiou & Van Wassenhove, 2020). The disaster operations (LO) area, as noted by Besiou and Van Wassenhove (2020), has been the subject of many studies on logistics operations. These studies help to improve the capacity of countries and the international community to get ready for and deal with large-scale natural disasters promptly and efficiently. Logistics operations encounter coordination, efficiency, and capabilities challenges, which are essential for ensuring robust and agile logistics. Additionally, the ability to adapt to change—referred to as dynamic capabilities (DC)—is crucial during responses to major earthquakes (Brusset & Teller, 2017; Teece et al., 1997; Mitrega et al., 2017; Craighead et al., 2020).

Academic and managerial interest in LO has been highlighted as essential for the humanitarian sector's capacity to respond effectively to significant earthquakes (Kovács & Spens, 2007). LO refers to the activities conducted before, during, and after a disruption to minimize its impact on the affected population (Altay & Green, 2006). The occurrence of major earthquakes has underscored the need to reassess the role of LO in managing increasingly complex events that can have far-reaching effects on society's critical infrastructure. Given these challenges, this study defines critical infrastructure in terms of building redundancy and meeting the essential needs of affected individuals, such as food, water, healthcare, housing, and transportation (Suppasri et al., 2021). Therefore, The LO field is viewed as a highly dynamic and efficient system (Besiou & Wassenhove, 2020). Research demonstrates that communication, collaboration, and adaptation in this context cannot be treated as in traditional unidirectional, linear supply chains. Instead, these aspects should be examined as part of a dynamic capabilities system (Teece et al., 1997), a perspective that, to the best of our knowledge, remains understudied.

By examining the scale and timing of recent major earthquakes, we focus on the logistical pressures faced by response systems and how these systems adapt their dynamic capabilities to deliver necessary resources and expertise promptly where required. To achieve this, we use the theoretical framework of DC (Teece et al., 1997). In the humanitarian literature, logistics operations are often challenging (Besiou & Wassenhove, 2020). These challenges arise when adapting to disaster responses globally. By analyzing successful and flawed LO efforts, we can gain valuable in-depth exploration of the DC necessary to effectively address logistical challenges in diverse contexts.

The purpose is to analyze the response to major earthquakes and meet logistics challenges in logistics operations, using the experiences from the major earthquakes that struck Türkiye. To fulfill this purpose, we answer the following RQ:

RQ 1: What dynamic capabilities are critical in addressing the logistics challenges in response to logistics operations during major earthquakes in Türkiye?

In this sense, estimating LO is vital for preventing logistics challenges and achieving a rapid, adaptable, and well-coordinated response. Effectively addressing the logistics challenges posed by a large-scale seismic event in a densely populated urban environment is a capability toward minimizing the impact of an expected earthquake and safeguarding the well-being of a population. As such, Istanbul is one of the cities in Türkiye most vulnerable due to its location, a major weakness in line with houses constructed below adequate standards, posing a significant risk to its population and potentially devastating consequences in the case of a severe earthquake.

This study enhances the literature on logistics operational efficiency by exploring the challenges related to the dynamic capabilities faced by humanitarian logistics providers and responsible organizations. It draws insights from humanitarian responses, critical infrastructures, and operations and supply chain management to develop the concept of logistics challenges. Specifically, it analyzes how dynamic capabilities pose significant challenges to logistics operations in response to major earthquakes.

The remainder of this paper is structured as follows. The subsequent section reviews the relevant literature on logistics operations (LO), dynamic capabilities (DC), and logistics challenges in humanitarian response. Section 3 outlines the methodology of the study. Section 4 reviews the study findings. Section 5 provides a discussion. Section 6 is about the conclusions, implications, limitations and future research.

Literature Review

Logistics operations

Logistics operations (LO) refer to the activities performed before, during and after a disaster to reduce its impact on humanitarian contexts. LO is defined as a "special branch of logistics management response supply chain of critical supplies and services with challenges such as demands, uncertain supplies, critical time windows and vast scope of its operations," (Apte, 2009 p. 17). A definition given by Thomas and Mizushima, (2011 p. 60) to humanitarian response refers to logistics as "the process of planning, implementing and controlling the efficient, cost-effective flow and storage of goods and materials, as well as related information, from the point of origin to the point of consumption to meet the end beneficiaries' requirements". As such, the management of humanitarian response involves many logistics challenges including conflicting interests among stakeholders, issues with coordination and cooperation, substantial uncertainty, and resource shortages. In this study, we offer an outline of LO logistics and its main application areas while outlining current research trends and the major challenges faced in the area today (Çelik, et al., 2012).

LO occurs in a volatile, uncertain, and ambiguous environment that has an impact on response efficiency (Schiffling et al., 2022; Christopher & Peck, 2004). However, current views on LO are believed to be incomplete and not fully aligned with the nature of humanitarian LO, which represents a mismatched paradigm (Adobor, 2020). Interestingly, however, humanitarian actors use "logistics" as a broad term covering various responsibilities handled by the LO. These include managing and maintaining hospitals and feeding centers in collaboration with medical teams; overseeing the supply chain for essential medical supplies, equipment, and other materials (procurement, customs, transportation, and inventory management); installing and maintaining technical equipment; constructing and maintaining water and sanitation (WatSan) facilities; managing computers, communication systems, and IT equipment; overseeing vehicle fleets and fleet operations; recruiting, training, and supervising national staff; handling data management; preparing security reports, and more. (Medecins Sans Frontieres, 2009; Blecken, 2019).

Dynamic capabilities

Dynamic capabilities (DC) are often referred to for providing the robustness and agility (visibility and velocity) of logistics as well as the ability to adapt to change (Brusset & Teller, 2017; Teece et al., 1997; Mitrega et al., 2017; Craighead et al., 2020). Humanitarian actors have responded to large-scale humanitarian disasters for decades (Kovács & Spens, 2009). The number of actors (organizations) in the field of operation, the relationships between and across actors' boundaries and broader interactions beyond LO have significantly increased (Kaneberg, 2018; Balcik *et al.,* 2010), involving military, governmental, donors, private, public, voluntary, media, and the public (Kovács & Spens, 2009; Balcik et al., 2010). Actors often have different levels of expertise, and their differing views and objectives often have a significant impact on the efficiency of the response operations performance and increasing collaboration (Kaneberg et al., 2016; Heaslip & Barber, 2014). DC are essential for managing and adapting logistics operations efficiency in response to major earthquakes (Craighead *et al.*, 2020; Besiou *et al.*, 2018; Kaneberg, 2018; Brusset & Teller, 2017). As such, early studies have suggested that persistence, adaptation, and transformation can increase flexibility, collaboration, visibility, velocity, technology, communication, and networks, thereby enabling rapid changes (Teece, 2007; Craighead et al., 2020) in humanitarian response.

DC is an area considered when responding to major earthquakes to consider cooperation more than just the performance of individual actors (Kovács and Spens, 2009) and logistical challenges when facing major earthquakes (Barten et al., 2021). During these events, both internal and external disruptions can be expected, requiring regulations to ensure that critical infrastructures like hospitals, housing, and transportation are built to withstand the impact of major earthquakes and minimize their effects on the population (Jafari et al., 2022). In the field of response operations, efficiency is not just about the performance of a single actor (Kaneberg et al., 2016; Heaslip & Barber, 2014). It also has logistical implications when dealing with major earthquakes that need to be quickly resolved (Kovács & Spens, 2009). Major earthquakes can cause both internal and external disruptions, which highlights the need for regulations that ensure infrastructure, such as hospitals, housing, and transportation, are built to withstand the impact of earthquakes and mitigate their effects on the population (Barten et al., 2021). This is especially important as earthquakes can have cascading effects that further disrupt the normal functioning of a region (Ebi & Semenza, 2008; Pescaroli & Alexander, 2016). Dynamic capabilities must be hastily formed under extreme uncertainty and logistical disruptions (Jafari, et al., 2022).

DC are critical for providing the robustness and agility (visibility and velocity) of LO as well as the ability of actors to adapt to change (Brusset & Teller, 2017; Teece et al., 1997; Mitrega et al., 2017; Craighead et al., 2020). Humanitarian actors have responded to large-scale disasters for decades (Kovács & Spens, 2009). The number of actors (organizations) in the field of operation, the relationships between and across actors' boundaries and broader interactions beyond LO have significantly increased (Kaneberg, 2018; Balcik *et al.,* 2010), involving military, governmental, donors, private, public, voluntary, media, and the public (Kovács & Spens, 2009; Balcik et al., 2010). Actors often have different levels of expertise, and their differing views and objectives often have a significant impact on the efficiency of the response operations performance and increasing collaboration (Kaneberg et al., 2016; Heaslip &Barber, 2014; Craighead *et al.*, 2020; Besiou *et al.*, 2018; Kaneberg, 2018; Brusset & Teller, 2017).

DC is a concept referring to the firms' processes—specifically the processes to integrate, build, and reconfigure internal/external competencies to address a rapidly changing environment (Lucien Fobi, 2017). Laaksonen and Peltoniemi, (2018) listed more specific dynamic capabilities such as flexibility, coordination, and collaboration to the robustness of LO. Wieland and Wallenburg (2012) referred to robustness and agility, which recognize a mixture of operations re-engineering, collaboration, agility, risk awareness, and knowledge management (Alzate, et al., 2022), and developed a system-level approach. Thus, DC could help address logistical challenges when actors (organizations) need to achieve competitive advantage and, at the same time, continuously adapt and reconfigure their operations and resources (Chen et al., 2021). To improve the understanding of LO, we use the dynamic capabilities (DC) lens to address the logistics operations challenges in building and maintaining efficient response to major earthquakes e.g. major earthquakes in Türkiye. This is an established approach (Tatham & Christopher, 2018) that provides a coherent framework for the response operations efficiency (e.g., Lucien Fobi, 2017; Liu, et al., 2021; Teece et al., 1997; Mitrega et al., 2017). Subsequently, this section focuses on logistics operations and the challenges in two major response operations in Türkiye´s context:

Logistics challenges in major earthquakes

Earthquake in Türkiye, 1999

In the response operations during the 1999 earthquake in Türkiye, the lack of coordination was the most widely discussed shortcoming of the disaster response. This included challenges in coordinating the efforts of three government disaster response teams: the fire company department, search and rescue unit, and emergency aid and rescue services. Additionally, there were difficulties in organizing support for providing food and accommodation for the personnel (cf. Altintas & Delooz, 2004). One of the major issues concerning the response operations and rescue phase in Türkiye is that there are several central government agencies with coordinative functions. The ineffectiveness of this system became clear in the aftermath of the August 17, 1999, earthquake (Walker, M., 2000). Despite the willingness of thousands of international and domestic voluntary organizations to assist after the earthquake, their emergency response and rescue efforts were ineffective, partly due to a lack of coordination at the central level (Ganapati, 2008).

The absence of a comprehensive plan and coordination—both crucial for improving the effectiveness of aid in such disasters—led to severe delays in the delivery of food and water. As a result, large quantities of uneaten bread and other perishable food spoiled, accumulating into massive piles of waste in the disaster area (Cetin, 2013). The main issue was the coordination among all parties involved in the disaster response. Effective communication, which is essential for coordination, could not be ensured during the critical phase. Additionally, there was a communication gap due to the shortage of personnel fluent in foreign languages, which would have supported the efforts of international workers (Aslanzadeh *et al.,* 2009). Challenges in accessing and sharing timely and accurate disaster-related information hindered coordination during the Marmara response (Celik & Corbacioglu, 2010). The absence of significant open communication channels between the affected provinces and the central government, combined with chaotic traffic conditions, disrupted the country's information infrastructure during the Marmara earthquake (Corbacioglu & Kapucu, 2006). The restricted flow of information between medical emergency centers, rescue teams, police, military, and volunteers greatly hindered prompt and informed actions, particularly during the initial three days of the Marmara earthquake (Comfort & Sungu, 2001). The transport infrastructure was severely damaged by the earthquake and initially overwhelmed by outsiders trying to drive to the region. This, in turn, prevented the arrival of civil defense rescue units and medical teams until early times (Bibbee et al., 2000).

The relief and rescue efforts were primarily provided by neighbors, family members, individuals, spontaneously organized volunteer groups, political parties, foreign rescue teams, and more established NGOs. The local state authority struggled to manage the crisis, and there was no existing mechanism to coordinate volunteer aid with the needs of the affected population (Jalali, 2002). One of the major problems was the organization of patients as well as materials transported to hospital units outside the damaged area (especially crushed victims who need dialysis) when most roads were destroyed (Vanholder *et al.,* 2001). Also, the bureaucratic procedures for importing equipment from abroad, customs clearance for communication devices, and legal processes for other equipment and land vehicles led to significant delays. Additionally, the lack of a proper needs assessment prevented international organizations from effectively guiding relief efforts, resulting in challenges in delivering aid materials (Aslanzadeh et al., 2009).

Earthquake in Türkiye, 2023

According to Yilmaz *et al.* (2023), on the first day of the disaster, transportation issues and a shortage of personnel hindered access to affected areas. By the second day, there was a lack of essential medical equipment. By the third day, healthcare workers were unprepared in terms of knowledge and experience to handle the disaster. Furthermore, the deployment of medical personnel was uncoordinated and poorly planned, leaving them unable to meet even their basic needs, such as food, heating, and shelter. Throughout the first week, coordination was consistently reported as the most critical challenge.

Lots of distressed people are perceived and people without homes are living in tents provided efficiently by the state. Moreover, food and water supplies are also sufficient, and the state is providing medical care with charity help. However, both locals and aid workers choose to live in tents fear of the risk of aftershocks (Howard, 2023). The affected region posed challenges in swiftly deploying search and rescue teams to local areas and provinces. Delays in search-and-rescue operations occurred due to transportation and communication disruptions, which hindered the timely arrival of professional teams and logistical support in the immediate aftermath of the disaster (Deger & Ozdinc, 2023). Moreover, the amount of assistance provided by the foreign search and rescue teams fell short of meeting the needs of all earthquake survivors (Supartono *et al.,* 2023).

The degree and duration of the disaster experienced in Türkiye made almost all previous preparations insufficient. Although there are no deficiencies in terms of legislation, there have been serious disruptions in the activities in the field. An earthquake is not a disaster that can be easily detected with early warning systems, but its potential has been mentioned by many experts in the region for a long time. These warnings were taken into consideration based on district administrations, drills were carried out, and disaster action plans were created, but no benefit was achieved because living with the reality of disaster could not be turned into a culture. AFAD, public authority, and civil initiative had a hard time making the first response to the earthquake that spread over a very wide area (cf. Sipal, 2023).

Summary of the literature review

Table 1

The main areas of logistics challenges in the response (logistics) operation context

Response focus	Logistics challenges context
Transportation infrastructure	Concerns with outsiders trying to drive to the region that comprises the logistics challenges. Challenges the arrival of civil defense rescue units and medical teams. Examines the connectivity and ability to large quantity of reinforcement.
Coordination	Concerned with the factors essential to increasing the effectiveness of logistics challenges.Challenges in the delivery of food, water, medical care, and shelter. Examine the coordination between all actors involved in the disaster response
Communication	Concerned communication to the efficiency of logistics challenges.Challenges the coordination and collaboration among the actors.Examines the knowledge of foreign languages facilitating information channels

Response focus	Logistics challenges context
Cooperation of foreign forces	Concerned with logistics challenges in international and national cooperation.Challenges with the balance of demand and supply. Examines logistics knowledge and experience in disaster response.
Lack of medical supplies	Concerned with the preparation and response to logistics challenges. Challenges the medical staff's coordination to deploy health-skilled personnel to the disaster area. Examines immediate response coordination challenges.

Sources: *(Kovács &Spens, 2009; Teece, 2007; Craighead et al., 2020; Brusset & Teller, 2017; Teece et al., 1997; Mitrega et al., 2017; Craighead et al., 2020).*

In summary, focusing on logistics operations (LO) can reveal the challenges faced in disaster response environments (Balcik et al., 2010). **Table 1** provides a summary of these key areas. these areas are interconnected. For instance, the effectiveness of transportation infrastructure is influenced by the coordination among various actors (Kovács & Spens, 2009), as well as their ability to communicate (Teece, 2007; Craighead et al., 2020) and adapt to changes (Brusset & Teller, 2017; Teece et al., 1997; Mitrega et al., 2017; Craighead et al., 2020). This interconnectedness suggests that different actors at various levels of a logistics operation share similar concerns and must collaborate to address the imbalances in demand and supply that arise during response efforts (Kovács & Spens, 2009). While each actor aims to resolve their specific concerns, their actions may inadvertently disrupt the logistics arrangements of similar actors within the broader response operation (cf., Besiou & Wassenhove, 2020).

This study stands out from existing research by providing important insights for logistics operations in both research and practice. It emphasizes how response operations interpret and mediate dynamic capabilities, including transportation infrastructure, coordination, communication, cooperation among foreign forces, and challenges posed by insufficient medical supplies. These logistics challenges hinder the efficiency of responses to major earthquakes. This study makes a unique contribution by specifying the essential roles of various response organizations, such as civil defense, rescue units and medical teams. This creates a comprehensive understanding of the effectiveness of logistics responses. Additionally, it offers valuable insights for public decision-makers, emphasizing the importance of effective communication in achieving intended goals, including the mediation effects identified in the study.

Methodology

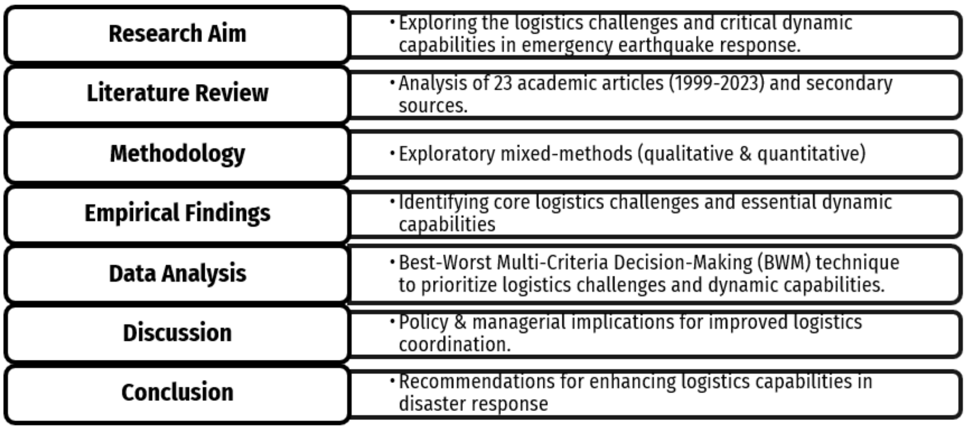
The present study uses exploratory elements to address the humanitarian response efficiency and effectiveness (in Türkiye). Logistics operations (LO) through dynamic capabilities (DC) to reduce logistics challenges, explore the data triangulation (cf. Dezing, 1978) of secondary materials and (one) semi-structured interview **(Table 4)** to estimate requested DC in the response to major earthquakes.

This exploratory study provides a foundation for future research in logistics operations. It creates assumptions that can be tested through quantitative methods and qualitative approaches. Furthermore, using the data gathered from this study in other research projects can enhance the significance of humanitarian research (Ellram 1996, p. 97; Flynn et al. 1990, p. 251). Based on several reasons, this view suggests that using a mixed quantitative and qualitative methodology is ideal for exploring and examining emerging and changing topics. This approach combines the rigor and precision of explorative approaches, as suggested by Miles et al. (2020). *First,* this is particularly valuable in growing research fields such as humanitarian response, LO, and DC. Research on major earthquakes has constantly challenged logistics and is still at an exploratory stage because existing knowledge is scarce, as noted by Kunz et al. (2017), Leiras et al. (2014), L'Hermitte et al. (2016), and Yin (2014). *Second*, the exploratory research design that was used in this study allowed for an in-depth understanding of truthful practices and the collection of empirical data (Eisenhardt

& Graebner, 2007). By analyzing academic and secondary materials, as well as conducting one interview, the study was able to provide a structured data collection process that also allowed for unexpected and new statements to be taken seriously (Döringer, 2021). *Third*, previous research has shown that the approach used in this study is reliable for addressing issues related to LO and logistics challenges in the humanitarian field. Some examples of such studies are Besiou and Wassenhove (2020), Gupta et al. (2019), and Teece et al. (1997). The current study builds upon the work of Eisenhardt and Graebner (2007), which has been used in various studies to examine how organizations from business and service sectors collaborate closely to deal with major earthquakes. However, we also consider the critical role of governments in dealing with LO and supply challenges that may threaten critical infrastructure. Considering the research of Yeow et al. (2018) and Alcaraz and Zeadally (2015), the logistics area is facing challenges, including collaboration, flexibility, transportation, trust, information, management culture, and technology, which are debated in articles focusing on the Türkiye response operation system. This study enhances the generalizability and comparability of LO by exploring the logistical challenges associated with it. The research employed a combination of quantitative data design, which included analyzing 23 academic articles from 1999 to 2023, and in-depth data analysis through secondary materials and an interview. This approach can be used to report different levels of analysis and complement each other, as reported by Lantagne et al. (2021). The research flowchart is illustrated in Figure 1.

Figure 1

Flowchart of the research



Data analysis

The first step is the collection of relevant material for analysis. Academic materials (23 articles), several secondary materials (news, websites, reports), and a single expert with high experience and knowledge with direct responsibility for earthquake response-related activities were carefully chosen as part of our sample. This section provides a detailed discussion of the criteria used for the collection of relevant data for the study.

Consequently, to establish our data criteria, (2015) suggested the Best-Worst Method (BWM), which is a multicriteria decision-making logic that compares the best data criteria (alternative) to the other criteria (alternatives) and all the other criteria (alternatives) to the worst criteria (alternative). According to the BWM, the decision-maker initially identifies the best (most desirable) and worst (least desirable) criteria. Pairwise comparisons are then made between each of these criteria and the others. A maximin problem is subsequently developed and solved to establish the weights of the different criteria. This process is repeated to determine the weights of the alternatives concerning each criterion. By aggregating these weights, the final scores for the alternatives are calculated, facilitating the selection of the best alternative. This process also makes it possible to use a smaller amount of data in the peer calculation to calculate the weight. The aim was to determine the optimal weights and consistency ratio through our simple optimization model constructed using the comparison system. Moreover, the method can be applied with the participation of a single subject matter expert. The BWM comprises five steps, as shown in **Appendix 1.** Steps of the Best-Words Method (BWM).

Empirical Findings

The Türkiye commitment: A humanitarian dilemma

Investing in logistics capabilities is crucial despite major earthquakes, and it is a critical element for minimizing the impact of expected earthquakes and safeguarding the well-being of the population in Türkiye. However, the anticipated earthquake in Istanbul presents a humanitarian dilemma as there are concerns regarding the ability of Türkiye's emergency system to respond on time. The dilemma lies in balancing the urgent need for structural reinforcements and safety measures to mitigate the impact of the earthquake against the logistical and financial challenges of implementing these measures effectively. Moreover, there is a dilemma in addressing the housing crisis resulting from the large number of residents living in at-risk buildings. Relocation efforts may be complicated by limited resources, the current economic situation, and the need to ensure equitable treatment for all affected individuals.

Türkiye is situated in a seismically active region, making it susceptible to earthquakes, which pose a significant threat to human lives and infrastructure. On *February 6, 2023*, the Kahramanmaras province in Türkiye experienced two significant earthquakes measuring 7.7 and 7.5 in magnitude, followed by two additional earthquakes of 6.4 and 5.8 magnitude on February 20. The impact extended to 11 provinces in the southeast region. The response to these earthquakes was led by the government and coordinated through the Disaster and Emergency Management Authority (AFAD), in collaboration with the Türkiye Red Crescent (TRC). According to the United Nations, an estimated 9.1 million individuals have been affected by the earthquakes. As of March 15, the reported casualties included 48,448 fatalities and over 115,000 injuries across the country (WHO, 2023). Similarly, On *August 17, 1999*, a seismic event with a magnitude of 7.6 struck the Kocaeli and Sakarya districts in northwestern Türkiye. Shortly thereafter, another significant earthquake with a magnitude of 7.2 occurred in the nearby area centered around Duzce. These calamities resulted in a staggering toll, with over 18,000 fatalities and more than 50,000 individuals sustaining serious injuries. A total of more than 51,000 buildings either suffered extensive damage or completely collapsed, rendering over 600,000 people homeless (Akgiray et al., 2004). These two major earthquakes in Türkiye stand as the most severe and extensive natural disasters in the history of the Türkiye Republic. In the aftermath of the earthquake that hit Türkiye in 1999, there has been a widespread acknowledgment of the necessity for comprehensive earthquake preparedness and response planning, grounded in detailed earthquake risk analysis nationwide.

In addition, the predicted Istanbul earthquake has received significant attention because this urban area is located along a significant geological fault. Numerous buildings are being constructed below acceptable standards, with estimates that over 25% of the population is vulnerable to experiencing significant damage to their homes during a significant earthquake (Los Angeles Times, 2023). Istanbul accommodates approximately one-sixth of the country's total population and holds half of Türkiye's industrial potential (Erdik, 2013). Considering the present condition of the building inventory in Istanbul and the elevated likelihood of a substantial earthquake occurring shortly, the city is confronted with enormous logistical challenges, potentially leading to large-scale disruption of unprecedented magnitude (Pyper Griffiths et al., 2007). Moreover, with elevated seismic risk in the Istanbul metropolitan area, accurately predicting the distribution of damage and casualties across both the European and Asian sides is crucial for the establishment of an effective rapid response system (Zulfikar et al., 2017).

In this sense, disaster operations are vital for ensuring a rapid, adaptable, and well-coordinated response that can effectively address the complex challenges posed by a large-scale seismic event in a densely populated urban environment. Investing in logistics capabilities is assumed to be an imperative step toward minimizing the impact of the expected earthquake and safeguarding the well-being of the population in Istanbul. This is nevertheless also part of the humanitarian dilemma surrounding the anticipated earthquake in Istanbul. For example, the city's vulnerability is due to its location on a major fault line and the high number of buildings constructed below adequate standards. This situation poses a significant risk to the population, with potentially devastating effects.

Findings building from the literature review

Table 2 and Table 3 disclose the most common logistics challenges that appear under the reviewed literature from each earthquake. A large number of academics denoted logistics challenges found in the most prominent literature on disaster operations (preparedness and response). From the review of the Türkiye's response to earthquakes in 1999 and 2023 (23 articles).

Our analysis shows that coordination and communication (11 articles) were the most prominent challenges impacting logistics operations during the response effort shown in **Table 2.,** we use these logistics challenges as criteria for our analysis.

Table 2

Areas challenging the logistics operations during the response to the Türkiye Earthquake in 1999

Logistics Challenges	Reference											
	Vanholder et al., 2001	Caymaz et al., 2013	Bibbee et al., 2000	Baycan, 2004	Altintas& Delooz, 2004	Corbacioglu & Kapucu, 2006	Celik& Corbacioglu, 2010	Comfort& Sungu, 2001	Jalali, 2002	Cetin, 2013	Aslanzadeh et al., 2009	Ganapati, 2008
Transportation infrastructure			*									
Coordination		*			*		*		*	*	*	*
Communication						*	*	*			*	
Food distribution					*							
Accommodation					*							
Transport of the materials	*										*	
Transport of patients	*											
Transport of rubble				*								

During the response to the Türkiye Earthquake in 2023, on the other hand, the transportation infrastructure and coordination (12 articles) were appointed as areas challenging the logistics operations, according to our analysis shown in **Table 3**. We use these logistics challenges as the criteria for our analysis.

Table 3

Areas challenging the logistics operations during the response to the Türkiye Earthquake in 2023

Logistics Challenges	Reference										
	Kolivand et al., 2023	Yilmaz et al., 2023	Howard, 2023	Cinar et al., 2023	Deger& Ozdinc 2023	Supartono et al., 2023	Dal Zilio and Ampuero (2023)	Tabak, 2023	Genc, 2023	Sipal, 2023	Unuvar and El
Transportation infrastructure		*		*	*	*	*		*		
Coordination	*	*		*		*			*	*	
Communication					*						
Cooperation of foreign forces	*										
Lack of medical supplies	*	*									
Lack of compatibility of the aid items	*										
Security and safety of the aid materials	*										
Risk of aftershocks			*								
Transport of rubble								*			
Transport of food											*

Findings building from the expert respondent.

To weigh the criteria and alternatives, **Table 4.** shows the areas resulting from the survey answered by our chosen subject expert. The dynamic capabilities (DC) found in the literature review (section 2.2) we used to structure the survey questions; as such, the most relevant DC were robustness, agility, organizational learning, visibility/information capability, responsiveness and delivery reliability/speed. Table 4 demonstrates the expert-assessed impact of logistics capabilities on logistics challenges, highlighting its role in shaping our findings.

Table 4

Interview findings

Please indicate the impact level of **robustness** (logistics capability) on the **logistics challenges** on the following criteria on a scale of 1-9 (1 refers to "lowest impact" and 9 refers to "highest impact")									
	1	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**
Transportation infrastructure									x
Coordination								x	
Communication								x	
Cooperation of foreign forces	x								
Lack of medical supplies								x	
Risk of aftershocks	x								
Transport of rubble						x			
Transport of food								x	
Please indicate the impact level of **agility** (logistics capability) on the **logistics challenges** on the following criteria on a scale of 1-9 (1 refers to "lowest impact" and 9 refers to "highest impact")									
	1	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**
Transportation infrastructure					x				
Coordination								x	

Communication								x	
Cooperation of foreign forces							x		
Lack of medical supplies									x
Risk of aftershocks						x			
Transport of rubble									x
Transport of food									x
Please indicate the impact level of **organizational learning** (logistics capability) on the **logistics challenges** on the following criteria on a scale of 1-9 (1 refers to "lowest impact" and 9 refers to "highest impact")									
	1	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**
Transportation infrastructure						x			
Coordination									x
Communication									x
Cooperation of foreign forces								x	
Lack of medical supplies							x		
Risk of aftershocks				x					
Transport of rubble	x								
Transport of food					x				
Please indicate the impact level of **visibility/information capability** (logistics capability) on the **logistics challenges** on the following criteria on a scale of 1-9 (1 refers to "lowest impact" and 9 refers to "highest impact")									
	1	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**
Transportation infrastructure								x	
Coordination									x
Communication									x
Cooperation of foreign forces							x		
Lack of medical supplies						x			
Risk of aftershocks	x								
Transport of rubble				x					
Transport of food					x				
Please indicate the impact level of **responsiveness** (logistics capability) on the **logistics challenges** on the following criteria on a scale of 1-9 (1 refers to "lowest impact" and 9 refers to "highest impact")									
	1	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**
Transportation infrastructure									x
Coordination									x
Communication								x	
Cooperation of foreign forces								x	
Lack of medical supplies									x
Risk of aftershocks	x								
Transport of rubble		x							
Transport of food									x
Please indicate the impact level of **delivery reliability/delivery speed** (logistics capability) on the **logistics challenges** on the following criteria on a scale of 1-9 (1 refers to "lowest impact" and 9 refers to "highest impact")									
	1	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**
Transportation infrastructure									x

Coordination							x		
Communication			x						
Cooperation of foreign forces	x								
Lack of medical supplies									x
Risk of aftershocks	x								
Transport of rubble		x							
Transport of food								x	

Criteria and Alternatives

There are many ways of mixing models with different levels of analysis. We employed the Best-Worst Method. This method was introduced by Rezaei (2015) to determine the importance weights of each criterion and used these weights to determine the priority values for each alternative. Here, we describe the steps of our methodology and findings building on the identified logistics challenges and DC required in **Table 5**.

Table 5

Criteria (logistics challenges) and Alternatives (DC) of the MCDM Problem

Alternatives	Criteria
Robustness	Coordination
Agility	Communication
Organizational Learning	Lack of medical supplies
Visibility/Inf. Capability	Transportation infrastructure
Responsiveness	Risk of aftershocks
Delivery Reliability/Speed	Transport of Rubbles
	Transport of Food
	Cooperation of Foreign Forces

Step 1. Identify the criteria and alternatives.

In the first step, we identify the criteria and alternatives for the MCDM problem. Our analysis criteria are concerned with the challenges in the aftermath of an earthquake from the aftermath of the February 6, 2023, earthquake in Türkiye (Ganapati, 2008), while alternatives are concerned with the different capabilities of the "logistics operations" to prompt responding to complex earthquakes reflected in early studies for permitting resilience (Teece, 2007) and the capability to deal with the rapid changes (Craighead et al., 2020).

Step 2. Determine the weight of the criteria by applying the BWM method.

Criteria weights were determined via the BWM method. The criteria were determined from an extensive literature review in section 2. Then, pairwise, a comparison matrix was created.

The Best-Worst Method (BWM) was selected for this study because of its effectiveness in providing reliable and consistent results in multi-criteria decision-making (MCDM) problems. Unlike traditional pairwise comparison approaches such as the Analytic Hierarchy Process (AHP), BWM reduces the number of comparisons required while maintaining a high level of consistency, making it a more efficient and robust method.

According to Rezaei (2015), one of the key advantages of BWM is its ability to minimize inconsistency in decision-making by using only two reference points: the best (most important) and worst (least important) criteria. This approach improves decision reliability by reducing the cognitive burden on experts and ensuring a more structured elicitation of preferences. Additionally, BWM generates an optimal weight distribution with a consistency ratio, allowing for the validation of the decision-making process.

Table 6

Best-to-others (BO) and others-to-worst (OW) pairwise comparison vectors

Criteria	Best	Worst
Coordination	1	9
Communication	2	7
Lack of medical supplies	3	6
Transportation infrastructure	2	8
Risk of aftershocks	6	3
Transport of Rubbles	9	1
Transport of Food	4	2
Cooperation of Foreign Forces	3	4

After determining the pairwise comparison vectors, the criteria weights shown in Table 3 were obtained by solving Eq. (9) in the Appendix using the Excel Solver.

Table 7

Criteria weight according to the BWM method

Criteria	Weights
Coordination	0.283
Communication	0.165
Lack of medical supplies	0.110
Transportation infrastructure	0.165
Risk of aftershocks	0.055
Transport of Rubbles	0.026
Transport of Food	0.082
Cooperation of Foreign Forces	0.110

The third step of the BWM method is applied to determine the importance weights of the criteria. The pairwise comparison consistency was found to be 0.125, which is acceptable and under the threshold value of 0.362. The steps of the BWM method are given in the Appendix. Steps of the Best-Words Method (BWM).

Step 3. Determine the priority of the alternatives. The Weighted Sum Model (WSM) is used to prioritize the alternatives.

Table 8

Collecting data from experts

Alternatives/Criteria	Coordination	Communication	Lack of Medical Supplies	Transportation Infrastructure	Risk of aftershocks	Transport of Rubbles	Transport of Food	Cooperation of Foreign Forces
Robustness	8	8	8	9	1	1	8	1
Agility	8	8	9	5	6	9	9	7
Organizational Learning	9	9	7	6	4	1	5	8

Alternatives/Criteria	Coordination	Communication	Lack of Medical Supplies	Transportation Infrastructure	Risk of aftershocks	Transport of Rubbles	Transport of Food	Cooperation of Foreign Forces
Visibility/Information Capability	9	9	6	8	1	4	5	7
Responsiveness	9	8	9	9	1	2	9	8
Delivery Reliability/ Speed	7	3	9	9	1	2	8	1

Table 9

Normalize the data by dividing the maximum value on each criterion column

Alternatives/Criteria	Coordination	Communication	Lack of Medical Supplies	Transportation Infrastructure	Risk of aftershocks	Transport of Rubbles	Transport of Food	Cooperation of Foreign Forces
Robustness	0.889	0.889	0.889	1.000	0.167	0.111	0.889	0.125
Agility	0.889	0.889	1.000	0.556	1.000	1.000	1.000	0.875
Organizational Learning	1.000	1.000	0.778	0.667	0.667	0.111	0.556	1.000
Visibility/Information Capability	1.000	1.000	0.667	0.889	0.167	0.444	0.556	0.875
Responsiveness	1.000	0.889	1.000	1.000	0.167	0.222	1.000	1.000
Delivery Reliability/ Speed	0.778	0.333	1.000	1.000	0.167	0.222	0.889	0.125

Table 10

Multiply each normalized value by the criterion weights

Alternatives/Criteria	Coordination	Communication	Lack of Medical Supplies	Transportation Infrastructure	Risk of aftershocks	Transport of Rubbles	Transport of Food	Cooperation of Foreign Forces
Robustness	0.252	0.147	0.098	0.166	0.009	0.003	0.074	0.014
Agility	0.252	0.147	0.110	0.092	0.055	0.026	0.083	0.097
Organizational Learning	0.284	0.166	0.086	0.110	0.037	0.003	0.046	0.110
Visibility/Information Capability	0.284	0.166	0.074	0.147	0.009	0.012	0.046	0.097
Responsiveness	0.284	0.147	0.110	0.166	0.009	0.006	0.083	0.110
Delivery Reliability/ Speed	0.221	0.055	0.110	0.166	0.009	0.006	0.074	0.014

Table 11

Find priority values for each alternative by summing up the criteria values

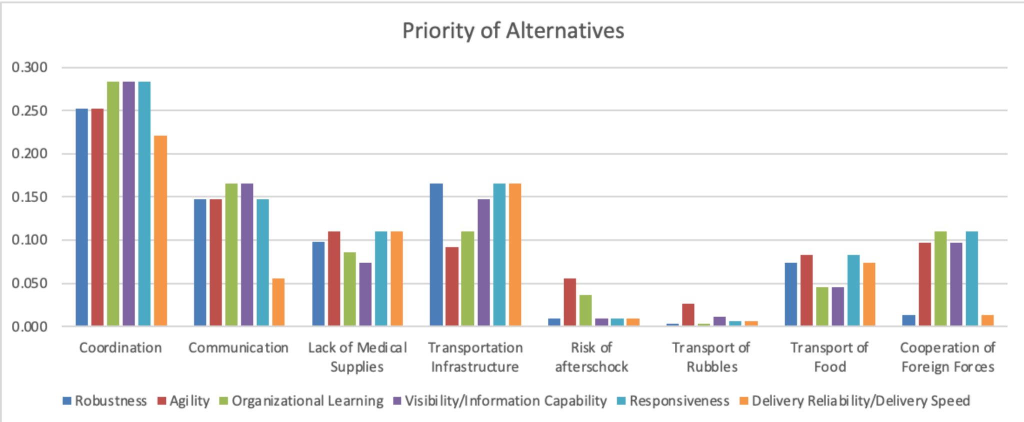
Alternatives/Criteria	Coordination	Communication	Lack of Medical Supplies	Transportation Infrastructure	Risk of aftershocks	Transport of Rubbles	Transport of Food	Cooperation of Foreign Forces	Overall
Robustness	0.252	0.147	0.098	0.166	0.009	0.003	0.074	0.014	0.763
Agility	0.252	0.147	0.110	0.092	0.055	0.026	0.083	0.097	0.863
Organizational Learning	0.284	0.166	0.086	0.110	0.037	0.003	0.046	0.110	0.842

Alternatives/Criteria	Coordination	Communication	Lack of Medical Supplies	Transportation Infrastructure	Risk of aftershocks	Transport of Rubbles	Transport of Food	Cooperation of Foreign Forces	Overall
Visibility/Information Capability	0.284	0.166	0.074	0.147	0.009	0.012	0.046	0.097	0.834
Responsiveness	0.284	0.147	0.110	0.166	0.009	0.006	0.083	0.110	0.915
Delivery Reliability/ Speed	0.221	0.055	0.110	0.166	0.009	0.006	0.074	0.014	0.654

Based on our calculations, the most desired alternative is responsiveness, followed by agility, organizational learning, visibility/information capability, robustness, and delivery reliability/speed. **Figure 2** depicts the priority values of each alternative based on each criterion. The graph also shows the importance of each criterion by plotting each criterion on the bar chart.

Figure 2

Priority of the Alternatives



Analysis And Discussion

Overall, the study analyzed the interview survey (a single expert) along with 23 academic articles published between 1999 and 2023. To structure our findings, we build on our data analysis in Figure 2, showing the most desired alternatives (dynamic capabilities) such as responsiveness, followed by agility, organizational learning, visibility/information capability, robustness, and delivery reliability/speed of the LO. Based on the literature review (Tables 3 and 4), the most emphasized challenges were found in coordination, transportation infrastructure, and communication. We use these findings to explore the answer to our question:

What dynamic capabilities are critical in addressing the logistics challenges in the response to logistics operations during major earthquakes in Türkiye?

In LO, major earthquakes imply logistics challenges that are, in turn, impeding the evolving critical DC to the response efficiency. However, our findings disclosed that anticipating an earthquake in Istanbul presents a humanitarian dilemma as there are concerns regarding the ability of Türkiye's emergency system to respond on time. The dilemma lies in balancing the urgent need for structural reinforcements and safety measures to mitigate the impact of the earthquake against the logistical and financial challenges of implementing these measures effectively. Moreover, there is a dilemma in addressing the housing crisis resulting from the large number of residents living in at-risk buildings. Relocation efforts may be complicated by limited resources, the current economic situation, and the need to ensure equitable treatment for all affected individuals. Istanbul is one of the cities in Türkiye most vulnerable due to its location, a major weakness in line with houses constructed below adequate standards posing a significant risk to its population, and potentially devastating consequences in the event of a major earthquake.

One of the foremost challenges in humanitarian logistics is coordination among various stakeholders. In the aftermath of an earthquake, numerous organizations, both local and international, mobilize to aid. However, the lack of coordination mechanisms often leads to duplication of efforts, resource wastage, and gaps in coverage. During disasters, there is a pressing necessity to coordinate logistics resources from both the public and private sector to prevent arbitrary resource allocation. Furthermore, communication breakdowns between relief suppliers, logistics operators, and those in need aggravate the complexity of disaster resource coordination, especially under emergency circumstances (Sheu, 2007). Such disasters also exert significant adverse effects on the physical infrastructure of the affected region, causing widespread destruction to transportation infrastructure like roads, bridges, railways, and airports, as well as disrupting electricity grids and communication networks (Barabaşoğlu et al., 2002). These impediments hamper the timely delivery of aid supplies to affected areas, prolonging the suffering of communities in need. Moreover, the limited availability of vehicles suitable for navigating rugged terrains worsens the problem. By cultivating dynamic capabilities, decision-makers can better address logistical challenges such as coordination, communication, and transportation infrastructure.

Our findings reveal that responsiveness, agility, and organizational learning are DCs that need the most attention by the state and humanitarian organizations. In this sense, our study results align with the literature. *First*, prior research indicates that responsiveness is crucial in the post-disaster setting following sudden-impact events (Naor & Bernardes, 2016). According to Ghosh *et al.* (2004), responsiveness is a vital capability to achieve the efficiency of activities and the seamless integration of processes throughout the chain. Our analysis indicates that responsiveness is crucial in addressing rapidly changing situations and demands when logistics challenges occur.

According to our analysis, both the state and humanitarian organizations and being able to adapt swiftly to evolving circumstances ensure effective and timely responses to large-scale disasters. This is, nevertheless, a humanitarian dilemma surrounding the anticipated earthquake in Istanbul and the ability of Türkiye ´s emergency system to respond in time (cf. Caymaz *et al.,* 2013). The study showed the dilemma in balancing the urgent need for structural reinforcements and safety measures to mitigate the impact of the earthquake against the logistical and financial challenges of implementing these measures effectively. This capability involves not only quick decision-making but also the ability to implement and adjust strategies promptly.

Second, agility is the capacity to detect immediate shifts in the environment and demonstrate swift and adaptable responses to those changes (cf. Alzate, *et al.,* 2022). According to our findings, humanitarian organizations are engaged in disaster relief to enhance the rapid and efficient transport of relief supplies and to save victims. Achieving this goal necessitates the backing of a responsive and agile supply chain network (Dubey *et al.,* 2015). *Third*, our analysis (BWM) indicated that organizational learning is vital to DC. However, according to the study, in more complex and unpredictable logistics challenges, the ability to learn together (from experiences) continues to be a challenging improvement. According to Labib *et al.,* (2019), involved organizations in the response operations (e.g., foreign aid, NGOs, voluntary workers, and national authorities) can enhance their effectiveness by fostering a culture of learning, enabling them to refine their approaches based on past rare events.

The study reveals, on the other hand, that robustness, visibility/information capability, and delivery reliability/speed are the most desired capabilities to overcome logistics challenges. According to Brandon Jones *et al. (2014),* by investing in logistical robustness, organizations can maintain their functions even during sudden demand changes despite disruptions due to major earthquakes. Visibility/information capability was found to be vital for gathering, analyzing, and disseminating relevant information promptly, according to Francis (2008). The study indicated that for effective coordination, both the state and humanitarian organizations need to invest in robust information systems and processes, ensuring that key stakeholders are well-informed and equipped to make informed decisions. Moreover, delivery reliability/speed also holds significant importance for those involved in logistics challenges. According to Walton et al., (2011), the existing literature on emergency response strongly advocates for speedy logistical processes to deliver goods and services during humanitarian crises.

Conclusions

The purpose of this study was to analyze the response to major earthquakes (natural), meeting logistics challenges in disaster operations using the experiences from the major earthquakes that struck Türkiye. It is essential to acknowledge that logistical challenges during disaster operations are not unique to a single country but are pervasive worldwide. We used dynamic capabilities to explain their critical potential to address logistics challenges when responding to major earthquakes. Examining the LO in response to major earthquakes in Türkiye, our findings showed that several logistics areas pose challenges to the LO. As such, the transportation infrastructure, coordination, communication, cooperation (among foreign forces), and the lack of medical supplies were logistics challenges impeding the efficiency of the response to major earthquakes (e.g., 1999 and 2023). The study showed that humanitarian actors use "logistics" as an umbrella term encompassing a broad variety of tasks covered by the LO, which, in turn, also represent logistics challenges. For instance, coordinating the management and maintenance of hospitals and feeding centers alongside medical teams; overseeing administration and organization; handling health supplies, equipment, and other materials (including procurement, customs, transportation, and inventory management); installing and maintaining technical equipment; managing construction and upkeep; maintaining communication systems and IT infrastructure; overseeing vehicle fleet operations; recruiting, training, and supervising national staff; managing data; and preparing security reports. As we found support for the facilitation of DC to mitigate logistics challenges, we content that during LO, dynamic capabilities would effectively influence the response to complex disruptions (i.e., due to earthquakes that struck Türkiye), and responsible authorities should consider exploiting the coordination and communication capabilities. Hence, our study addresses the associated results from previous research regarding the lack of medical supplies and transportation disruptions. As such, in the mitigation of aftershock risks (e.g., transport of rubble, food, and water), the cooperation involves foreign aid, NGOs, voluntary workers, and national authorities bound by employment mechanisms, as these have been disregarded in early responses.

This study adds to the existing body of literature on logistics operational efficiency by assessing the challenges related to the dynamic capabilities that humanitarian logistics providers and responsible organizations face. It draws upon insights from humanitarian responses, critical infrastructure, and operations and supply chain management to develop the concept of logistics challenges. Specifically, this study analyzes how dynamic capabilities present significant obstacles to logistics operations in the aftermath of major earthquakes. Additionally, we use the logistics operational framework to highlight logistical challenges that could be addressed through the implementation of dynamic capabilities. We emphasize the critical need to improve coordination, communication (including communication channels), and transportation infrastructure to enhance the overall logistics operational efficiency. Our findings also reveal the importance of other specific DCs, such as responsiveness, agility, organizational learning, visibility, and information, robustness, and delivery reliability/speed, to effectively route these logistics challenges. Among these capabilities, responsiveness emerges as highly critical for enabling organizations to promptly adapt to changing circumstances. Additionally, agility is highlighted for its role in maintaining flexibility and quick adaptability to unforeseen disruptions, providing an asset in overcoming logistical challenges during response operations. In essence, the present study advocates responsiveness, agility, and organizational learning as the key dynamic capabilities to be developed. By doing so, organizations can proactively address coordination, communication, and transportation infrastructure challenges, ensuring a robust and adaptive logistical framework capable of meeting the demands of unpredictable events.

Implications

The various possibilities of doing good research involve, at the same time, implications. One important aspect is the policy implications of this study. That is, regarding the dilemma of balancing the urgent need for structural reinforcements (e.g., The Türkiye response system) and mitigating the logistical challenges (e.g., coordination, communication, and transportation). Policy development would be required as impactful guidance to the humanitarian system involving foreign aid, NGOs, voluntary workers, and the national authorities to efficiently face rapid and challenging changes. Moreover, in line with Türkiye's adaptation process to the EU's Green Deal, responsive and adaptive logistics strategies are not only critical for economic cooperation but also ensure that logistics performance responds swiftly to disasters (Cura & Demir, 2022). The policy can not only provide guidance but also mechanisms to make the response to major earthquakes (e.g., shoving organizations the potential impact of internal and external disruptions) approachable (cf. Barten, et al., 2021). Policy can also support regulations that easily ensure access to vital infrastructures (e.g., hospitals, housing, and transportation) and how these would mitigate the effects on the population (cf. Yeow, *et al.,* 2018).

The other is the managerial implications. The managerial issue in which the role of public and private organizations has been raised at the cost of NGO, voluntary, and national authorities' sectors. Here the implications concern an increasingly specialized work on safety (and security) to protect workers and victims (e.g., as the Türkiye response system appeared to be weak). Responsible managers in the national authorities have to be bound by employment mechanisms for providing conditions and policy guidance to humanitarian workers. However, ultimately, to guarantee a more efficient response, operations work.

Limitations and future research

The Best-Worst Method (BWM) can only be applied with the participation of a single subject matter expert; thus, this study is built on secondary materials and ONE interview. However, future research needs to integrate the analysis of multicriteria decision-making logic by broadening the sample, i.e., different groups of respondents, and research in the area to allow validity and applicability to similar conditions. Using BWM, there is a limited number of expert materials and convenient sample interviews needed to critically establish applicability, following Corbin and Strauss's (1990) on the significance of collecting and analyzing data until redundancy is achieved and additional data only provides slightly new insights. The data-gathering questionnaire was developed based on a comprehensive review of relevant academic literature, ensuring the validity, accuracy, and appropriateness of the selected questions. This approach was chosen for its flexibility, enabling the assessment of various aspects while still aligning with the predefined data collection objectives (Yin, 2014). However, determining from whom data will be collected and where was analogous tour consideration of sampling, is a limitation on representative sampling to generate findings from the sample to the population.

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Appendix

STEPS OF THE BEST-WORDS METHOD (BWM)

BWM is a multicriteria decision-making method that compares the best criteria (alternative) to the other criteria (alternatives) and all the other criteria (alternatives) to the worst criteria (alternative). This process creates a comparison system composed of two comparison vectors. The goal is to find the optimal weights and consistency ratio through a simple optimization model constructed using the comparison system. The BWM comprises five steps (Rezaei, 2015).

Step 1. Determine a set of decision criteria

Step 2. Determine the best (e.g., most desirable, most important) and the worst (e.g., least desirable, least important) criteria.

Step 3. Determine the preference of the best criterion over the other criteria using a number between 1 and 9. The resulting Best-to-Others vector would be:

$A_B = (a_{B1}, a_{B2}, ..., a_{Bn})$

where a_{Bj} indicates the preference of the best criterion C_B over criterion C_j. It is clear that $a_{BB} = 1$.

Step 4. Determine the preference of the criteria over the worst criterion using a number between 1 and 9. The resulting Others-to-Worst vector would be:

$A_W = (a_{1W}, a_{2W}, ..., a_{nW})$

where a_{jW} indicates the preference of criterion C_j over the best criterion C_W.It is clear that $a_{WW} = 1$.

Step 5. Find the optimal weights.

$(w_1^*, w_2^*, ..., w_n^*)$

The optimal weight for the criteria is the one where for each pair of $\frac{w_B}{w_j}$ and $\frac{w_j}{w_W}$, we have $\frac{w_B}{w_j = a_{Bj}}$ and $\frac{w_j}{w_W = a_{jW}}$.To satisfy these conditions for all j, we should find a solution where the maximum absolute differences $\left|\frac{w_B}{w_j} - a_{Bj}\right|$and $\left|\frac{w_j}{w_W} - a_{jW}\right|$ for all j is minimized. Considering the non-negativity and sum condition for the weights, the following problem results:

$$\min \max_j \left\{ \left| \frac{w_B}{w_j} - a_{Bj} \right|, \left| \frac{w_j}{w_W} - a_{jW} \right| \right\}$$
$$s.t.$$
$$\sum_j w_j = 1 \tag{1}$$
$$w_j \geq 0, for\ all\ j$$

Problem (8) can be transferred to the following problem:

$$\min \xi$$
$$s.t$$
$$\left|\frac{w_B}{w_j} - a_{Bj}\right| \le \xi \; for\; all\; j$$
$$\left|\frac{w_j}{w_W} - a_{jW}\right| \le \xi \; for\; all\; j \tag{2}$$
$$\sum_j w_j = 1$$
$$w_j \ge 0, \; for\; all\; j$$

Solving problem (9), the optimal weights $\left(w_1^*, w_2^*, ..., w_n^*\right)$ and ξ^* are obtained.