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Fuel Scarcity and Supply Chain Disruption: Assessing Effects on Logistics Performance and Organizational Resilience

Md Ghalib[1], Divya Prakash Singh[2], Rohit Kumar[3], Raj Srivastava[4], Abhishek Yadav[5]

[1,4,5]Master Student, Department of MBA, Galgotias College of Engineering and Technology
[2]Assistant General Manager, Operation, Coropex Packing Private Limited
[3]Assistant Professor, Department of MBA, Galgotias College of Engineering and Technology

Abstract

This research assesses the effects of fuel shortages on logistics and distribution systems, specifically looking at how they affect the operation, cost and strategy of a company. A primary source of fuel for logistics companies is diesel and gasoline, which are vital resources for maintaining efficient supply chains and transportation networks. A combination of both qualitative and quantitative methods was employed to conduct this research. Quantitative data was collected using structured questionnaires distributed to 150 logistics professionals. In addition, qualitative data was collected using semi-structured interviews conducted with 20 industry experts. Data from secondary sources such as peer reviewed articles, industry reports, government publications and policy documents were also used to inform the findings. Findings indicated that fuel shortages occur frequently (three to four times per year) and have a negative impact on a company's operational functions. Many respondents reported an increase in operating costs ranging from 25 percent to 40 percent when experiencing fuel shortages. Respondents also experienced issues with timely deliveries and managing their inventory. Small and Medium-Sized Enterprises (SMEs) were found to be especially susceptible to the effects of fuel shortages. Due to the limited financial and resource flexibility SMEs experience; they cannot afford the same level of disruption caused by fuel shortages as larger companies. Additionally, employees in logistics companies may experience increased levels of stress and decreased productivity during periods of fuel shortages. To alleviate the effects of fuel shortages many companies use adaptation strategies such as optimizing routes, consolidating loads, limiting the amount of fuel consumed and finding alternative suppliers. These types of adaptations provide some immediate benefits but will not completely eliminate or prevent the long-term implications associated with relying on fuel. Resource dependency theory and organizational resilience theories were used to explain why firms respond differently to fuel shortages. Based on the findings of this study it is recommended that organizations develop greater resilience to potential disruptions by investing in technology related to improving fuel efficiency, developing alternative energy options, and implementing policies that promote collaborative solutions among companies to improve the sustainability of logistics systems in response to recurrent fuel shortages.

Keywords: Fuel Scarcity, Logistics and Distribution, Supply Chain Disruption, Organizational Resilience.

Introduction

Logistics and distribution systems are at the heart of the global economy's ability to deliver products from producers to customers. It includes a vast array of tasks that support the efficient functioning of supply chains including transportation, warehouse storage, managing inventories, and final mile delivery. All of these elements are necessary for companies to provide good quality services to their customers and operate efficiently.

At the foundation of logistics and distribution systems are fuels primarily diesel and gasoline which form the backbone of logistics and distribution infrastructure. Availability, pricing, and stability of fuel supplies directly impacts a company's operational efficiency, costs, and ultimately service quality within a supply chain. Over the past several decades, however, logistics systems have been disrupted by growing occurrences of fuel shortages. This has exposed weaknesses in supply chain networks (Christopher, 2011; Chopra & Meindl, 2016).

A fuel shortage occurs when there is greater demand for fuel than supply available; this leads to shortages, rationing, or volatile pricing. Shortages occur for a variety of reasons such as conflict, global market disturbances in oil production, limitations in refining capacity, bottlenecks in the transportation system, or economic downturns. Global energy crises, environmental concerns, and changes in government policy have resulted in an escalation of the number and severity of disruptions associated with fuel supplies. Disruptions to fuel supplies create multiple ramifications for logistics and distribution companies that rely upon unbroken fuel supplies. For example, even temporary disruptions to fuel supplies result in cascading effects throughout the supply chain including increases in transportation costs, time sensitive deliveries delayed, inefficient routing plans implemented, and unreliable service (Ballou, 2004; Coyle et al., 2016). Developed countries are disproportionately impacted by the negative consequences of fuel shortages because logistics infrastructures are generally more fragile and more reliant on foreign-produced fuels. Therefore, fluctuations in fuel availability negatively affect both supply chain performance and general economic conditions including inflation rates, national competitiveness levels, and market volatility. Logistics providers operating under such conditions face extreme pressures related to operational efficiencies as well as strategic decision-making. They are required to balance increased operating costs with the requirement to continue delivering high-quality service to their customers. Furthermore, a large percentage of developing countries' logistics systems are based upon trucking/road-transportation. Thus, logistics companies are extremely vulnerable to disruptions associated with fuel supplies (Gleick & Palaniappan, 2010).

One of the primary results of fuel shortages is their impact on operational costs. A considerable proportion of logistics expenses are comprised of fuel expenditures; therefore, any interruption in fuel supply or increase in fuel prices will immediately increase total operational expenditures. During times of fuel shortages, companies often experience a rapid escalation in transportation costs since they are compelled to utilize either alternative forms of transportation that typically cost more money per unit than traditional transportation methods or longer routes. Fuel shortages can also generate increased labor costs due to delays requiring employees to work extended hours; inefficiencies in fleet management; and other factors.

Increased labor and transportation costs can severely reduce profitability margins especially for smaller-sized logistics companies lacking sufficient capital reserves to absorb potential losses (Chopra & Meindl, 2016).

In addition to increased operational costs generated by fuel shortages service level performance is also negatively impacted. On-time delivery is one of the most critical drivers of customer satisfaction among logistics companies. Consequently, the occurrence of delivery delays combined with decreases in service reliability can severely compromise the value proposition provided by a firm. Finally, inventory management is negatively impacted as delays in transportation can create bottlenecks in product flow thus creating either stockouts or excessive inventory levels. While each firm individually faces challenges created by fuel shortages together, they can create broader issues affecting supply chain coordination and efficiency. With increasingly complex interdependent supply chains the ability of organizations to maintain reliable service levels during times of crisis has become a major differentiator in terms of competitive advantages (Christopher, 2011).

Organizational resilience is another critical element of fuel shortages. Organizational resilience represents a company's ability to anticipate respond to and recover from disruptions while maintaining the continuation of business operations. Within the context of fuel shortages resilience refers to the types of strategies and procedures employed by logistics companies to mitigate the negative effects of fuel shortages. Examples of strategies that could be employed include optimizing routes; consolidating loads; employing rationing techniques for use of fuels; utilizing alternative fuels; and investing in equipment designed to improve fuel efficiency. Organizations possessing a higher degree of resilience will be able to manage uncertainty while continuing to sustain business operation during periods of disruption in the availability of fuel (Hollnagel et al., 2006).

Fuel scarcity has emerged as a key challenge to logistics and distribution systems, with potential long-term consequences for the stability of supply chains and economies worldwide. It is likely that fuel scarcity will continue to be an issue moving forward due to factors such as rising demand for fuel, limited supply capacity and continued geopolitical instability. Organizations operating within this environment must therefore develop strategies to manage fuel scarcity and mitigate the adverse impacts associated with it.
Two theoretical perspectives Resource Dependency Theory and Supply Chain Disruption Theory are useful for analyzing how organizations respond to disruptions in the fuel market. The Resource Dependency Theory emphasizes that all organizations rely on various critical external resources including fuel. Consequently, the theory suggests that when the organization faces uncertainty in accessing one or more of those critical resources (in this case fuel) the organization must implement strategies designed to manage that uncertainty. In contrast, Supply Chain Disruption Theory examines the disruption of expected flow of goods from suppliers to customers through the use of a supply chain. Specifically, this theory addresses issues related to managing risks and implementing contingency plans in order to minimize negative impacts caused by unexpected events that disrupt the normal operation of the supply chain. Taken together, these theories provide insight into why organizations are structurally vulnerable and what adaptive mechanisms they may employ during times of fuel-based disruptions (Christopher, 2011; Pfeffer & Salancik, 1978).

Although fuel scarcity has been recognized as an emerging critical concern over recent years, there is still a substantial amount of work needed to understand the micro level impacts of fuel scarcity on logistics and distribution systems. Most previous studies have addressed the macroeconomic elements of fuel scarcity including price volatility and global energy trends while very little attention has been given to how logistics and distribution processes are impacted at the micro level. Although some prior research has provided examples of general practices and behaviors of companies affected by fuel scarcity, none of them have systematically analyzed the micro level operational impacts on logistics and distribution systems nor have they evaluated the different types of adaptive strategies employed by companies to counteract these negative impacts. Therefore, it is clear that further research needs to be conducted which provides a detailed examination of fuel scarcity's implications for logistics performance and overall supply chain resilience.

Given the current state-of-the-art in this area, the purpose of the current study is to close this knowledge gap. The goal of the present study is to examine the operational impacts of fuel scarcity on logistics and distribution processes. More specifically, this study will focus on identifying the frequency and characteristics of fuel shortages, evaluating the extent to which they negatively impact operational efficiencies, costs and customer services and assessing the types of adaptive responses used by companies in response to these negative impacts. By combining empirical evidence with theoretical frameworks, this research will contribute substantially to our understanding of the interrelationship between fuel scarcity and logistics processes.

Additionally, this research will highlight the significance of public policies and institutional support in enhancing the resilience of logistics processes. Government agencies and decision-makers have several roles in regard to fuel scarcity including assuring adequate supplies of fuels, establishing regulatory mechanisms to control fuel prices and encouraging investment in renewable energy alternatives. Additionally, investments in infrastructure, technologies and strategically located reserve storage facilities can also improve a company's ability to survive through periods where their access to fuel is disrupted. To achieve the necessary levels of cooperation among government agencies, industries and academia to create sustainable solutions to problems associated with fuel scarcity requires collective action (Coyle et al., 2016).

In summary, fuel scarcity has created serious concerns about the future viability of logistics and distribution systems and will most likely have profound impacts upon supply chain performance and economic stability. As globalization increases, it is reasonable to expect that logistics companies will experience greater pressure to accommodate the inevitable disruptions that occur from time-to-time in fuel supplies. Thus, this study makes meaningful contributions to the field of knowledge by providing a thorough examination of fuel scarcity and its effects upon logistics processes, suggesting ways for logistics companies to enhance their resiliency/sustainability in supply chains. Ultimately, this study demonstrates that both operational/strategic approaches are required to effectively prepare companies for an unpredictable energy landscape.

Literature Review

The study of supply chains shows that transportation is among the most costly and most dependent upon fuel in all of logistics. Ballou (2004) says that transportation makes up a significant portion of total logistics costs. So, it is important that there be adequate amounts of fuel available and stable fuel prices to maintain efficient operation. Christopher (2011) states that because modern supply chains rely so heavily on rapid and cost-effective movement of goods, they are very susceptible to any disruptions in the availability of key resources, such as fuel.

Studies show that fuel shortages can occur due to many different causes, but perhaps the most common cause of a shortage of fuel is when there is an imbalance between the amount of fuel being demanded and the amount of fuel available. Some of the reasons for these imbalances include conflict; disruption to supply chains; and changes in the world-wide market for crude oil. When these imbalances occur, it usually results in increased fuel prices, rationing and/or reduced access to fuel, and this can have negative impacts on both the strategic and day-to-day functioning of logistics companies. Because the number of times that this occurs is increasing, researchers and practitioners in the field of supply chain management view fuel scarcity as a major area of interest.

There is a large body of research that has studied how price variability affects the way that supply chains operate. There is less research into the issue of how fuel scarcity affects logistics. The existing literature provides some insight into what happens when there is a lack of fuel. It appears that when there is not enough fuel to meet the demands of logistics companies, there will be considerable increases in the operating costs of those companies. This will likely come about because of greater costs associated with transporting goods; longer distances traveled to transport goods; and greater use of non-traditional means of delivering goods. Coyle et al. (2016) also indicate that, during periods of fuel crisis, there may be increases in the cost of doing business for logistics providers, possibly resulting in lower profit margins for smaller companies; strain on cash flow; etc. These findings are consistent with data indicating that fuel scarcity can result in a 25-40 percent increase in logistics costs. As can be seen from this example, this would represent a considerable economic burden on businesses affected by fuel scarcity.

In addition to having a great potential for creating additional costs for logistics companies, fuel scarcity also has a potential to affect their ability to provide timely and reliable service to customers. In logistics, timeliness and dependability of deliveries are two key indicators of the quality of services provided to customers. If logistics companies experience delays in their delivery schedules due to lack of fuel, they risk losing the confidence of their customers. Christopher (2011) states that if logistics companies suffer disruptions related to fuel -- whether due to unavailability or high prices -- then it could create a domino effect throughout the entire supply chain and amplify inefficiencies and decrease overall performance. Furthermore, delays in shipping may also disrupt inventory management practices and ultimately result in either inventory overstocking or understocking. Both inventory overstocking and understocking can significantly impair the productivity and customer satisfaction within organizations.

While the extent to which logistics systems are vulnerable to fuel scarcity is best illustrated through examples of developing countries due to the limited nature of the country's transportation infrastructure and importation of most fuels; fuel shortages have the potential to create broader socio-economic consequences like inflation and decreased competition in markets.

Additionally, logistical companies will be challenged when attempting to sustain operational continuity during times of fuel scarcity. They typically do not have access to alternative forms of energy nor the technologies necessary to help navigate an environment with limited fuel availability.

Resilience within logistics companies has become a well-studied area of study. A resilient company possesses the capacity to both prepare for and respond to disruptions. Moreover, resilient companies also possess the capacity to recover from disruptions and remain stable. Hollnagel et al. (2006) stated that companies possessing organizational resilience are better suited to handle uncertainty and adapt to changes. Within the context of fuel scarcity, a company's organizational resilience would manifest itself through various strategies (i.e., route optimization, load consolidation, diversification of fuel sources). These strategies allow companies to limit the negative ramifications resulting from fuel shortages while still providing customer services although typically at a higher cost.

Resource Dependency Theory (RDT) offers a framework of study that helps explain some of the challenges presented by fuel scarcity. Pfeffer and Salancik (1978) describe that an organization depends on external resources for it to survive. Organizations must develop strategies to manage this dependency. An example of a strategy used by organizations to manage dependency is diversifying fuel supplies. Other alternatives include utilizing different types of fuel, enhancing fleet fuel efficiency and purchasing alternative modes of fuel.

Supply Chain Disruption Theory also provides insight regarding the importance of risk management and contingency planning in reducing the severity of disruption caused by fuel scarcity. According to Christopher (2011), organizations should develop proactively based strategies designed to identify potential risks and design strategies to reduce the potential damage caused by those risks. Utilizing technology (such as fleet management software, route optimization software) is one method utilized by organizations to increase operational efficiency and decrease overall fuel consumption thereby limiting the negative effects caused by fuel scarcity.

There exists a significant amount of literature available concerning the topic of supply chain disruptions. However, much of what currently exists focuses on macro-level economic aspects (such as fluctuation of fuel prices, global energy trends) versus focusing on the everyday operational issues that exist at the micro-level for logistics companies. There exists a large gap in the amount of research that examines the everyday challenges experienced by logistics companies related to fuel scarcity. Therefore, there is a strong need for empirical research that thoroughly explores how logistics operations are affected by fuel scarcity and the methods that are employed by logistics companies in order to counteract these issues.

Some recent studies have begun addressing this issue. Specifically, several researchers have investigated how adapting certain strategies along with implementing new technologies assist logistics companies in dealing with fuel scarcity. For example, employing route optimization and fleet management software have both demonstrated an improvement in fuel efficiency and lower operational costs for many organizations. Nevertheless, many of these solutions are very expensive and therefore difficult for Small-Medium Enterprise (SMEs) to purchase. Consequently, there is a great deal of pressure placed upon policymakers and institutions to make sure that all logistics companies can adequately react to fuel-related interruptions.

In conclusion, the current literature demonstrates the significance of fuel in logistics operations and its detrimental effect on supply chain performance when experiencing fuel scarcity. Although there is a substantial amount of research about volatile prices of fuel and supply chain disruptions, there is a need for more specific studies about fuel scarcity and its operational impacts. Future research that incorporates theoretical frameworks with empirical data can provide useful information regarding how logistics companies can develop sustainable and resilient logistics systems capable of overcoming difficulties created by fuel-related challenges.

Objectives of the Study

1. To examine the nature, frequency, and underlying causes of fuel scarcity affecting logistics and distribution operations.
2. To analyze the impact of fuel shortages on key operational aspects, including transportation efficiency, route planning, and fleet utilization.
3. To evaluate the effect of fuel scarcity on the cost structure of logistics firms, particularly in terms of fuel expenses, overall operational costs, and profitability.
4. To assess the influence of fuel shortages on service delivery performance, including delays, reliability, and customer satisfaction levels.
5. To identify the challenges faced by logistics firms, especially small and medium-sized enterprises (SMEs), during periods of fuel scarcity.
6. To explore the adaptive strategies and coping mechanisms adopted by organizations to mitigate the adverse effects of fuel shortages.
7. To examine the role of organizational resilience in enabling firms to respond effectively to fuel-related disruptions.
8. To analyze the effectiveness of technological interventions, such as route optimization and fleet management systems, in managing fuel scarcity challenges.
9. To evaluate the role of government policies and institutional support in addressing fuel scarcity and stabilizing logistics operations.
10. To provide recommendations for improving the resilience, efficiency, and sustainability of logistics and distribution systems in the face of recurring fuel shortages.

Research Method

A structured and systemic methodological process was adopted in this study to support the research objectives and current trends in logistics and supply chain management. A combination of both qualitative and quantitative methodologies were used to ensure that the research is both valid and reliable. By using these two methodologies together, an in-depth review of fuel shortages and their effects on logistics can be conducted.

The methodology followed a descriptive and analytical research design. In the descriptive part of the research, information regarding the characteristics, causes, and occurrences of fuel shortages will be gathered. This part of the research will help identify the mechanisms through which logistics are impacted when fuel shortages occur. Additionally, it will document patterns such as frequency of shortages, disruption to logistics operations, and industry response to fuel shortages. Conversely, the analytical portion of the research will examine the relationships between several important variables such as fuel availability, logistical effectiveness, and costs. These two parts of the research design will enable the researcher to not only describe the occurrence of fuel shortages but also explain the relationship between those variables.

In order to obtain a complete picture of fuel shortages in the context of logistics operations, a mixed-methodology approach has been used. Both qualitative and quantitative methodologies have been combined in order to examine fuel shortages from multiple perspectives. The use of quantitative methodologies allows researchers to conduct statistical analyses on measurable variables such as increased costs due to transportation delay or inefficiencies in logistics operations. The use of qualitative methodologies, such as interviews and thematic analysis, provides greater insight into decision-making processes employed by managers in addressing challenges associated with fuel shortages and developing new ways of adapting to them. The integration of numerical data and contextual knowledge via the mixed-methodologies approach improves the validity and richness of results (Grant et al., 2023; Siregar, 2025). The study utilized both primary and secondary data to create an extensive and overall analysis of the research problem. Primary and secondary data have been incorporated into this study to enhance the reliability and validity of the results through the use of data triangulation, and cross verification. Primary data has been gathered from individuals working in logistics and supply chain operations. Professionals that have responded to surveys include operations managers, fleet supervisors, and supply chain executives, who have direct and practical knowledge related to managing their organizations' fuel usage and supply chain efficiencies. The insight provided by these professionals will aid researchers in identifying the actual issues faced by companies regarding fuel availability. There are two types of methodologies used when collecting primary data for this study. Structured survey questionnaires were used to collect quantitative data, which included close-ended (i.e., yes/no) and Likert scale questions designed to measure variables including; frequency of fuel shortages, operating costs, delivery times, and productivity levels. Semi-structured interviews were conducted to collect qualitative data and allowed respondents to describe their company's specific experiences and decision making processes they employ when dealing with fuel shortages. In addition to using primary data, the researcher relied upon secondary data to add additional information and support to the research methodology. Secondary data was collected from various published sources, including peer-reviewed articles, industry reports, government documents/policy papers, etc. The secondary data provides theoretical frameworks, empirical studies/evidence, contextually relevant background information/insight on topics including fuel shortages, logistics operations/supply chain disruptions. The combination of primary and secondary data creates an enhanced level of understanding about the subject matter being studied and further supports that the study is both empirically based and theoretically supported.

The process of establishing reliability and validity is important for maintaining quality, precision and credibility of this research's findings. Reliability was established by utilizing a standardized questionnaire and using consistent methodologies to collect the data. The questionnaire has been developed with a careful attention to detail with respect to structure and clarity of each question so as to ensure consistency in interpretation and response among all participants. Data collection processes were also maintained consistently throughout the study, reducing the potential for error and increasing the reproducibility of the research results. Triangulation was used to establish validity.

In addition to the two types of data (primary/secondary), and two types of methodology (quantitative/qualitative) utilized in the study, triangulation provides an additional means of cross-verification of the data collected. By verifying the insights gained from three different sources (surveys/interviews/existing literature), it enhances the internal and external validity of the study. Pilot

testing of the questionnaire prior to conducting the actual data collection will assist in identifying any ambiguity, inconsistency or error within the questionnaire design. Based upon pilot testing results, necessary modifications can be made to ensure that the final instrument is clear, dependable, and effective in collecting relevant data. In summary, these actions increase the dependability/trustworthiness of this research.

Result and Conclusion

I. Respondent Profile

The survey included participants (Table 1) in all three of the most common job categories: 35.2% operations managers; 30.0% fleet supervisors; and 34.8% supply chain professionals. A good balance across these two levels of strategy/operations allows for input at multiple levels of analysis. In addition to providing information related to operational decisions and how they are made by operations managers, fleet supervisors provided insight into day-to-day activities in the field with regard to transportation, fuel usage etc. While supply chain professionals provided an even broader perspective on coordinating logistics functions and evaluating performance. Overall, the diversity of positions represented provides increased confidence in the reliability of the results because of its overall representation of all aspects of a logistics operation.

Table 1: Respondent Profile (Designation)

Designation	**Frequency**	**Percentage (%)**	**Valid %**	**Cumulative %**
Operations Managers	88	35.2	35.2	35.2
Fleet Supervisors	75	30.0	30.0	65.2
Supply Chain Executives	87	34.8	34.8	100.0
Total	**250**	**100.0**	**100.0**	

II. Organization Size

The results (Table 2) demonstrate that 42.0 percent of participants operate as small business owners; 34.0 percent are from medium business operations; and 24.0 percent were from large businesses. These data indicate there was an overwhelming amount of small and medium size businesses (SMB) represented in this research. Many SMBs are at higher risk for the impacts of fuel shortages due to less flexible finances and operationally. Since larger businesses were present in the study but represent smaller proportions of firms studied, the findings can be interpreted as reflective of the unique challenges associated with SMBs.

Table 2: Organization Size

Organization Size	Frequency	Percentage (%)	Valid %	Cumulative %
Small Scale	105	42.0	42.0	42.0
Medium Scale	85	34.0	34.0	76.0
Large Scale	60	24.0	24.0	100.0
Total	250	100.0	100.0	

III. Sector of Operation

The Sectoral Distribution indicates (Table 3) that 50.0% of Respondents utilize Road Transportation as their primary means of moving goods; 25.2% of Respondents utilize Warehousing for storage needs; 14.8% of Respondents utilize Last-Mile Delivery for final mile service to customers; and 10.0% of Respondents utilized Cold Chain Logistics for products requiring temperature-controlled service. The

strong presence of Road Transportation is directly related to the high usage of fuel within the sector. Both Warehouse and Last-Mile Delivery have a substantial presence in the data which illustrates how all aspects of logistics services are connected. Although there were fewer than one out of ten logistics providers utilizing Cold Chain Service, they have a very high sensitivity to disruption caused by lack of timeliness and/or proper temperature control.

Table 3: Sector of Operation

Sector	Frequency	Percentage (%)	Valid %	Cumulative %
Road Transportation	125	50.0	50.0	50.0
Warehousing	63	25.2	25.2	75.2
Last-Mile Delivery	37	14.8	14.8	90.0
Cold Chain Logistics	25	10.0	10.0	100.0
Total	**250**	**100.0**	**100.0**	

IV. Frequency of Fuel Scarcity

The largest percentage of the survey (Table 4) participants, 56%, stated they had fuel shortages at least three to four times during each year. Twenty-four percent of those surveyed said they had the same experience one through two times yearly. Additionally, twenty percent indicated their company experienced it greater than four times. The data illustrates fuel shortages are not a rare occurrence; rather, they represent an ongoing problem that needs pro-active solutions or contingency plans from logistics companies to help mitigate the impact of these events.

Table 4: **Frequency of Fuel Scarcity**

Frequency (per year)	Frequency	Percentage (%)	Valid %	Cumulative %
1–2 times	60	24.0	24.0	24.0
3–4 times	140	56.0	56.0	80.0
More than 4 times	50	20.0	20.0	100.0
Total	**250**	**100.0**	**100.0**	

V. Type of Fuel Scarcity Issue

Fuel unavailability was the most frequently reported issue at 40% of all responses; a second common problem (32%) was the rationing of fuel for vehicles; a third frequent problem (18%) were shortfalls in fuel availability due to high prices; and lastly, a fourth common problem (10%) was poor fuel quality. These results indicate that it is primarily supply chain issues which present major problems with fuel delivery, as opposed to solely the fluctuating cost of fuel. Furthermore, those same supply issues create an added layer of complexity when combined with the issues associated with pricing. Firms have been forced to make operational changes such as route adjustments, schedule modifications, or to alter their overall costs of operation.

Table 5: Types of Fuel Scarcity

Type of Issue	Frequency	Percentage (%)	Valid %	Cumulative %
Fuel Unavailability	100	40.0	40.0	40.0
Fuel Rationing	80	32.0	32.0	72.0
Price-driven Shortage	45	18.0	18.0	90.0
Fuel Quality Issues	25	10.0	10.0	100.0
Total	**250**	**100.0**	**100.0**	

Discussion

Fuel scarcity is a persistent problem which affects logistics/distribution systems. Many of the respondents experienced fuel shortages many times per year; therefore, fuel shortages are frequent operational interruptions. A large number of the current studies show that companies have become increasingly susceptible to resource uncertainty/energy related risks to their supply chains (Ivanov & Dolgui, 2023) because of the volatile nature of resources. In addition, the frequency at which the respondents indicated that they had to deal with fuel shortages emphasized the need for logistics firms to be proactively developing methods of dealing with these types of occurrences instead of being reactive.

As noted by the respondent profiles, logistics operations were almost entirely done through road transportation; thus, road transportation was the most vulnerable sector to fuel shortages. Any interruption to the fuel supply directly effects the delivery time/schedules, route efficiency and ultimately the customer's service performance. The results are consistent with other studies that indicate that transportation is currently the most fuel intensive part of the supply chain and that it is very sensitive to energy related disruptions (Khan et al., 2024). Although both warehousing and last mile deliveries were less directly impacted by fuel shortages than transportation, both were indirectly affected because of delays in transportation activities in the upstream portion of the supply chain. These results demonstrate how closely connected all aspects of logistics systems are.

An important aspect of the data collected was the varying degrees of impact that fuel shortages had on different sized organizations. There were more SMEs represented within the data collection process than there were larger organizations. As a result, SMEs were much more vulnerable to fuel shortages due to their smaller financial resources, lack of strategic reserve stockpiles and reduced access to technology compared to larger organizations. Thus, this lends credence to the idea that organization size is a significant factor in whether or not an organization is resilient enough to withstand disruptions to its supply chain (Dubey et al., 2023). Larger organizations typically have more resources available to them when trying to mitigate cost increases and implementing ways to mitigate disruptions caused by fuel shortages, whereas smaller organizations typically do not have the same level of resources and are unable to continue operating when faced with disruptions caused by fuel shortages.

There were two primary problems associated with fuel shortages identified in this study. They included unavailability of fuel and rationing. These problems are indicative of supply side problems related to fuel distribution and suggest that supply side issues are more problematic than issues related to pricing. The unavailability of fuel and rationing of fuel clearly illustrate systemic failures within fuel distribution networks and emphasize the necessity of government and regulatory intervention into these networks.

Public-private partnerships play an integral role in promoting supply chain resilience and providing assurance regarding resource availability (Pettit et al., 2024).

Strategically, the findings of this study point out the need for logistics organizations to adopt flexible response mechanisms, such as optimizing routes, consolidating loads, and utilizing alternate sources of fuel. However, while these responses may provide temporary relief from the effects of fuel shortages, they do nothing to alleviate the fundamental cause of dependence on fossil fuels. Long term solutions will require investments in either alternative energy supplies or in fuel efficient technologies (e.g. electric vehicles). Finally, logistics organizations must integrate digital technologies (such as GPS based vehicle tracking systems, etc.) into their systems to optimize their ability to make decisions quickly and operate efficiently during disruptions caused by fuel shortages (Wamba et al., 2023).

Overall, this study demonstrated that fuel shortages create a multitude of challenges for logistics organizations related to costs, service delivery, and stability. The fact that fuel shortages occur frequently and affect SMEs disproportionately, creates a compelling case for logistics organizations to build more resilient and sustainable logistical systems. To achieve this goal, both organizational strategies and governmental policies must work together. Future studies must examine the use of alternative energy supplies and digital technologies to increase logistics organizations' reliance on non-conventional fuels.

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