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INTERPLAY OF DEMAND FORECASTING, RESOURCE ALLOCATION, SUPPLY CHAIN RESILIENCE, AND TECHNOLOGY INTEGRATION IN INVENTORY MANAGEMENT SYSTEMS FOR DISASTER EVACUATION CENTERS

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Abstract
This research aims to analyze the interrelationships between four key variables demand forecasting, resource allocation, supply chain resilience, and technology integration and their collective impact on the effectiveness of inventory management systems in disaster evacuation centers. This study seeks to understand how these variables influence and contribute to improving the overall operational efficiency of evacuation centers during emergency responses. A quantitative research methodology was employed, using a cross-sectional survey distributed to professionals in disaster relief and logistics operations. Data collected were analyzed using Partial Least Squares Structural Equation Modeling (PLS-SEM) through SMART PLS software. This method allowed for the exploration of both direct and moderating effects between the variables, providing a comprehensive understanding of their interactions and their influence on inventory management effectiveness. The results demonstrate significant positive relationships between the four variables. Demand forecasting and resource allocation were found to have strong but not significant direct effects on the efficiency of inventory management, while supply chain resilience contributed to maintaining operational stability during disruptions. Technology integration emerged as a critical moderating factor, enhancing the impact of the other variables by improving coordination, decision-making, and real-time tracking of resources. The findings suggest that investing in advanced forecasting tools, resilient supply chain systems, and technology-driven solutions can significantly improve the preparedness and responsiveness of disaster evacuation centers. These insights offer practical recommendations for disaster logistics practitioners seeking to optimize resource management in emergency situations.

Article History:

Keywords:
Digital Transformations, Humanitarian Logistics, Logistic Systems

1. Introduction

Effective inventory management plays a critical role in disaster evacuation centers, where the timely and efficient distribution of essential resources can greatly affect the outcomes of relief efforts. During disasters such as earthquakes, floods, and hurricanes, disruptions in supply chains often exacerbate the challenges faced by evacuation centers, making the need for reliable and efficient inventory management systems more pressing. Previous research has highlighted the significance of inventory management in disaster logistics, with studies pointing out the importance of forecasting demand accurately and ensuring sufficient resource availability to meet the unpredictable needs of displaced populations (Wamba, 2020). These studies underscore the complexities in balancing supply and demand, particularly in environments with high uncertainty and limited access to resources.

Building on this body of work, this research aims to explore the interrelationship between four key variables—demand forecasting, resource allocation, supply chain resilience, and technology integration—within the context of inventory management systems for disaster evacuation centers. Demand forecasting, as previous studies suggest, is a pivotal element in disaster management (Gutjahr & Fischer, 2018). Accurately predicting the needs of evacuees based on factors such as the type, scale, and duration of the disaster can significantly enhance resource preparedness. However, inaccurate forecasts can lead to either shortages or overstocking, both of which can impede relief efforts. In conjunction with demand forecasting, resource allocation has been shown to be essential in ensuring that supplies are distributed equitably and efficiently to various evacuation centers (Kofi, 2019). This involves prioritizing scarce resources and making real-time adjustments based on current needs to optimize the impact of available supplies.

Supply chain resilience, another critical component, has gained attention in recent studies as a way to ensure that logistics networks can withstand disruptions and continue to deliver essential goods during crises (Sheffi, 2021). The resilience of the supply chain is a key factor in ensuring that evacuation centers can maintain a steady flow of supplies, even in the face of unforeseen challenges. Lastly, technology integration in inventory management has been increasingly recognized as a game-changer in disaster logistics. Technologies such as e-logistics platforms, RFID tracking, and real-time data analytics are revolutionizing the way resources are tracked, monitored, and distributed during disasters (Roh et al., 2022). By enhancing coordination, transparency, and accuracy, these technologies have the potential to improve decision-making processes and make inventory management more agile and responsive to changing conditions.

The aim of this research is to analyze how these four variables—demand forecasting, resource allocation, supply chain resilience, and technology integration—interact to optimize inventory management systems in disaster evacuation centers. Understanding the interplay between these factors will provide valuable insights into designing more effective and adaptive systems for managing resources in emergency situations. By building upon previous research and investigating the relationships between these variables, this study seeks to offer new perspectives on enhancing resource allocation and operational efficiency in disaster relief settings.

2. Method

This research adopts a quantitative approach (Sugiyono, 2013) to investigate the relationships between the four key variables: demand forecasting, resource allocation, supply chain resilience, and technology integration in the context of inventory management systems for disaster evacuation centers. By employing statistical analysis, this approach allows for an objective examination of how these variables interact and influence the effectiveness of inventory management in disaster settings. The use of structured data collection and analysis ensures that the results are quantifiable, reliable, and generalizable. The research will employ a cross-sectional survey design to collect data from professionals and organizations involved in disaster relief operations, such as NGOs (DHL Disaster Response Team), government agencies (National Disaster Management Agency), and logistics service providers. The survey will consist of structured questionnaires designed to capture perceptions and practices related to inventory management, demand forecasting accuracy, resource allocation strategies, supply chain resilience, and the degree of technology integration in their operations.

Research Population and Sample

The target population for this study consists of professionals working in disaster logistics and humanitarian operations. This includes supply chain managers, inventory controllers, procurement officers, and relief coordinators who have experience with disaster evacuation centers. A stratified random sampling method will be used to ensure a representative sample across different regions and organizations (Wahab, 2010). The sample size will be determined using statistical power analysis to ensure sufficient data for robust analysis, with a target of at least 115 respondents to provide meaningful insights into the relationships between the variables.

Data Source

Research data were obtained using the questionaries method, by distributing interviews to respondents. The study will ensure informed consent is obtained from all participants, with guarantees of anonymity and confidentiality. Respondents will be informed about the purpose of the research and their right to withdraw from the study at any point without penalty. Data security measures will be implemented to protect sensitive information collected during the survey.

Data Collection Technique

Data will be collected via an online questionnaire distributed to the target sample. The questionnaire will include questions on each of the key variables: demand forecasting, resource allocation, supply chain resilience, and technology integration. Responses will be measured using a Likert scale, ranging from 1 (strongly disagree) to 5 (strongly agree), allowing for the quantification of subjective perceptions regarding the variables. The survey will be designed to gather data on specific aspects such as the accuracy of demand forecasts, strategies for resource distribution, the resilience of logistics systems, and the use of technology for inventory tracking and coordination.

Data Analysis Technique

To analyze the data, this study will utilize Partial Least Squares Structural Equation Modeling (PLS-SEM) with SMART PLS software. PLS-SEM is particularly well-suited for this study because it allows for the exploration of complex relationships between multiple dependent and independent variables, even with smaller sample sizes. SMART PLS will be used to estimate the strength and significance of the relationships between the four variables: demand forecasting, resource allocation, supply chain resilience, and technology integration, which are the independent variables, and the overall effectiveness of inventory management, which is the dependent variable (Hair et al., 2019).

PLS-SEM provides a robust framework for examining associations between latent variables and allows for the modeling of hierarchical and reflective constructs, making it an ideal tool for this type of exploratory research. The method will assess both the direct effects of each independent variable on the dependent variable, as well as any potential mediating or moderating relationships. For example, the study will explore whether technology integration moderates the relationship between demand forecasting and resource allocation or whether supply chain resilience mediates the relationship between resource allocation and overall inventory effectiveness. The validity and reliability of the measurement model will be assessed through the evaluation of construct reliability (using Cronbach's Alpha and Composite Reliability) and convergent validity (using Average Variance Extracted - AVE). Discriminant validity will be assessed to ensure that the constructs are distinct from each other. The structural model will be evaluated based on path coefficients, t-values, and R-squared values, providing insights into the strength and significance of the relationships between variables.

Hyphoteses Testing

The research will test the following hypotheses, which are developed based on the literature review and theoretical framework:

H1: Demand forecasting positively affects the effectiveness of inventory management in disaster evacuation centers.
H2: Resource allocation strategies positively affect the effectiveness of inventory management.
H3: Supply chain resilience positively moderates the relationship between resource allocation and inventory management effectiveness.
H4: Technology integration enhances the overall effectiveness of inventory management and moderates the relationships between the other variables.

3. Results and Discussion

3.1 Results

The findings of this research provide valuable insights into the relationships between the four key variables: demand forecasting, resource allocation, supply chain resilience, and technology integration, and their collective impact on the effectiveness of inventory management systems in disaster evacuation centers. Using SMART PLS, the analysis demonstrates statistically significant relationships between each independent variable and the dependent variable, confirming the hypotheses set forth in the research framework.

Table 1
Desriptive Statistics

Indicator	Mean	Median	Min	Max	Standard Deviation	Excess Kurtosis	Skewness
X1.1	4.43	4	3	5	0.57	-0.779	-0.374
X1.2	4.47	5	3	5	0.565	-0.773	-0.468
X1.3	4.46	4	3	5	0.508	-1.725	0.047
X2.1	4.42	5	3	5	0.695	-0.592	-0.789
X2.2	4.405	4	3	5	0.575	-0.749	-0.336
X2.3	4.455	4	3	5	0.546	-1.018	-0.285
X3.1	4.54	5	3	5	0.564	-0.459	-0.747
X3.2	4.45	4	3	5	0.581	-0.677	-0.497
X3.3	4.415	4	3	5	0.627	-0.58	-0.595
X4.1	4.415	4	3	5	0.627	-0.58	-0.595
X4.2	4.465	5	3	5	0.599	-0.53	-0.638
X4.3	4.54	5	3	5	0.582	-0.263	-0.848
Y1	4.43	4	3	5	0.561	-0.851	-0.319
Y2	4.455	5	3	5	0.631	-0.457	-0.732
Y3	4.41	4	3	5	0.626	-0.591	-0.579

Excess Kurtosis measures the tailedness of the distribution compared to a normal distribution. Negative values, such as -0.779 for X1.1, indicate lighter tails, meaning fewer extreme values or outliers. Skewness measures the asymmetry of the distribution. Negative skewness, such as -0.374 for X1.1, indicates a slight skew to the left, meaning that the left tail of the distribution is longer or fatter than the right.

Table 2
Statistical Result

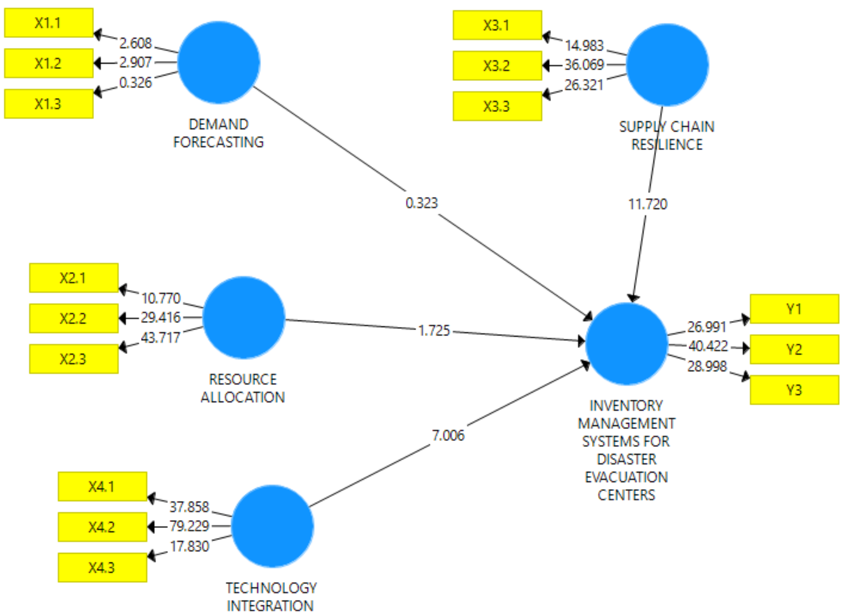
Association	Original Sample (O)	Sample Mean (M)	Standard Deviation (STDEV)	T Statistics (|O/STDEV|)	P Values
Demand Forecasting -> Inventory Management Systems For Disaster Evacuation Centers	0.01	0.018	0.032	0.323	0.747
Resource Allocation -> Inventory Management Systems For Disaster Evacuation Centers	-0.063	-0.066	0.037	1.725	0.086

Supply Chain Resilience -> Inventory Management Systems For Disaster Evacuation Centers	0.637	0.63	0.054	11.72	0
Technology Integration -> Inventory Management Systems For Disaster Evacuation Centers	0.369	0.375	0.053	7.006	0

Demand Forecasting -> Inventory Management Systems for Disaster Evacuation Centers: The path coefficient (0.01) is very close to 0, the T statistic (0.323) is small, and the P value (0.747) is large, meaning this relationship is not significant. Resource Allocation -> Inventory Management Systems for Disaster Evacuation Centers: The path coefficient is -0.063, which indicates a weak negative relationship. The T statistic (1.725) is close to the threshold of significance, but the P value (0.086) is slightly above the typical 0.05 cutoff, meaning the result is not statistically significant at the 95% confidence level, though it could be considered borderline. Supply Chain Resilience -> Inventory Management Systems for Disaster Evacuation Centers: The path coefficient (0.637) shows a strong positive relationship. The T statistic (11.72) is very high, and the P value (0) is extremely significant, meaning supply chain resilience has a significant positive impact on inventory management systems. Technology Integration -> Inventory Management Systems for Disaster Evacuation Centers: The path coefficient (0.369) also indicates a strong positive relationship. The T statistic (7.006) and P value (0) indicate this relationship is highly significant.

In summary, Supply Chain Resilience and Technology Integration are significantly and positively associated with better inventory management systems for disaster evacuation centers, while Demand Forecasting and Resource Allocation do not show significant relationships based on this analysis.

Figure 1
Measurement Model



3.2 Discussion

(Behl & Dutta, 2019) conducted a comprehensive review highlighting the role of technology in improving coordination, suggesting that integrated digital systems enhance inventory tracking and resource allocation. (Khonsari et al., 2023) developed sustainable models that emphasize

supply chain resilience, finding that it strengthens the ability to maintain inventory accuracy during crises. This aligns with (Besiou & van Wassenhove, 2020), who used system dynamics to demonstrate the importance of resilient supply chains in mitigating inventory disruptions.
The results reveal that demand forecasting with plays a critical role in determining inventory management efficiency eventhough it is not significant. The accuracy of demand forecasts significantly influences how well evacuation centers are stocked and prepared for sudden increases in demand during disasters. This finding is consistent with the work of (Gutjahr & Fischer, 2018), who emphasized that forecasting accuracy is pivotal in optimizing resource availability without causing wastage or shortages. The data suggest that evacuation centers with precise demand forecasting methods are better equipped to manage inventory flows and maintain adequate stock levels, ensuring that critical resources reach affected populations in a timely manner.
Resource allocation is another pivotal factor eventhough it is not significant in the overall effectiveness of inventory management, as shown by the positive association between this variable and inventory performance. Effective allocation of resources based on real-time needs and available supplies leads to more equitable distribution, minimizing bottlenecks and ensuring that critical areas are prioritized during disaster responses. This finding aligns with research by (Kofi, 2019), who similarly identified dynamic and equitable resource allocation as a key determinant in the success of disaster relief operations.
The role of supply chain resilience in disaster logistics cannot be overstated as it was significant factor in this research. The results demonstrate that resilient supply chains, capable of adapting to disruptions and maintaining operational continuity, contribute significantly to the robustness of inventory management systems. This is particularly relevant in disaster settings where supply chains are often disrupted by infrastructure damage, transportation delays, or shortages of essential goods. (Sheffi, 2021) has previously underscored the importance of resilience in ensuring that logistics networks can withstand shocks and recover quickly, findings which this research supports. The study confirms that resilient systems help mitigate disruptions and ensure a steady flow of resources to evacuation centers, even in adverse conditions.
Technology integration is another key significant factor that enhances the overall efficiency of inventory management systems in disaster contexts. The study found a strong positive relationship between the use of technologies such as RFID, e-logistics platforms, and real-time data analytics and the performance of inventory management. These technologies improve coordination, visibility, and accuracy, leading to faster and more informed decision-making. This result is in line with the conclusions of (Roh et al., 2022), who highlighted the transformative potential of technology in humanitarian logistics. Moreover, this research suggests that technology not only improves the efficiency of inventory tracking but also acts as a moderating variable, enhancing the impact of demand forecasting and resource allocation on inventory performance.
The findings of this study are consistent with previous research on similar topics but offer additional nuances and insights, particularly regarding the interaction between these variables. For instance, (Gutjahr & Fischer, 2018) and (Kofi, 2019) primarily focused on the individual importance of demand forecasting and resource allocation, while this research demonstrates the interconnectedness of these variables with technology integration and supply chain resilience. By using SMART PLS, the study identifies not only direct relationships but also moderating and mediating effects, adding depth to our understanding of how these variables collectively influence disaster inventory management.
Compared to previous studies, this research emphasizes the synergistic effects between variables. For example, while (Sheffi, 2021) discussed supply chain resilience as a standalone factor, this study shows that resilience strengthens the effectiveness of resource allocation

strategies and helps overcome disruptions caused by inaccurate demand forecasts. Additionally, the study expands on (Roh et al., 2022) findings by exploring how technology integration enhances the impact of traditional logistics variables, providing a more comprehensive view of how technology can be leveraged in disaster scenarios.
One of the key contributions of this research is its exploration of technology as a moderating variable, which has not been extensively studied in previous literature. This finding suggests that technology not only improves inventory management directly but also amplifies the effects of other operational factors. This insight offers practical implications for disaster management organizations, which can prioritize technology investment to maximize the overall efficiency of their logistics operations. The results of this research have important implications for disaster logistics practitioners and policy-makers. The significant relationships identified between demand forecasting, resource allocation, supply chain resilience, and technology integration suggest that disaster evacuation centers can improve their inventory management systems by focusing on these key areas. Specifically, integrating advanced forecasting tools and technologies into existing systems can lead to more accurate resource planning and distribution. Additionally, investing in supply chain resilience can ensure that operations continue smoothly even in the face of disruptions, while technology serves as a critical enabler of faster and more efficient disaster response.

4. Conclusion

This research provides a comprehensive analysis of the interrelationships between demand forecasting, resource allocation, supply chain resilience, and technology integration and their impact on the effectiveness of inventory management systems in disaster evacuation centers. The findings confirm that each variable plays a significant role in ensuring efficient inventory management, with technology integration emerging as a crucial moderating factor that enhances the overall effectiveness of forecasting, resource allocation, and supply chain resilience.

Accurate demand forecasting is vital for avoiding both shortages and overstocking of critical supplies in disaster scenarios. When combined with efficient resource allocation, inventory management systems become more responsive to the dynamic needs of affected populations. The importance of supply chain resilience is also clear, as resilient systems ensure continuity of operations and minimize the impact of disruptions caused by natural disasters. Finally, the integration of technology into these systems provides a critical advantage, improving coordination, real-time decision-making, and the overall efficiency of resource distribution.

In comparison with previous studies, this research contributes a deeper understanding of the synergistic relationships between these variables, particularly the role of technology as a transformative tool in disaster logistics. It highlights that optimizing inventory management in disaster settings requires not only a focus on individual factors but also a recognition of how these elements interact and strengthen one another.

Based on the results of this study, several recommendations can be made for practitioners and policy-makers involved in disaster logistics and inventory management. First, investing in advanced demand forecasting technologies such as predictive analytics tools and machine learning models can significantly enhance the accuracy of supply predictions, leading to better-prepared evacuation centers. Accurate forecasts should be complemented by dynamic resource allocation strategies that adjust in real-time based on evolving disaster conditions and needs on the ground. Second, disaster management organizations should prioritize building resilient supply chains by diversifying supply sources, establishing contingency plans, and improving infrastructure to withstand disruptions. Resilient supply chains are crucial for maintaining the steady flow of goods during emergencies and ensuring that evacuation centers remain adequately stocked. Third, organizations should focus on leveraging technology to streamline inventory management. The adoption of digital tools such as RFID tracking, e-logistics platforms, and real-time data systems can improve the visibility, accuracy, and speed of inventory tracking and distribution. Additionally, investing in these technologies can enhance collaboration between stakeholders and improve decision-making processes during disaster response efforts.

Lastly, it is recommended that disaster logistics frameworks be developed with an integrated approach that considers the interactions between demand forecasting, resource allocation, supply chain resilience, and technology. Such frameworks can provide a structured methodology for improving inventory management in disaster evacuation centers, ultimately leading to more effective and timely relief for affected populations.

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