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Resilient and Sustainable Seafood Supply Chains: Integrating Strategic Supply Chain Management for Environmental and Economic Sustainability

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ABSTRACT

Seafood supply chain networks (SSCNs) are complex socio-ecological systems that are essential to global food security, livelihoods, and trade. With these networks being increasingly threatened by climate change, geopolitical tensions, and market disturbances, it becomes imperative to build their resilience and sustainability. The present research was conducted to examine strategic supply chain management practices that would enhance resilience and sustainability simultaneously in SSCNs by balancing economic viability with environmental sustainability. Using a mixed-method design, information was gathered from 250 stakeholders at different stages of the seafood supply chain using interviews, focus groups, and structured questionnaires, with additional secondary data in the form of industry reports and literature. Descriptive statistics, correlation analysis, and regression modelling were applied to examine the relationship between supply chain strategies and resilience/sustainability outcomes. The research indicated that both economic and environmental sustainability have a positive impact on supply chain resilience, with businesses focusing on contingency planning, coordination, and green sourcing strategies. Regression analysis reaffirmed the statistical significance of the effect of economic and environmental sustainability on resilience ($p < 0.05$), pointing out the value of combined approaches. The research emphasizes that strengthening SSCNs demands strategies that weigh economic performance against environmental responsibility, promoting collaboration, information exchange, and diversity in operations. The present research adds to the gaps in the literature by providing empirical evidence on how strategic supply chain practices can avoid disruptions and secure equitable, adaptive, and sustainable seafood supply chains despite global challenges.

Keywords: Seafood Supply Chain Networks, Resilience, Sustainability, Economic Viability, Environmental Sustainability, Supply Chain Management Strategies

INTRODUCTION

Connecting marine ecosystems to land-based nations, regions, businesses, and marketplaces, SSCNs are complex socio-ecological networks. Instead of focusing on the value-adding processes carried out by a company, supply chains handle the product's distribution to the customer (Lim-Camacho et al. 2021). Producers (i.e., farmers and fishers) source seafood from ecosystems or aquaculture systems (i.e., ponds and tanks) and distribute it to customers (i.e., through a network of middlemen) (Pullman and Wu 2021).

With 34% of global fisheries and aquaculture production going toward export in 2020 (FAO 2022). Seafood is both a vital and extensively traded food source. Many populations rely on it for their

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livelihoods and diet, including Indigenous communities along the coast, small-scale fishermen, and nations with low to medium incomes that are directly involved in international trade (Cisneros-Montemayor et al. 2016). Climate change, geopolitical tensions, and market fluctuations pose a growing challenge to the seafood industry, which is trying to meet the rising demand for seafood and other proteins around the world (Farmery et al., 2022). (FAO 2022). Communities reliant on seafood are especially vulnerable to the domino effect that can occur when these globally linked supply networks are disrupted on a variety of sizes (Bassett et al. 2021). Stronger seafood supply chains are essential for long-term sustainability on a global scale in light of the growing number and intensity of food system disturbances (Gephart et al., 2017).

Research on the resilience of seafood systems has employed network-based methodologies to model SSCN (Plagányi et al. 2014) or has recorded reactions to interrupted seafood supply (Ogier et al. 2021). The COVID-19 pandemic has significantly revealed numerous weaknesses in seafood supply chains, such as market and transportation losses, which are guiding new research on the resilience and sustainability of seafood supply chains. Nevertheless, since SSCNs function within diverse contexts and are interconnected across various sizes, the specific strategies or adaptive possibilities documented may not be transferable. Consequently, a comprehensive and integrative strategy is essential for cultivating resilience.

Manufacturing processes and their effects on the environment have been the primary foci of prior work on sustainable seafood supply (Simmance et al., 2022). The importance of equity, socioeconomic sustainability, wellbeing, and the realization of the Sustainable Development Goals has been brought to light in recent study on the topic of sustainability in seafood systems (Farmery et al. 2022). However, the question of how sustainability may be achieved in the face of disruption while simultaneously meeting current and future goals remains unanswered. Addressing the local and global dimensions of these processes is a huge issue, but it is interconnected with ensuring an equitable and adaptive seafood supply and improving socio-ecological resilience and sustainability (Cockburn et al. 2020). To achieve this goal, we will first analyze the features of a flexible and equitable seafood supply system by defining sustainability and resilience in the context of disruptions to the supply chain.

Consequently, the purpose of this research is to enhance seafood supply chains through the incorporation of strategic supply chain management practices that improve resilience and sustainability. It attempts to reconcile economic viability with environmental sustainability so that seafood supply systems are stable, adaptive, and equitable amidst growing disruptions and global challenges.

Objective of Study: To investigate and incorporate strategic supply chain management strategies that improve the resilience and sustainability of seafood supply networks by reconciling economic viability with environmental sustainability.

REVIEW OF LITERATURE

There are major problems with social, economic, environmental, and food chain sustainability in the New England groundfish fishery, which are discussed in this study by Tolley et al., 2015. Overfishing has persisted throughout the industrialization of fishing in the last century because management have ignored problems connected to scale. By establishing public seafood markets, community-supported fisheries, and the "boat-to-hospital" and "boat-to-school" programs, which are based on procurement contracts that require sustainable and local catches, the FLC has restored local food supply chains.

The purpose of the research by Tseng et al., 2022 is to better understand and enhance the performance of the Vietnamese seafood industry. According to the results, supply chain collaboration and lean management lead to financial benefits.

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Mangano et al., 2022 examined whether or whether integrated multi-trophic aquaculture (IMTA) was present in various agricultural techniques, comparing land-based and sea-based systems, extensive and intensive methodologies, and so on. The overarching goal of this research is to provide a foundation for better understanding and operating the Vietnamese seafood industry. According to the results, there are financial benefits to implementing lean management and collaborative components into the supply chain.

Although Kelling et al., 2023 primarily focuses on the UK, their research on the causes of revolutionary transformation in the seafood supply chains has techniques that can be applied to other affluent nations as well. A thorough and coordinated approach, in addition to proactive cooperation, is required to address the complex, multi-faceted, and long-lasting issues affecting the food system as a whole if we are to build a food system that is more resilient and sustainable.

In their 2023 assessment, Subramaniam et al. documented how seafood supply networks responded to interruptions and used one example to show what makes a supply chain robust. Social (including equality and well-being), economic, and environmental sustainability are all outlined in the paper as potential outcomes of these responses. Diversity (in products, markets, consumers, or processing), connectivity, support from all levels of government, and the ability for participants in the supply chain to learn and collaborate through trust-based interactions were the characteristics that showed resilience in the study of seafood supply networks.

Hypothesis of Study

H_0: Strategic supply chain management practices have no real impact on enhancing the resilience and sustainability of seafood supply chains in terms of balancing economic viability and environmental sustainability.
H_1: Strategic supply chain management practices have an important impact in enhancing the sustainability and resilience of seafood supply chains by achieving a balance between environmental sustainability and economic viability.

RESEARCH METHODOLOGY

This research employed a mixed-method approach, integrating qualitative & quantitative methods to fully evaluate strategic supply chain management strategies that improved resilience and sustainability in seafood supply chains.

There were two types of data: primary and secondary. Key players in the "seafood supply chain, including farmers, processors, wholesalers, exporters, and retailers, were surveyed using semi-structured interviews, focus groups, and questionnaires". Secondary data were obtained from literature, industry reports, trade databases, and published statistics by organizations like the FAO.

A target sample size of 250 respondents was aimed at. The sampling strategy integrated purposive sampling (for qualitative focus groups and interviews to achieve representation by supply chain stages) and stratified random sampling (for quantitative surveys to achieve diversity in firm size, region, and stakeholder type).

Data analysis included qualitative thematic analysis to determine patterns and insights from interviews and focus groups, whereas quantitative data were analyzed through descriptive statistics, correlation analysis, and regression modelling to investigate the relationship between supply chain strategies and resilience/sustainability outcomes. The combination of qualitative and quantitative findings allowed strong and comprehensive conclusions to respond to the research objective.

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RESULTS AND DISCUSSION

Demographic Profile of Respondents

Table 1. Demographic Profile of Respondents

Variable	Sub-Construct	Frequency (n=250)
Age	18-30	75
	31-45	100
	46-60	50
	60+	25
Position	Manager	50
	Executive	75
	Supervisor	80
	Other	45
Experience	1-5 years	100
	6-10 years	80
	11+ years	70
Firm Size	Small	40
	Medium	90
	Large	120

Descriptive Analysis

a) Variable 1: Supply Chain Resilience

Table 2. Responses for Supply Chain Resilience

Statements	Strongly Agree	Agree	Neutral	Disagree	Strongly Disagree
The seafood supply chain is able to recover quickly from disruptions.	35%	45%	15%	5%	0%
Our company has contingency plans for unexpected disruptions.	50%	40%	7%	2%	1%
Information sharing across the supply chain enhances resilience.	30%	50%	15%	3%	2%
Collaboration with stakeholders improves adaptability to changes in the market.	40%	45%	10%	3%	2%

b) Variable 2: Economic Sustainability

Table 3. Responses for Economic Sustainability

Statements	Strongly Agree	Agree	Neutral	Disagree	Strongly Disagree
The seafood supply chain generates consistent revenue.	25%	60%	10%	4%	1%
Our company's supply chain reduces operational costs through efficiency.	20%	55%	15%	8%	2%
Economic profitability is a major focus in our seafood supply chain strategy.	45%	40%	10%	3%	2%
Financial resources are regularly invested in improving supply chain systems.	30%	50%	15%	4%	1%

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c) Variable 3: Environmental Sustainability

Table 4. Responses for Environmental Sustainability

Statements	Strongly Agree	Agree	Neutral	Disagree	Strongly Disagree
Our supply chain practices focus on reducing environmental impacts.	40%	45%	10%	4%	1%
We are adopting sustainable packaging and waste reduction methods.	35%	50%	10%	4%	1%
Our seafood sourcing practices consider the health of marine ecosystems.	50%	40%	8%	2%	0%
The supply chain incorporates renewable energy sources for production.	30%	45%	15%	8%	2%

Correlation Analysis

Table 5. Correlation Matrix

Variable	Supply Chain Resilience	Economic Sustainability	Environmental Sustainability
Supply Chain Resilience	1		
Economic Sustainability	0.55	1	
Environmental Sustainability	0.47	0.61	1

The correlation matrix indicates moderate positive correlations among all the variables. The highest correlation is between environmental sustainability and economic sustainability ($r = 0.61$), which is an indication that companies pursuing economic viability also incorporate more sustainable environmental measures. Resilience in the supply chain also correlates with economic sustainability ($r = 0.55$) and indicates that resilient supply chains enhance financial stability.

Regression Analysis

Table 6. Regression Results

Variable	Unstandardized Coefficient (B)	Standardized Coefficient (Beta)	t-Value	p-value
Constant	2.85	-	5.64	0.000
Economic Sustainability	0.42	0.35	4.12	0.000
Environmental Sustainability	0.38	0.31	3.45	0.001

The regression analysis reveals that economic sustainability and environmental sustainability both have a positive impact on supply chain resilience. Both variables are statistically significant at $p < 0.05$, with economic sustainability exerting a slightly higher impact. This implies that enhancements in sustainability practices can improve the resilience of seafood supply chains.

INTERPRETATION OF RESULTS

The findings of the research were that the respondents agreed very much with the resilience of seafood supply chains, where most companies have developed contingency measures and recovery mechanisms, in addition to a distinct focus on both economic and environmental sustainability in their operations. Correlation analysis identified positive and moderate associations among supply chain resilience, economic sustainability, and environmental sustainability, which imply that strengthening one dimension will tend to benefit the others. Regression analysis also showed that economic and environmental sustainability significantly and positively affect supply chain resilience, although economic sustainability had a marginally greater effect. Overall, the results proved that sustainability-prioritizing strategic supply chain management practices not only enhance the resilience of seafood

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supply chains but also enable firms to deal with disruptions more effectively and ensure long-term sustainability.

Results of Hypothesis Testing

Table 7. Results of Hypothesis Testing

Objective	Hypothesis	Result
To investigate and incorporate strategic supply chain management strategies that improve resilience and sustainability of seafood supply networks.	**H_0:** "Strategic supply chain management practices have no real impact on enhancing the resilience and sustainability of seafood supply chains in terms of balancing economic viability and environmental sustainability".	**Rejected**
	H_1: "Strategic supply chain management practices have an important impact in enhancing the sustainability and resilience of seafood supply chains by achieving a balance between environmental sustainability and economic viability".	**Accepted**

DISCUSSION

The research fully illustrated that strategic supply chain management practices that incorporate both economic and environmental sustainability are key to improving the resilience of seafood supply networks. The respondents' demographic profile, which consisted of an even mix of age groups, professional roles, experience levels, and firm sizes, provided varied views, with significant contributions from large firms and mid-career professionals who were directly involved in supply chain operations. Descriptive analysis showed high consensus among respondents that their firms actively pursue resilience-enhancing practices like contingency planning, stakeholder collaboration, and information sharing, in addition to a clear emphasis on creating consistent revenue, operational efficiency, and reinvestment in supply chain enhancements.

In addition, widespread use of environmentally sustainable practices like sustainable sourcing, waste reduction, and consideration of marine ecosystem health reflects an increasing convergence of business strategies with ecological responsibility. Correlation analysis validated positive and moderate relationships among supply chain resilience, economic sustainability, and environmental sustainability, with the highest correlation found between economic and environmental sustainability, indicating that the former enhances the latter in a reinforcing manner. Regression analysis validated the same and indicated that both economic and environmental sustainability significantly and positively affect supply chain resilience with economic sustainability having a slightly higher influence.

These collective findings support that businesses focusing on cost-effectiveness while integrating sustainable environmental practices are better able to resist shocks, transform in line with market conditions, and attain lasting stability. Thereafter, the testing of the hypotheses resulted in null hypothesis rejection and alternative hypothesis acceptance, thereby substantiating that there are meaningful improvement effects of strategic supply chain practices on the resilience and sustainability of seafood supply chains by balancing between economic viability and environmental stewardship.

CONCLUSION

Therefore, this research proved that strategic supply chain management practices have a substantial impact on seafood supply chain resilience by reconciling economic feasibility and environmental sustainability. Economic and environmental strategies were both found to have a positive impact on supply chain resilience, with practices like efficiency improvement, revenue stability, responsible sourcing, and waste reduction having an impact on higher adaptability and resilience against disruptions. The close relationships between resilience, economic sustainability, and environmental

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sustainability highlight the necessity of an integrated strategy that blends profitability with ecological accountability. Interconnected relationships, contingency planning, and knowledge exchange further enhance resilience capacities. These results underscore the necessity of embedding sustainability in business strategies to create adaptive and resilient seafood supply chains that can cope with global uncertainties. The research enhances theory and practice by showing how concerted economic and environmental measures lead to sustainable supply networks and challenges future research to investigate long-term effects and advances in technology within supply chain resilience.

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