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Cold Chain Logistics of Imported Frozen Fish Products in Nigeria: A Conceptual Framework

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Abstract:- The purpose of this study is to assess the main factors that influence the adoption of cold chain logistics for imported frozen fish products in Nigeria. To accomplish this, a literature review was conducted, and focus group discussions with importers and dealers were held. The analysis method used to evaluate the main and alternative components influencing the adoption of cold chain logistics involved comparing the weight scores. The data shows that the government has the highest value, followed by the main industry and support industry sections with weighted scores of 0.567, 0.367, and 0.355, respectively. In terms of the alternative components within the main industry, the cost of operations was found to have the highest weight score of 0.690. This suggests that operational costs are a significant factor in the adoption of cold chain logistics in the fish import industry. Additionally, the synergetic operations of all practitioners involved in cold chain logistics were given a weighted score of 0.245, and the availability of professional dealers in the adoption of cold chain logistics garnered a score of 0.129. This study generated a framework utilizing the Analytical Hierarchy Process (AHP) to evaluate the principal components of cold chain logistics for imported fish products. The study aims to provide guidance and create synergy between stakeholders to ensure the seamless adoption of cold chain logistics for imported frozen fish products.

Keywords:- *Cold Chain, Frozen Fish, Products, Logistics, Nigeria.*

I. INTRODUCTION

Over the years, food security has become a global priority, outlined as goal number two (2) in the sustainable development goals (SDGs). This goal aims to end hunger, achieve food security, and improve nutrition. The fisheries sector plays a crucial role in ensuring a steady supply of fish products to achieve food security and improved nutrition. Fisheries are a valuable resource in the marine environment, providing seafood and revenue to coastal states (Nwokedi et al., 2020). However, the increasing demand for fishery products due to rapid population growth, particularly in developing countries like Nigeria, has influenced decisions regarding fish imports.

Nigeria is the 7th most heavily populated country in the world, with a population of over 211 million, which is approximately 2.64% of the global population. It is projected to grow to over 401.3 million by 2050, which represents a 99.82% increase (Population Reference Bureau, 2021). In 2021, Nigeria's fish demand was 3.6 million metric tons, but domestic fish production only accounted for about 31.19% of this demand, leading to a reliance on fish importation to fill the gap of about 68.80% (Nigeria Ministry of Agriculture and Rural Development, 2021). The majority of imported frozen fish products arrive through the Lagos Port complex in Apapa and are distributed across Nigeria. However, due to their perishable nature, these products require a proper cold chain system to ensure quality preservation, given the complex logistics, exposure to uncertain climatic conditions, and shorter shelf life.

The importation of frozen fish products involves using cold-chain logistics to maintain their quality and value. Cold chain logistics refers to the management of a temperature-controlled supply chain for perishable goods, including frozen fish (International Trade Council, 2022). However, the fisheries sector, particularly the fish import industry, is greatly impacted by key factors that affect the efficient supply of fish to achieve food security and improve nutrition.

This study focuses on utilizing firms in the fish import industry to establish a framework for adopting cold chain logistics. The fish import industry is an ideal context for identifying the components, as Nigeria's cold chain infrastructure is driven by fish imports. According to EforA (2023), over 39% of the country's cold chain infrastructure is dedicated to fish imports. The main objective of this research is to evaluate the key components of the cold chain logistics framework using the Analytical Hierarchy Process (AHP). This study is expected to play a crucial role in establishing a strong foundation for collaboration among all stakeholders involved in the cold chain logistics of imported frozen fish products in Nigeria.

II. LITERATURE REVIEW

In recent years, food insecurity and malnutrition have escalated and become catastrophic as the world’s population increases, especially in low-income countries like Nigeria. This is a result of food inflation and shortages in food supply caused by postharvest losses majorly in the circulation stage. In 2023, the Food and Agriculture Organization reported that approximately 14 percent of the food produced annually suffers losses worth about USD 400 billion. Food losses and waste presently pose a threat to sustainable food systems (FAO, 2023). These losses are determined by the handling systems ranging from production, harvesting, storage, transport, and distribution. The handling system is called cold

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chain logistics for perishable food products such as fish. Cold chain logistics is distinct from other vertical sectors in logistics in terms of geography and resources (Cullen, 2023).

Cold chain logistics involves managing a temperature-controlled supply chain for perishable goods (International Trade Council, 2022). Pusporini et al. (2020) and Rodrigue (2024) view the cold chain from three perspectives: science, technology, and process. From a scientific perspective, it examines the chemical and biological compositions connected to perishability. The technology standpoint involves hardware devices and machines required to ensure proper protection of product quality and monitoring of temperature and humidity conditions throughout the entire supply chain. The process standpoint evaluates a series of operations ranging from production, storage, transportation, and distribution to protect the integrity of temperature-sensitive products.

Cold chain logistics encompasses all activities related to the production, storage, transportation, and distribution of temperature-sensitive and controlled products. It is a crucial aspect of the food supply chain, especially for perishable food products such as imported frozen fish. In the cold chain logistics of imported frozen fish products, there are risks of food waste, increased costs, and potential health risks if not managed properly. Temperature and humidity are key factors to consider in protecting the integrity of imported frozen fish throughout the entire distribution process until it reaches the final consumer. Therefore, it is essential to monitor the temperature in the entire cold chain process to maintain constant temperature, quality, and product safety (Xiao et al., 2019).

The sensitive data and conditions in the cold chain need continuous monitoring. This requires a technology-based monitoring system at all stages (Ceken & Abdurahman, 2019). Cold chain logistics is a method used to prevent food losses and inefficiencies, especially in fishery products (Pusporini et al., 2020). Many studies have been done on cold chains and are presented in a categorized and summarized form in Table 1. The table includes the publication year, authors, methodology adoption, and application cases.

Table1 Literature Review Summary and Classification

No.	Year	Authors	Methodology Adoption	Application cases
1	2018	Tsai and Pawar	ICT applications	Cold Chain logistics
2	2018	Cerchione, Singh et. al.	Literature review	Cold Chain Management
3	2018	Bremer	Object-oriented modeling approach	Cold chain logistics
4	2019	Ceken and Abdurahman	Regression technique	Cold chain temperature monitoring
5	2017	Tian	HACCP method	Cold chain logistics
6	2015	Pang, Chen, et al.	Internet –of –things (IoT) application	Food supply chain value-centric design
7	2016	Saif and Elhedhli	Mixed-inter Programming	Cold Chain design
8	2019	Gligor, Gligor et al.	Literature review	Supply chain agility and resilience
9	2020	Pusporini and Dahdah	Literature review	Conceptual framework of cold chain
10	2021	Hassan et al.	Experimental design	Cold logistics supply chain

Source: Authors compilation (2024)

According to Gligor et al. (2019), key obstacles to cold chain management efficiency include shortages of expertise, lack of standard, quality, and safety-control measures, supply chain density, infrastructural inadequacy, lack of proper information systems, high cost of installation and operation of cold chains, substandard training and education, insufficient government support and social norms. Nevertheless, Pusporini et al. (2020) also identified several factors highlighted by many researchers that affect efficient cold chain implementation, as shown in Table 2.

Table 2 Major Factors that Affect cold Chain Implementation

Major factors	References
Poor logistic infrastructure	Ashok et al., 2017; Baert et al., 2012; Duarte Alonso, 2013; Joshi et al., 2011; Joshi et al., 2012; Liao et al., 2011; M & K, 2016; Minten, 2016; Papargyropoulou et al., 2014; Shabani et al., 2012; Sharma, 2015; Shashi et al., 2017; Shukla, 2013)
Shortage of cold storage	Ashok et al., 2017; Baert et al., 2012; Duarte Alonso, 2013; Hsiao & Huang, 2016; Joshi et al., 2011; Joshi et al., 2012; Kristensen et al., 2016; Liao et al., 2011; M & K, 2016; Minten, 2016; Papargyropoulou et al., 2014; Shabani et al., 2012; Sharma, 2015; Shashi et al., 2017; Shukla, 2013)
Lack of refrigerated carriers	Joshi et al., 2011; Joshi et al., 2012; Shabani et al., 2012; Sharma, 2015; Shukla, 2013)
Lack of consciousness about the use of information technology	Ashok et al., 2017; Baert et al., 2012; Joshi et al., 2011; Joshi et al., 2012; Sharma, 2015)
Unavailability of power and water	Joshi et al., 2011; Joshi et al., 2012)

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Lack of incorporation	Baert et al., 2012; Hsiao & Huang, 2016; Joshi et al., 2011; Joshi et al., 2012; Shabani et al., 2012; Sharma, 2015; Shashi et al., 2017)
Great cost	Ashok et al., 2017; Baert et al., 2012; Joshi et al., 2011; Joshi et al., 2012; Kristensen et al., 2016; Liao et al., 2011; M & K, 2016; Minten, 2016; Papargyropoulou et al., 2014; Shabani et al., 2012; Sharma, 2015; Shukla, 2013;)
Lack of modern processing and packing method	Ashok et al., 2017; Baert et al., 2012; Duarte Alonso, 2013; Hsiao & Huang, 2016; Liao et al., 2011; Papargyropoulou et al., 2014)
shortage of experts in the food cold chain	Ashok et al., 2017; Joshi et al., 2011; Joshi et al., 2012; Kristensen et al., 2016; Liao et al., 2011; M & K, 2016; Shabani et al., 2012; Sharma, 2015)
inadequate education of farmers	Ashok et al., 2017; Baert et al., 2012; Duarte Alonso, 2013; Hsiao & Huang, 2016; Joshi et al., 2011; Joshi et al., 2012; Kristensen et al., 2016; Liao et al., 2011; M & K, 2016; Shabani et al., 2012; Sharma, 2015; Shashi et al., 2017; Shukla, 2013; Smigic et al., 2016; Thakur & Forås, 2015)
lack of information sharing	Ashok et al., 2017; Baert et al., 2012; Duarte Alonso, 2013; Hsiao & Huang, 2016; Joshi et al., 2011; Joshi et al., 2012; Kristensen et al., 2016; Liao et al., 2011; M & K, 2016; Shabani et al., 2012; Sharma, 2015; Shashi et al., 2017; Thakur & Forås, 2015)
lack of standardization	Ashok et al., 2017; Baert et al., 2012; Joshi et al., 2011; Joshi et al., 2012)
government regulation	Ashok et al., 2017; Baert et al., 2012; Duarte Alonso, 2013; Joshi et al., 2011; Joshi et al., 2012; M & K, 2016; Minten, 2016; Shabani et al. 2012; Sharma, 2015; Shashi et al., 2017)

III. METHOD

The purpose of this study is to evaluate the cold chain logistics of imported frozen fish products and their distribution among selected importers in Nigeria, specifically in Lagos state. The focus of the study is on building the structure of key components of cold chain adoption for imported frozen fish products. A literature review was conducted on cold chain logistics, and a focus group discussion was organized with various stakeholders in the fish import industry, including importers, shipping agents, clearing and forwarding agents, transporters, cold chain storage providers, wholesalers, and retailers in Lagos State. The Analytical Hierarchy Process (AHP), a multi-criteria decision-making tool, was employed to determine the value of the weights of each principal and alternate component. This tool has been utilized in the fishery industry. Additionally, a pairwise comparison (PC) was conducted to assess the hierarchical structure of several principal and alternate components.

IV. RESULT AND DISCUSSION

The study reveals that there are three primary components influencing the adoption of cold chain practices: government, main industry, and supporting industry, which aligns with Pusporini et al.'s (2020) findings. The government plays a critical role in regulating, developing infrastructure, and implementing information systems for cold chain logistics. Its responsibilities encompass regulating the annual fish import quota policy, foreign exchange monetary policy, licensing policy, import duties, and conducting facility inspections and assessments. The main industry encompasses importing firms in the fish import industry, including aggregators, as well as other industries that contribute to cold chain adoption, such as the shipping, clearing, and forwarding industries. The supporting industry involves businesses related to the distribution of imported fish under cold chain logistics, including cold storage service providers, transportation service providers (third-party logistics providers), wholesalers, and retailers. These components significantly influence the cold chain logistics of imported frozen fish products. For instance, the annual fish import quota will affect the level of fish supply to meet consumer demand.

The government plays a crucial role in infrastructural development to facilitate trade, port operations, power supply, and road construction. Additionally, the government provides information systems like satellite technology for weather predictions and the Internet of Things. The second factor is the main industry, which includes all the firms importing fish, also known as aggregators. These firms operate at different levels based on their capacity and obtain annual fish import quotas. Some of these importing firms own subsidiary firms that handle other related operations for efficient cold chain logistics of imported frozen fish products, such as clearing and forwarding, haulage service, and cold storage service. The third factor is the supporting firm, which includes cold storage service providers, transportation service providers, wholesalers, and retailers, all working to ensure the efficient distribution of these imported frozen fish products.

In this context, the three components can be divided into different alternative components that are associated with the principal components. Therefore, a hierarchical diagram was created, depicting the principal components and alternative components of the adoption of cold chain logistics for imported frozen fish products. This diagram also includes the weight score of each principal component and alternate component, as shown in Figure 1 below, based on the AHP analysis.

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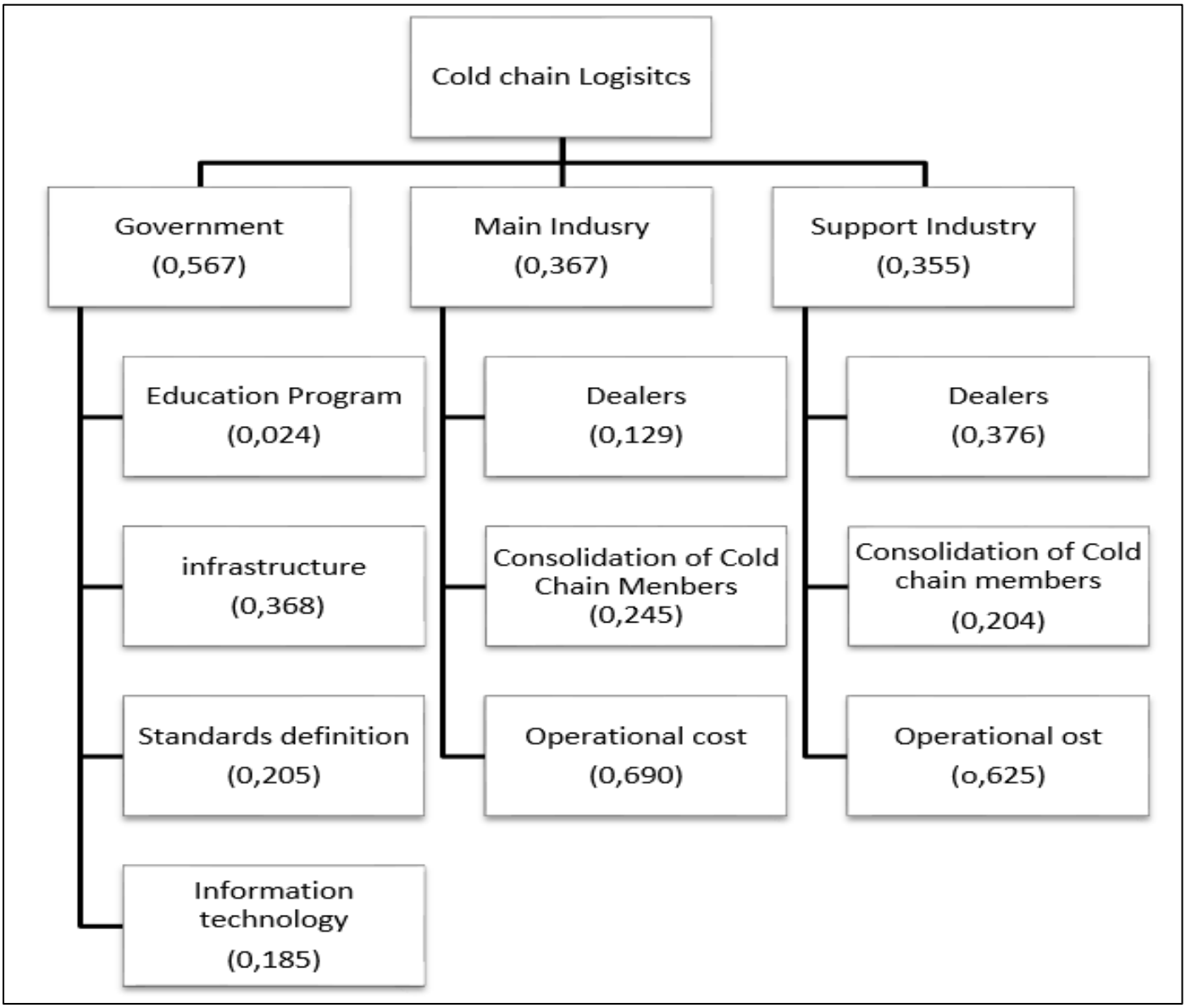

Fig 1 The Schematic Hierarchy of cold Chain Logistics Adoption

According to the comparison of the weight scores of the principal component, the government shows the highest weight score, followed by main industry and supporting industry aspects with a weighted score of 0.567, 0.367, and 0.355, respectively.

The first principal component is that the government is divided into four alternate components: education program, infrastructure, information technology, and standards. Based on the four alternate components, it was found that the infrastructure conveys the highest weight score, 0.357 followed by standards, information technology, and education programs with a weight score of 0.205, 0.185, and 0.024 in sequence. While in the main industry alternate components, it is depicted that the costs for installation and operation take the highest weight score, which shows that is 0,590 which is the third alternate component. This depicts that the importers lay more emphasis on the amount of costs involved in the adoption of the cold chain logistics of imported fish products is a very constant and dominant factor. The second alternate component is the consolidation and coordination of all parties involved in the cold chain logistics, showing a weighted score of 0,245, and the first alternate component is the dealers in the application of the cold chain logistics of imported frozen fish products in the field of 0,129.

The third component, the support industry comprises three alternate components, which are the dealers, consolidation, and operational costs incurred. According to these three alternate components, it is depicted that the cost of installation and operation convey the highest position with the weight score of 0.625 followed by the expert availability and consolidation of cold chain logistics parties of 0.204 and 0.376, respectively.

The weighted score for each of the principal components, alternate components, and the global score of each weight are depicted in the following table 3.

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Table 3. Local and Global Weight

Principal Component	Alternate Component	Score	Local Weight	Global weight
Government	Education program	0,567	0,024	0,018
	Infrastructure		0,368	0,159
	Standards definition		0,205	0,093
	Information technology		0,185	0,045
Main industry	Dealers	0,367	0,129	0,079
	Consolidation of chain members		0,245	0,167
	Operational cost		0,690	0,365
Support Industry	Dealers	0,355	0,376	0,139
	Consolidation of chain members		0,204	0,128
	Operational cost		0,625	0,233

Source: Authors Computation

V. CONCLUSION

The cold chain system relies on three main components: the government, the main industry, and the support industry. This system is essential for preserving the quality of perishable products, such as imported frozen fish. To establish an effective cold chain, there must be strong collaboration and commitment among these three sectors to provide infrastructure like cold storage facilities, power supply, refrigerated trucks, and a well-developed road network. Educational programs should be implemented to promote the understanding and application of cold chain practices for fishery products. These programs will also contribute to the development of expertise and skilled labor in cold chain logistics. Additionally, the establishment of standards and policies is crucial to ensure the adoption of proper cold chain practices, guaranteeing high service quality and safety from the arrival of fish vessels, through inspection, transportation, storage, and distribution, until the products reach the end consumer.

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