

Inventory Management Strategies for Business Continuity: A Study of the Eyeglass Lens Industry During Global Crises

Sarot Kankoon*, and Sataporn Amornsawadwatana

University of The Thai Chamber of Commerce
Ake.010321@gmail.com (Corresponding Author)

Abstract. This study investigates inventory management strategies in the eyeglass lens industry during global crises, encompassing COVID-19, transportation disruptions, and geopolitical conflicts from 2019 to 2024. Using structural equation modeling and path analysis with data from 252 industry professionals across five Asian countries, we develop a SIMPLE model (Safety Stock, Information Integration, Methodology Decision, Products Life Cycle, Logistics Management, and Economic Condition) for effective inventory management. Results reveal that Information Integration has the strongest impact (standardized coefficient 0.97), followed by Logistics Management and Methodology Decision (0.89), demonstrating the critical role of integrated information systems in crisis management. The study contributes to both theory and practice by providing a comprehensive framework for inventory management during global crises and offering practical guidelines for industry practitioners. Our findings suggest that successful inventory management requires balanced integration of all six SIMPLE components, with particular emphasis on information systems and logistics coordination.

Major Contributions: 1. Develops a novel SIMPLE model for inventory management in the eyeglass lens industry during global crises 2. Identifies six key domains affecting inventory control performance 3. Provides empirical evidence through structural equation modeling 4. Offers practical implications for industry practitioners

Minor Contributions: 1. Synthesizes multiple crisis impacts on supply chains 2. Integrates theoretical and practical perspectives 3. Validates factors affecting inventory management 4. Proposes risk reduction framework

Keywords: Eyeglass Industrial, Global crisis, Risk management, Inventory management, Supply Chain Management

1. Introduction

During 2019 to 2023, the worldwide crisis has exerted a significant influence on the overall industrial and manufacturing supply chains globally. The eyewear market signifies a sector that has been adversely influenced by interruptions within the supply chain, predominantly due to a lack of necessary eyeglass lenses that fail to sufficiently satisfy consumer requirements.

Coronavirus disease 2019, commonly referred to as COVID-19, is attributable to an infection with a novel strain of coronavirus. This strain, identified as Severe Acute Respiratory Syndrome Coronavirus 2 (SARS-CoV-2), prompted the Wuhan City Public Health Office in Hubei Province to issue an official announcement in late 2019 concerning a cohort of patients diagnosed with pneumonia, as reported by the World Health Organization (2021). The underlying causes of this disease, subsequently designated as COVID-19, has been linked to the Hua Nan market, recognized as the largest seafood trading market in Wuhan and central China, according to Xu et al. (2020). The rapid spread of COVID-19 has emerged as a significant global challenge, as it has infiltrated diverse regions globally, resulting in considerable consequences for industrial supply chains and causing extensive disruptions in international trade networks.

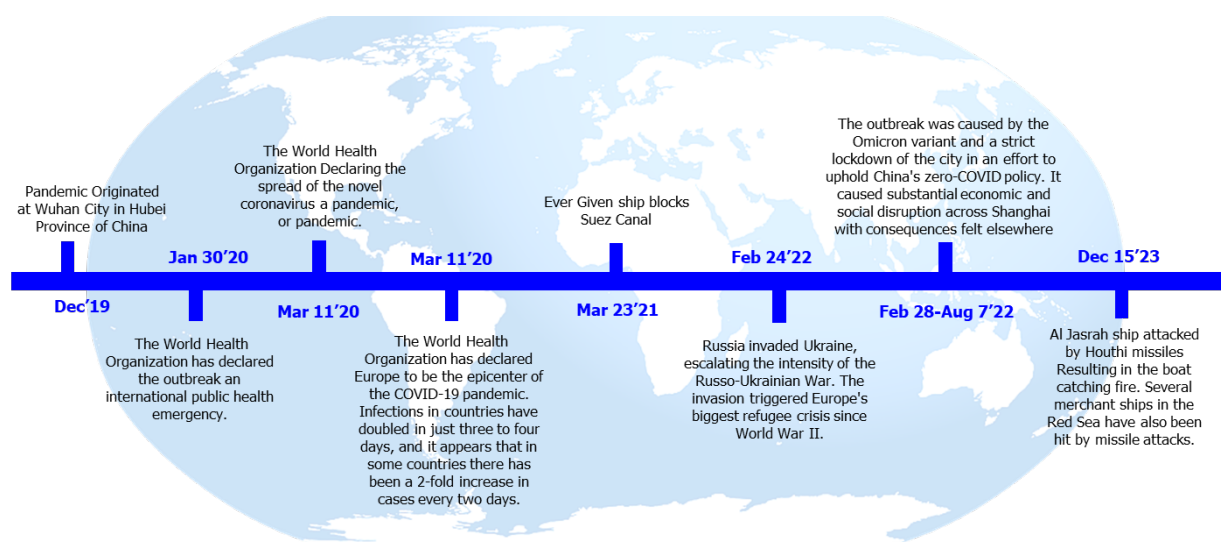


Fig. 1: Global crisis in FY 2019 to 2023 period

Source: World Health Organization (2021)

The Suez Canal Incident is exerting increased pressure on international trade dynamics. The obstruction has resulted in significant congestion, with over 370 vessels stranded at the Suez Canal. Various types of maritime vessels were compelled to await the removal of the obstruction to facilitate passage through the Canal. This blockage has precipitated disruptions affecting the delivery of goods valued at over \$9 billion daily, as cited by Das (2021), who indicated that this figure corresponds to approximately \$400 million in trade per hour. Given that the blockage persisted for more than six days, an estimated trade loss of around \$54 billion was reported by Suez Canal Blockage a Large Loss Event for Global Reinsurers (2021). In the context of supply chain management, this research endeavor aims to enhance risk prevention strategies within the eyeglass lens industrial supply chain.

In concerning the impact from the Russian-Ukrainian Conflict on DACHSER's Global Air and Sea Transport Operations, the acceptance of reservations for shipments originating from or destined for Ukraine has been suspended indefinitely. Furthermore, logistics service providers are not in a position to offer reservations for rail services connecting Asia and Europe. This cessation of bookings is similarly relevant to land transports linking Asia and Europe. According to Shams et al. (2022), the

limitations for the movement of shipments through Russia, Belarus, or Ukraine is linked to failure in securing the safety of clients' consignments traversing these countries. In addition to some specific measures, carriers foresee additional implications for operational capabilities affecting from the global oil and energy market.

The crisis currently unfolding in the Red Sea represents yet another significant disruption that is influencing the dynamics of maritime shipping and logistics. In recent years, interoceanic routes and passages have been significantly affected by a series of meteorological anomalies, notably the drought that has reduced the operational capacity of the Panama Canal by 36%, as reported by the Associated Press (2024). The overarching effects can only be reliably determined to a specific extent once the crisis has either reached its conclusion or has been sufficiently addressed to the level where the uncertainties and insecurities facing shipping and trade are diminished to tolerable levels.

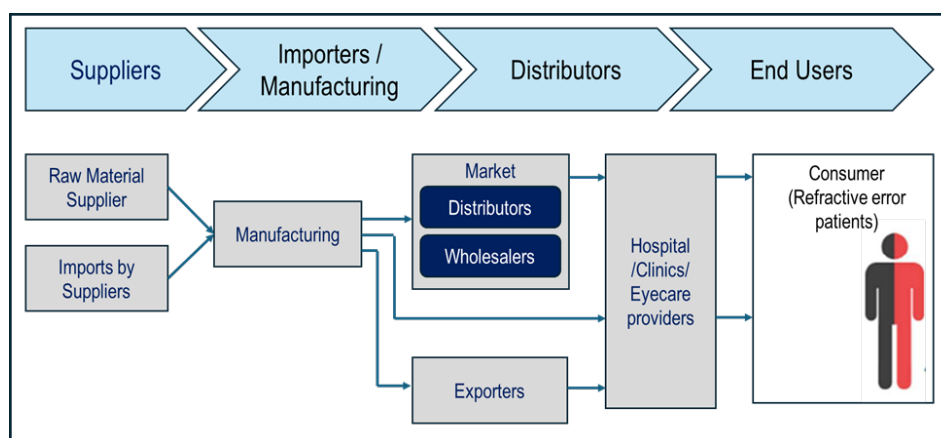


Fig. 2: Eyeglass Lens Industrial Supply Chain Management
Source: Proctor et al. (2022)

The supply chain associated with eyeglass lenses encompasses a diverse array of participants engaged in the operational chains, as represented in Fig 2. The management of the eyeglass lens supply chain entails the administration of resources and supplies, alongside the provision of eyeglass products and services to both eyecare professionals and individuals with refractive errors. The integrity of the process is characterized by the flow of medical products and services, which manifests as tangible goods and information traversing through numerous stakeholders. Proctor et al. (2005) clarified that the entities participating in the eyeglass lens supply chain include suppliers, manufacturers/importers, hospitals/clinics, eyecare providers, group purchasing organizations, and regulatory agencies.

The study of inventory management, risk mitigation, and operational efficiency in supply chain management has a rich theoretical foundation. These concepts are crucial in maintaining resilient supply chains, particularly during crises, when disruptions expose vulnerabilities across global supply networks. Each of these foundational elements contributes to sustaining supply chain continuity, reducing financial risks, and optimizing resource usage. The integration of theoretical foundations in inventory management, risk mitigation, and operational efficiency enables a holistic approach to manage the eyeglass lens industry's supply chain. For example, leveraging EOQ and safety stock theory ensures sufficient inventory levels, while contingency and agility theories allow for swift adaptation of production and logistics processes (Chen et al., 2023). Altogether, these theories form the foundation for crisis-resilient supply chain management, enabling companies to withstand shocks and maintain operational continuity even in the face of global disruptions.

Regardless of the particular field of study, risk is fundamentally associated with the potential for an unfavorable loss, particularly an undesirable negative result, along with uncertainty (Wang et al.,

2024). The risk associated with the eyeglass lens industry can be described as a “combination of the likelihood or frequency of a specified hazard and the severity of its occurrence,” according to Choi (2007). This perspective builds upon the contributions of various scholars who have characterized supply chain risk. Zsidisin et al. (2000) added that supply chain risk within the context of the eyeglass lens sector can be conceptualized as a situation that detrimentally impacts supply chain operations, thereby affecting essential performance metrics such as service levels across the entire chain and responsiveness, along with cost considerations. Wang and Hill (2006) conducted an analysis that illustrates the complicated interdependence of risks. When the costs tied to logistics are increasing, the endeavor of securing shipping vessels is progressively more difficult. Delays at the port can extend to a duration of two or three weeks. This phenomenon consequently exacerbates the necessity for safety stock, while surcharges on fuel are significantly inflating transportation expenditures. The aforementioned circumstances, in conjunction with the eyeglass industry, illustrate the complexities inherent in inventory management by necessitating the determination of optimal order quantities, optimal production volumes, safety stock thresholds, and other inventory policies that profoundly influence global supply chain efficacy within the eyeglass lens sector. A considerable amount of academic research exists that integrates a diverse range of models designed to effectively oversee inventory in relation to the relevant suppliers, manufacturing organizations, distribution centers, and customers.

Despite extensive research on general supply chain risks and inventory management models, there is limited research specifically addressing risk prevention and management strategies tailored for the unique demands of the eyeglass lens industry, especially in times of crisis. Furthermore, there is a need for comprehensive frameworks that can enhance resilience in eyeglass lens supply chains, concerning inventory management, risk mitigation, and operational efficiency. Hence, the primary objective of this research is to develop an optimized risk prevention framework for the eyeglass lens industry, addressing specific supply chain vulnerabilities in the face of global crises. This includes formulating inventory management policies and identifying optimal order quantities, production volumes, and safety stock levels that enhance resilience and minimize disruptions in the supply of eyeglass lenses.

2. Literature Review

2.1 Inventory Management

Inventory management represents an essential element of an organization's cost management strategies, involving activities that must be conducted in alignment with inventory management policies and procedures designed to effectively control inventory in order to ensure that each product maintains the appropriate quantity and is sufficient to meet consumer demands. Furthermore, inventory management plays a pivotal role within the supply chain framework, wherein the costs associated with holding inventory must be acknowledged as a significant element of the production expenses in manufacturing which in turn affecting one's competitive edge. As noted by Hasbullah and Santoso (2020), strategic considerations concerning inventory such as the availability of physical space, product quality, the return of damaged goods, and demand forecasting are indispensable in the context of manufacturing production costs. Shao et al. (2021) demonstrated that shifts in customer demand represent a risk associated with forecasts that may not accurately reflect actual demand, thereby affecting ongoing adjustments in production planning. Effective inventory management necessitates the determination of the requisite inventory levels during the grace period to satisfy customer demand, as cited by Godichaud and Amodeo (2019). The core concern of inventory management involves multiple domains, including the timing of inventory replenishment, production costs, warehousing financial implications, and inventory holding expenditures relevant to asset management. Rossit et al. (2019) demonstrated that the administration of inventory has a constructive

effect on the firm's growth, during which the dimensions of inventory forecasting, inventory appraisal, anticipations regarding forthcoming inventory prices, physical inventory evaluations, and the storage of products within warehouses lead to particular risk that the organization must appropriately manage due to the existence of stock.

2.2 Warehouse Management

Hamdy et al. (2022) pointed out that warehousing serves as a central aspect within the area of supply chain management, contributing importantly to the coordination of all supply chain activities.. Consequently, it constitutes a vital component of the operational process of products, as it significantly contributes to the smooth and uninterrupted execution of the production process until its transition into the distribution phase, as suggested by Torbacki and Kijewska (2019). In the past few years, new functionalities for warehouses have emerged to enhance the integration of processes throughout the entire supply chain, extending beyond mere product storage. This ability provides a refined viewpoint on service, thus increasing operational efficiency. It enables the mitigation of excessive inventory levels across the supply chain. The digitization of warehousing and the utilization of information exchange between partners regarding real-time inventory levels are importance for efficient and effective operation. Consequently, digital solutions associated with Industry 4.0 are rapidly being integrated into internal logistics processes, resulting in the formulation of sophisticated warehouse configurations, commonly designated as Warehouse 4.0 encompassing interoperability, virtualization, decentralization, real-time capabilities, service orientation, modularity, and the configurability of warehouse capacity (Zoubek & Šimon, 2021). Furthermore, warehouse management addresses customer demands by efficiently overseeing all warehouse processes and designing dynamic warehouse facilities that are readily accessible, as noted by Khan et al. (2022).

2.3 Economic Order Quantity (EOQ)

Kholil (2023) demonstrated that the effectiveness of a firm's business operations is dependent upon the availability of various tools that are essential for operational support. It is crucial to ensure that an adequate amount of equipment is accessible to meet optimal operational demands. Inadequate inventory levels may lead to interruptions in business operations and result in the loss of profit-generating opportunities, while excessive stock levels can lead to unnecessary storage costs. Consequently, Effective inventory planning and management is essential to maintain sufficient stock levels and prevent both shortages and excesses., thereby mitigating product storage costs to accomplish this business objective. Within this study, two methodologies are employed: the Economic Order Quantity (EOQ) method and the Just-in-Time (JIT) method as suggested by Lufti et al. (2022). The EOQ method determines the most cost-effective order quantity for raw materials, considering the reduction of expenses and the planning of new orders. Through EOQ calculations, the volume of stock can be optimized, leading to cost reductions and enhancements in inventory storage efficiency. The JIT method, as explained by Mu'min et al. (2023), represents an inventory management strategy that concentrates on procuring materials in the precise quantity and at the optimal time, conforming to the specific criteria for production or operational endeavors. JIT calculations are designed to enhance temporal efficiency and minimize procurement expenditures by implementing inventory control techniques. This allows the organization to improve the efficiency of inventory management, boost operational performance, and minimize expenses linked to surplus inventory or stock levels.

2.4 Inventory Optimization Model

Dutta et al. (2017) explained inventory optimization as a systematic approach aimed at ensuring the appropriate product is available at the correct location, within the designated timeframe, in the requisite quantity, and of sufficient quality to align with consumer demands, alongside the procurement of goods to fulfill customer requirements. The enhancement of inventory management

can be accomplished through the categorization of inventory and the implementation of demand forecasting models that facilitate effective inventory oversight. Ropi et al. (2021) highlighted the importance of effective inventory management and added that it is essential to follow protocols that are classified as 'Traditional' and 'Advanced' for predicting consumer needs to determine the most advantageous inventory level that a corporation should maintain. Several research articles emphasize the 'Optimization model' associated with 'inventory management. Becerra et al. (2021) investigated models that focus on the synergy of optimization frameworks for the identification and stochastic distribution of information within the supply chain. Krzyzaniak (2022) added that certain models are categorized as single stock models, while others are classified as multi-stock models.

The safety stock concept is vital for inventory management, particularly in volatile demand or disrupted supply chain scenarios. Maintaining safety stock helps firms avoid stockouts and sustain operations despite unexpected demand spikes or supply delays (Nahmias & Olsen, 2015). Studies on safety stock within inventory management highlight its role in achieving elevated service levels while controlling holding costs. Chopra and Meindl (2016) assert that safety stock choices significantly influence a firm's service capacity to meet consumer demands swiftly. Elevated safety stock levels decrease stockout risks and lost sales but escalate holding costs. Consequently, inventory management aims to find an optimal equilibrium where safety stock sufficiency ensures reliability without excessive cost inflation (Li & Zobel, 2024)). In crises, augmented safety stock may be crucial to buffer against significant supply and demand disruptions (Smith & Johnson, 2023; Christopher & Peck, 2004). By adeptly managing safety stock, firms can improve inventory practices, enabling responsive adjustments to both routine and extraordinary fluctuations, thereby bolstering supply chain efficiency. In this study, it is hypothesized as the following

H1: Safety stock has a significant impact on inventory management during a global crisis

The relationship between information integration and inventory management is vital, as precise, real-time data informs ordering and replenishment decisions. Information integration mitigates demand and supply uncertainty through data sharing across the supply chain (Zhang & Liu, 2023; Zhou & Benton, 2007). Gunasekaran and Ngai (2004) highlight that information integration promotes coordination and transparency, essential for optimal inventory management. Additionally, information integration fortifies inventory management by bolstering supply chain resilience. In times of disruption, it offers end-to-end visibility, facilitating effective adjustments in inventory and distribution strategies (Kumar & Chandra, 2024; Liu et al., 2023). In the eyeglass lens sector, sharing information regarding stock levels, forecasts, and lead times with suppliers and distributors ensures product availability continuity, even during disruptions (Cachon & Fisher, 2000). Consequently, information integration underpins effective inventory management by enhancing the precision, efficiency, and responsiveness of inventory control systems. This study hypothesized as the following

H2: Information integration has a significant impact on inventory management during a global crisis

Methodological choices in inventory management integrate advanced techniques like Machine Learning and Data Analytics, offering predictive capabilities that facilitate adaptive inventory strategies (Chopra & Meindl, 2016). Simulation techniques, including Monte Carlo simulations, evaluate intricate, multi-echelon inventory systems, aiding organizations in determining optimal inventory policies amidst uncertainty (Law, 2014). These methodologies improve inventory precision, yielding insights often absent in traditional models, particularly in complex or high-variability contexts. The selection of an appropriate methodology in inventory management significantly influences an organization's cost structure, service levels, and operational flexibility. An effectively selected inventory management methodology aligns stock levels with demand, mitigates stockouts,

and reduces surplus inventory, collectively improving overall supply chain performance (Zsidisin et al., 2000). This study hypothesized as the following

H3: Methodology decision has a significant impact on inventory management during a global crisis

The interplay between the product life cycle (PLC) and inventory management is essential for synchronizing stock levels with demand fluctuations at varying stages of a product's lifespan (Stevenson, 2020). Proficient inventory management throughout the product life cycle allows organizations to harmonize demand and supply, curtail holding costs, and enhance service levels (Christopher, 2011). Aligning inventory strategies with the product life cycle equips companies to adeptly respond to demand variances, ensuring that stock levels cater to the specific requirements of each stage while optimizing costs and profitability (Stevenson, 2020). This study hypothesized as the following

H4: Product life cycle has a significant impact on inventory management during a global crisis

Logistics management is essential for inventory transportation, storage, and distribution, in which efficient logistics can decrease lead times, enabling lower inventory levels without service loss (Bowersox et al., 2013). Logistics activities such as warehousing and transportation significantly influence inventory levels and the flow of goods in the supply chain (Lambert & Stock, 2001). Additionally, logistics and inventory management collaboratively address the costs of goods holding and transport. Strategic warehouse placement can minimize excessive inventory by situating stock near demand centers, thus lowering transport expenses and enhancing responsiveness (Rushton et al., 2017). In global supply chains, the logistics and inventory management relationship are increasingly vital. Variability in international shipping and customs complicates inventory management, necessitating collaboration with logistics to sustain stock levels (Coyle et al., 2016). Hence, this study hypothesized as the following

H5: Logistic management has a significant impact on inventory management during a global crisis

Global economic factors influence inventory through supply chain issues and geopolitical factors. A recession in a supplier market may cause shortages, leading to increased safety stock or supplier diversification. Studies indicate firms prioritize inventory flexibility during economic uncertainty to swiftly adapt to demand and supply changes (Christopher & Peck, 2004). During economic growth, heightened consumer demand necessitates higher inventory levels to satisfy expectations and leverage sales opportunities. Inventory strategies in a thriving economy may involve elevated reorder points and safety stock to avert stockouts and lost sales (Hopp & Spearman, 2008). In contrast, during economic downturns, businesses often lower inventory levels to reduce holding costs and prevent excess stock that could result in markdowns or obsolescence (Arnold, 2011). Hence, this study hypothesized as the following

H6: Economic condition has a significant impact on inventory management during a global crisis

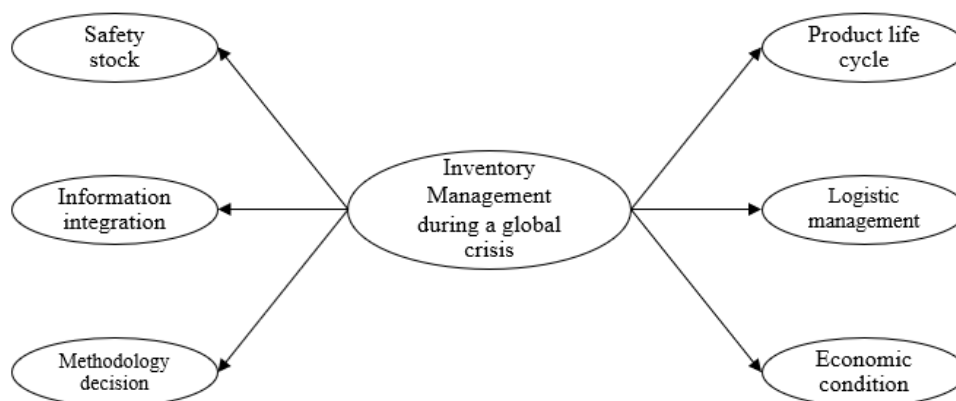


Fig. 3: Conceptual Model

3. Research Methodology

3.1 Research Approach

The objective of the investigation was to examine the inventory factors associated with eyeglass lenses in the context of managing risks and ensuring business continuity during periods of global crises. The quantitative methodological framework employed for this investigation comprised quantitative data collection. The operational research design encompassed a meta-analysis (PRISMA), Confirmatory Factor Analysis (CFA), Structural Equation Modeling (SEM), and Path Modeling within the eyeglass lens industry.

3.2 Sampling

The research sample comprises experienced individuals in supply chain management and specialists in the eyeglass lens industry. It encompasses all relevant aspects of the eyeglass lens business within the Supply Chain Department across 5 factories in the AISA zone. Consequently, the sample group consisted of representatives from pertinent agencies that consented to engage in the research study. In this research, purposive sampling is employed. This technique is utilized to include participants with expertise in supply chain management and the eyeglass lens sector. Purposive sampling enables the researcher to select subjects based on their relevant knowledge and experience, ensuring the inclusion of individuals who can provide valuable insights. For structural equation modeling (SEM), a minimum sample size of 200 is advisable, with larger samples enhancing model stability and result robustness (Hair et al., 2010). In this study, the sample size is 252.

3.3 Data Collection

A substantial volume of data was generated from the quantitative research. Participants possessed expertise in the eyeglass lens industry and manufacturing supply chain, facilitated by a questionnaire involving supply chain management experts, allowing for elaboration on their responses. The specifics of data collection are illustrated in Fig 4.

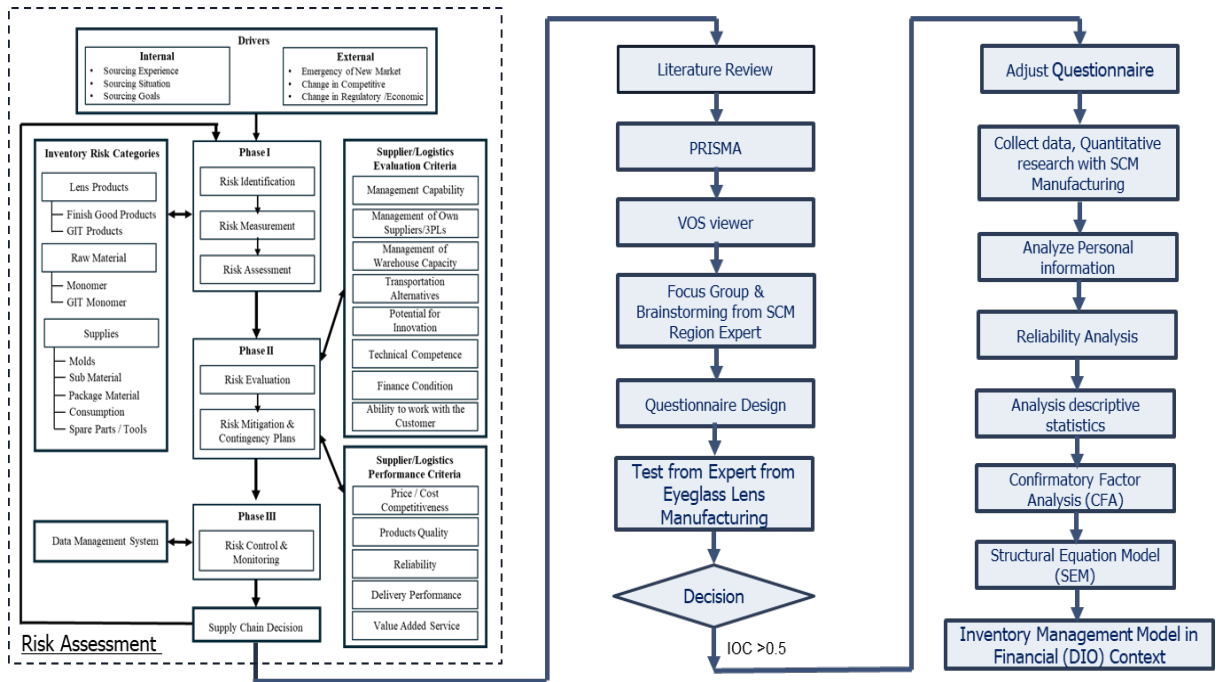


Fig 4: Data collection Flow

The data collection method employed is the online questionnaire, a widely used tool for gathering information from a large group of participants in a structured, cost-effective, and efficient manner. Given the geographic scope of the research, which spans China, Indonesia, the Philippines, Thailand, and Vietnam, and the need to reach experienced individuals in the supply chain management field within the eyeglass lens industry, an online questionnaire was chosen to facilitate data collection from diverse locations.

4. Data Analysis and Results

This study investigates "Inventory Management Impact Factors during a Global Crisis." A sample of 252 questionnaires was analyzed via SPSS and Amos. This analysis encompasses personal information such as Manufacturing, Gender, Working Position, Working Department, Supply Chain, and Management Working Experience, employing frequency and percentage analysis; the findings are summarized as follows.

4.1 Analyze Personal Information

This section analyzes personal information including Manufacturing, Gender, Working Position, Working Department, Supply Chain, and Management Experience through frequency and percentage analysis; results are summarized as follows:

Table 1: Frequency and percentage of respondent personal information (n = 252)

Personal Information		Frequency	Percent
Manufacturing	Factory#1	4	1.59
	Factory#2	8	3.17
	Factory#3	28	11.11
	Factory#4	144	57.14
	Factory#5	68	26.98
Gender	Male	76	30.16

	Female	176	69.84
Working Position	Management	41	16.27
	Staff	155	61.51
	Supervisor	56	22.22
Working Department	Customer Service	24	9.52
	Import & Export	24	9.52
	Lens & Material Purchase Planning	9	3.57
	Procurement	18	7.14
	Production Planning	56	22.22
	Storage and Material	26	10.32
	Warehouse management	95	37.70
Supply Chain Management Working Experience	Less than 1 Year	17	6.75
	More than 1 Year - 3 Years	38	15.08
	More than 3 Years - 5 Years	39	15.48
	More than 5 Years - 8 Years	31	12.30
	More than 8 Years	127	50.40

The analysis of respondent demographics indicated that 57.14% were from Factory#4, followed by Factory#5 at 26.98%, Factory#3 at 11.11%, Factory#2 at 3.17%, and Factory#1 at 1.59%. The data showed a higher proportion of female respondents at 69.84% (176 individuals), with males constituting 30.16% (76 individuals). The majority of respondents held Staff positions at 61.51% (155 individuals), with 22.22% (56 individuals) in supervisory roles and 16.27% (41 individuals) in management. In terms of departmental representation, warehouse management comprised the largest segment at 37.70% (95 individuals), followed by production planning at 22.22% (56 individuals) and storage and material at 10.32% (26 individuals). A smaller fraction of respondents were involved in customer service and import & export at 9.52% (24 individuals), procurement at 7.14% (18 individuals), and lens & material purchase planning at 3.57% (9 individuals). Regarding supply chain management experience, the predominant group had over 8 years of experience at 50.40% (127 individuals), followed by 15.48% (39 individuals) with 3-5 years, 15.08% (38 individuals) with 1-3 years, and 12.30% (31 individuals) with 5-8 years, while the minority had less than 1 year at 6.75% (17 individuals).

4.2 Reliability and Validation

The data demonstrates the reliability of Inventory Management Impact Factors during a Global Crisis, identifying 6 latent and 13 observable variables, including Safety Stock and Economic Condition. Reliability testing yielded values of 0.843 for Safety Stock, 0.783 for Information Integration, 0.840 for Methodology Decision, 0.854 for Product Life Cycle, 0.831 for Logistic Management, and 0.891 for Economic Condition. Overall reliability ranged from 0.732 to 0.909, with a Cronbach's alpha of 0.950, exceeding the standardized threshold of 0.70 (Pallant, 2007). Consequently, the questionnaire utilized in this research is deemed valid, as substantiated by the data presented in Table 2.

Table 2 : Analysis the reliability test (All Measures on 5-Point Scales, n = 252)

Latent variables	Observed Variables	Number of questions	Cronbach's Alpha
Safety Stock		(9)	0.843
	Inventory Management	(4)	0.815
	Machine Leaning	(2)	0.786
	Optimization Inventory	(3)	0.769
Information integration		(5)	0.783
	Service Level	(3)	0.759
	Social economic condition	(2)	0.732

Methodology decision		(5)	0.840
	Evaluation and Ranking	(2)	0.735
	Operation Planning	(3)	0.846
Products Life Cycle		(6)	0.854
	Distribution assessment	(3)	0.765
	Demand forecast	(3)	0.827
Logistic Management		(5)	0.831
	Digital Storage	(2)	0.840
	Site Selection	(3)	0.751
Economic condition		(5)	0.891
	Logistic Operation	(3)	0.848
	Environment Protection	(2)	0.909

This section analyzes descriptive statistics of Inventory Management Impact Factors amid a Global Crisis, encompassing Safety Stock, Information Integration, Methodology Decision, Product Life Cycle, Logistic Management, and Economic Conditions through mean and standard deviation analysis; the results are summarized as follows:

Table 3 : Analysis mean and standard deviation (n = 252)

Factor		\bar{x}	SD.	Meaning
Safety Stock		3.86	0.50	Agree
SAFE1	Inventory Management	3.89	0.72	Agree
SAFE2	Machine Learning	3.78	0.81	Agree
SAFE3	Optimization Inventory	3.91	0.73	Agree
Information integration		3.74	0.57	Agree
IMFO1	Service Level	3.77	0.65	Agree
IMFO2	Social economic condition	3.72	0.67	Agree
Methodology decision		3.56	0.73	Agree
METH1	Service Level	3.55	0.81	Agree
METH2	Social economic condition	3.56	0.82	Agree
Products Life Cycle		3.84	0.57	Agree
PROD1	Distribution assessment	3.91	0.75	Agree
RPOD2	Demand forecast	3.56	0.82	Agree
Logistic Management		3.73	0.65	Agree
LOGI1	Digital Storage	3.63	0.80	Agree
LOGI2	Site Selection	3.82	0.65	Agree
Economic condition		3.77	0.71	Agree
ECON1	Logistic Operation	3.81	0.72	Agree
ECON2	Environment Protection	3.73	0.82	Agree

4.3 Confirmatory Factor Analysis

This section analyzes the confirmatory factor analysis (CFA) model regarding Inventory Management Impact Factors during a global crisis. The CFA aimed to assess the suitability of items for the factors and the dimensionality of the construct in this empirical model (Bollen, 1989), while also identifying dependent variables through a confirmatory factor analysis to evaluate data fit to the empirical study (Jorgensen, Boer, & Laugen, 2006). Results reveal that the confirmatory factor analysis identifies six latent variables: Safety Stock (SAFE), Information Integration (IMFO), Methodology Decision (METH), Products Life Cycle (PROD), Logistic Management (ECON), and Economic Condition (ECON), summarized as follows:

Table 4 : Analysis statistics of Second Order Confirmatory Factor Analysis Model

Second Order Confirmatory Factor Analysis Model	Standardized Factor loading	Error Variances	t-value	R2
Safety Stock				16.0%
SAFE1	0.70	-	-	49.0%
SAFE2	0.58	0.14	7.374***	33.0%
SAFE3	0.75	0.12	9.529***	57.0%
Information Integration				23.0%
IMFO1	0.74	-	-	54.0%
IMFO2	0.64	0.09	10.415***	45.0%
Methodology Decision				34.0%
METH1	0.73	-	-	53.0%
METH2	0.85	0.10	11.827***	72.0%
Products Life Cycle				24.0%
PROD1	0.79	-	-	63.0%
PROD2	0.80	0.09	11.410***	64.0%
Logistic Management				33.0%
LOGI1	0.72	-	-	52.0%
LOGI2	0.85	0.08	12.314***	73.0%
Economic Condition				33.0%
ECON1	0.80	-	-	64.0%
ECON2	0.85	0.09	13.302***	73.0%

** Sig. < 0.001

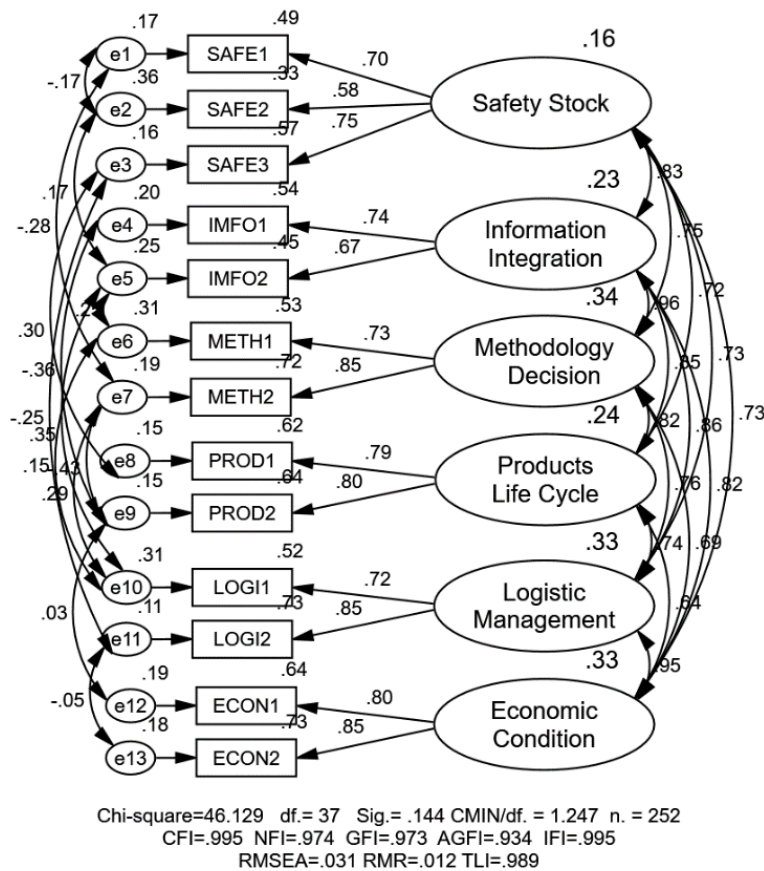


Fig. 5: Analysis Second Order Confirmatory Factor Analysis Model.

The analysis of the second-order confirmatory factor analysis model reveals six latent constructs:

Safety Stock, Information Integration, Methodology Decision, Products Life Cycle, Logistic Management, and Economic Condition. The squared multiple correlation coefficients (R^2) ranged from 33.0% to 73.0%, while the correlations among latent variables were between 16.0% and 34.0%. The standardized factor loadings ranged from 0.58 to 0.85. Therefore, it can be concluded that the second-order confirmatory factor analysis of the Inventory and Production Impact Factors during a Global Crisis demonstrates acceptable values, indicating that each item set represents a unified underlying construct and supports evidence for discriminant validity, ultimately suggesting an excellent fit for the testing model.

4.4 Structural Equation Modeling

Structural Equation Modeling (SEM) is a multivariate method for hypothesis testing on variable influences. SEM has become a preferred technique for researchers across various fields. This study employs SEM to analyze Inventory and Production Impact Factors amid a Global Crisis, testing relationships among constructs as illustrated in the table 5.

Table 5 : Fit Indices for the Model

Index	Criteria	Result	References	Result
Chi – Square	= 40.312	df. = 40.0		
Sig.	> 0.05	0.456	Hair et al. (2010), and Sorbon (1996)	Good fit
CMIN/df.	< 3.0	1.008	Hair et al. (2010), Diamantopoulos (2000), Kelloway (2015)	Good fit
GFI	≥ 0.90	0.976	Hair et al. (2010), Browne and Cudeck (1993)	Good fit
AGFI	≥ 0.80	0.945	Baumgartner, H., & Hombur, C.,(1996), Zikmund (2003)	Good fit
NFI	≥ 0.90	0.977	Hair et al. (2010), Mueller (1996), Hu and Bentler (1999)	Good fit
IFI	≥ 0.90	1.000	Hair et al. (2010), Hu and Bentler (1999)	Good fit
CFI	≥ 0.90	1.000	Hair et al. (2010), Mueller (1996), Goffin (2007)	Good fit
RMR	< 0.08	0.013	Hu & Bentler (1999), Diamantopoulos & Sigauw (2000)	Good fit
RMSEA	< 0.08	0.006	Hair et al. (2010), Schumacker & Lomax (2010)	Good fit
TLI	> 0.90	1.000	McDonald and Marsh (1990)	Good fit

The analysis identified six latent and thirteen observable factors affecting inventory and production during a global crisis, including Safety Stock and Economic conditions. The Chi-Square value serves as a traditional metric for assessing model fit, indicating the difference between sample and fitted covariances as articulated by Hu and Bentler (1999). A model exhibiting good fit should yield a non-significant result at the 0.05 level. The findings met acceptable thresholds consistent with Hair et al. (2010), showing Chi-Square statistics of 40.312, $df = 40.0$, and Sig. of $0.456 > 0.05$, with CMIN/df. of $1.008 < 3.0$. Additionally, the structural equation modeling analysis indicated a reasonable fit across seven model indices based on various fit statistics.

4.5 Analysis Path Testing

This section examines the path testing within the structural equation modeling of Inventory Management Impact Factors amid a Global Crisis, with results analyzed accordingly.

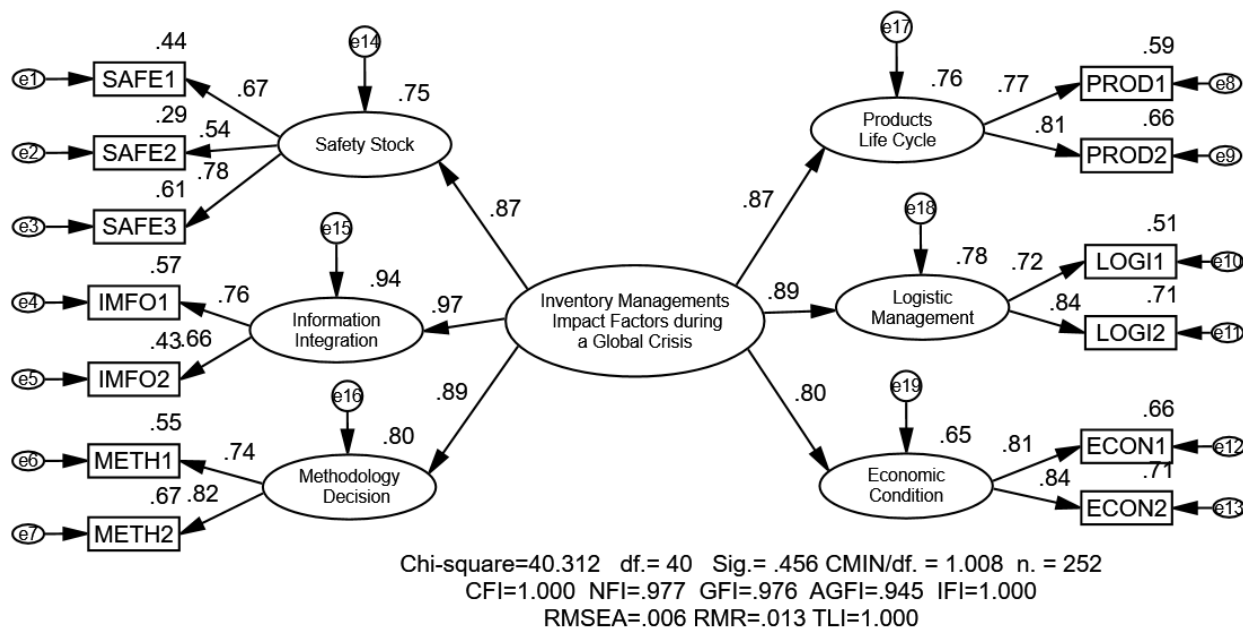


Fig. 6: SEM Analysis of Inventory Management Model during a Global Crisis

Table 6. SEM of Inventory Management Model during a Global Crisis.

Latent variable	λ	t.	R ²	Observed Variables	λ	S.E.	t.	R ²
Safety Stock	0.87	-	75.0%	SAFE1	0.67	-	-	44.0%
				SAFE2	0.54	0.14	7.424***	29.0%
				SAFE3	0.78	0.13	9.527***	61.0%
Information Integration	0.97	8.689***	94.0%	IMFO1	0.76	-	-	57.0%
				IMFO2	0.66	0.09	9.720***	43.0%
Methodology Decision	0.89	8.291***	80.0%	METH1	0.74	-	-	55.0%
				METH2	0.82	0.10	11.168***	67.0%
Products Life Cycle	0.87	8.240***	76.0%	PROD1	0.77	-	-	59.0%
				PROD2	0.81	0.10	11.292***	66.0%
Logistic Management	0.89	7.998***	78.0%	LOGI1	0.72	-	-	51.0%
				LOGI2	0.85	0.09	11.195***	71.0%
Economic Condition	0.81	8.165***	65.0%	ECON1	0.81	-	-	66.0%
				ECON2	0.84	0.10	12.365***	71.0%

*** Significant at the 0.001 level

The analysis confirmed the structural equation modeling (SEM) of Inventory and Production Impact Factors during a Global Crisis, encompassing 13 observable variables: Safety Stock, Information Integration, Methodology Decision, Product Life Cycle, Logistic Management, and Economic Conditions. The findings demonstrated that the squared multiple correlation coefficients (R²) for the observed variables ranged from 29.0% to 71.0%, with standardized factor loadings

between 0.54 and 0.85, and error variances spanning from 0.09 to 0.14; the path coefficients are summarized as follows;

1. Safety Stock (SAFE) consists of three latent variables (SAFF1 – SAFF3) with standardized factor loadings ranging from 0.54 to 0.78 and squared multiple correlation coefficients between 22.0% and 61.0%. The analysis revealed that the latent variable of safety stock significantly influenced structural equation modeling related to inventory and production during a Global Crisis. The regression weight estimate for standardized coefficients was 0.87, with a significance level of 0.000, indicating a model change (R^2) of 75.0%, significant at or below the 0.001 level. This can be represented as a structural equation modeling framework designed to analyze inventory and production impact factors during a Global Crisis, with standardized estimates presented for the safety stock model accordingly.

$$\text{SAFE} = 0.67^{***}(\text{SAFF1}) + 0.54^{***}(\text{SAFF2}) + 0.78^{***}(\text{SAFF3})$$

2. Information Integration (IMFO) reveals two latent variables (IMFO1 – IMFO2) with standardized factor loadings ranging from 0.66 to 0.76 and squared multiple correlation coefficients between observed variables of 43.0% to 57.0%. The findings indicate that the latent variable of information integration significantly influences the structural equation modeling analysis of inventory and production factors amid a Global Crisis. This is evidenced by a regression weight estimate of standardized coefficients at 0.97, $t = 8.689$, and $\text{Sig. } 0.000 < 0.05$, demonstrating a change in the model (R^2) at 94.0%, significant at or below the 0.001 level. The results can be represented in a structural equation modeling framework that elucidates the inventory and production impact factors during a Global Crisis, reflecting the information integration model in standardized estimates.

$$\text{IMFO} = 0.76^{***}(\text{IMFO1}) + 0.66^{***}(\text{IMFO2})$$

3. Methodology Decision (METH) identifies two latent variables (METH1 – METH2) with standardized factor loadings ranging from 0.74 to 0.82 and squared multiple correlation coefficients between 55.0% and 67.0%. The findings indicate that the latent variable of methodology decision significantly impacts the structural equation modeling analysis concerning inventory and production factors during a Global Crisis. This is evidenced by a regression weight estimate of standardized coefficients at 0.89, $t = 8.291$, and $\text{Sig. } 0.000$, indicating a model change influence (R^2) of 80.0%, significant at or below the 0.001 level. The results can be illustrated through a structural equation modeling of inventory and production factors during a Global Crisis, represented in standardized estimates.

$$\text{METH} = 0.74^{***}(\text{METH1}) + 0.82^{***}(\text{METH2})$$

4. Products Life Cycle (PROD) comprises of two latent variables (PROD1 – PROD2) with factor loadings ranging from 0.77 to 0.81, and observed variable correlation coefficients between 59.0% and 66.0%. The findings indicate that the products life cycle latent variable significantly affects the structural equation modeling analysis of inventory and production factors amidst a Global Crisis. This is evidenced by a regression weight estimate of standardized coefficients at 0.87, $t = 8.240$, and $\text{Sig. } 0.000$, indicating significance below 0.05, with a model change influence (R^2) of 76.0%, significant at the 0.001 level. Thus, it can be represented as a structural equation modeling of the inventory and production factors during a Global Crisis within the products life cycle model, with standardized estimates as follows.

$$\text{PROD} = 0.77^{***}(\text{PROD1}) + 0.81^{***}(\text{PROD2})$$

5. Logistic Management (LOGI) reveals two latent variables (LOGI1 – LOGI2) with standardized factor loadings ranging from 0.72 to 0.85 and squared multiple correlation coefficients between observed variables from 51.0% to 71.0%. The findings indicate that the latent variable of logistic

management significantly impacts the structural equation modeling analysis concerning inventory and production factors amid a Global Crisis. This is evidenced by a regression weight estimate of standardized coefficients at 0.89, $t = 7.998$, and $\text{Sig. } 0.000 < 0.05$, demonstrating a model change (R^2) of 78.0%, significant at or below the 0.001 level. The results can be illustrated as a structural equation modeling framework for inventory and production factors during a Global Crisis, represented by standardized estimates as follows;

$$\text{LOGI} = 0.72^{***}(\text{LOGI1}) + 0.85^{***}(\text{LOGI2})$$

6. Economic Condition (ECONI) encompasses two latent variables (ECON1 – ECON2) with standardized factor loadings ranging from 0.81 to 0.84 and squared multiple correlation coefficients between 66.0% and 71.0%. The analysis indicates that the latent variable related to economic conditions significantly influences the structural equation modeling pertaining to inventory and production factors amidst a Global Crisis. This is evidenced by a regression weight estimate of standardized coefficients at 0.81, $t = 8.165$, and a significance level of 0.000, which is less than 0.05, along with a model change influence (R^2) of 81.0% that is significant at or below the 0.001 level. The findings can be represented through structural equation modeling of the inventory and production impact factors during a Global Crisis as per the economic condition model in standardized estimate scores.

$$\text{ECON} = 0.81^{***}(\text{ECON1}) + 0.84^{***}(\text{ECON2})$$

In summary, the research examines path testing and structural equation modeling of Inventory and Production Impact Factors amid a Global Crisis. The predominant factor identified was Information Integration, possessing a standardized coefficient of 0.97, elucidating a 75.0% influence rate. The subsequent factor was Logistic Management and Methodology Decision, with a standardized coefficient of 0.89, succeeded by Safety Stock and Products Life Cycle at 0.87. The Economic Condition, with a standardized coefficient of 0.81, demonstrated significance at or below the 0.001 threshold. The findings can be articulated through a structural equation model representing inventory and production impact factors during a Global Crisis, with standardized estimates presented accordingly.

$$\begin{aligned} \text{IMIF} = & 0.87^{***}(\text{SAFE}) + 0.97^{***}(\text{IMFO}) + 0.89^{***}(\text{METH}) \\ & + 0.87^{***}(\text{PROD}) + 0.89^{***}(\text{LOGI}) + 0.81^{***}(\text{ECON}) \end{aligned}$$

The results presented in SEM provide valuable insights into the key factors influencing inventory and production dynamics amid a global crisis. The model illustrates the relationships between various impact factors, with the standardized coefficients quantifying the strength of these relationships. Each factor's influence is indicated by the magnitude of its standardized coefficient, with higher values signifying a stronger influence. Information Integration, with a coefficient of 0.97, is the primary factor affecting inventory and production during global crises, explaining 75% of variance. This coefficient indicates that effective information exchange across the supply chain is vital during disruptions. Information Integration facilitates enhanced decision-making, rapid demand response, and improved stakeholder coordination, crucial for disruption mitigation in crises (Christopher, 2011).

5. Findings and Discussion

The study identifies six domains and thirteen factors influencing inventory control performance in the eyeglass lens sector during global crises. The eyeglass lens manufacturing process encompasses four functions: Supplier, Manufacturing, Distribution Inventory, and Hospital & Eyecare providers, all pertinent to operational management during crises. The SIMPLE model serves as a central operational driver within Supply Chain Management. This study proposes a model for managing Eyeglass Lens

inventory to mitigate supply loss during global crises. The model aids in implementing inventory control strategies to enhance performance within the Eyeglass Lens industry during these critical periods, as illustrated in Fig 7.

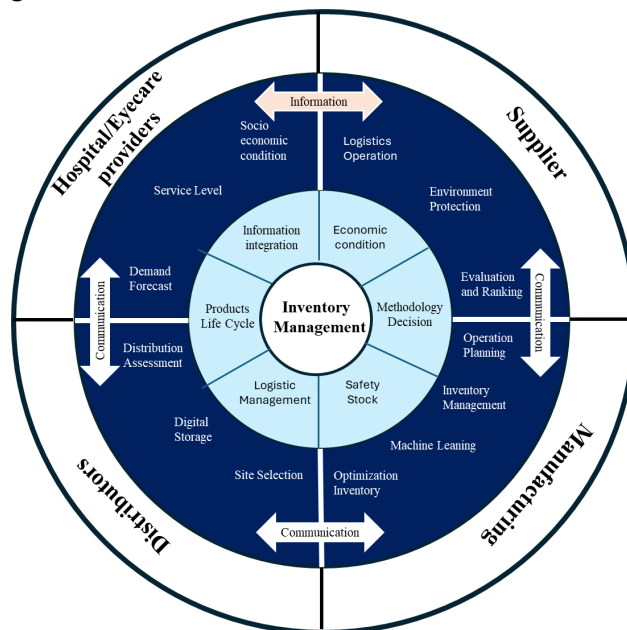


Fig. 7: The SIMPLE Model

S: Safety stock pertains to Manufacturing and Distribution functions, relating to Inventory management, Machine Learning, and Optimization Inventory. The principal risk affecting inventory holding costs arises from finished goods and raw materials to align with customer demand and supply. According to Swain et al. (2021), optimal ordering policy formulation under generalized time-dependent demand demonstrates the impact of quadratic holding costs on inventory management, while Singh and Rana (2020) examine inflation and variable holding costs in a lifetime inventory model featuring multi-variable demand and lost sales.

I: Information integration involves the functions of Hospital & Eyecare providers and Suppliers, linked to Service Level and socio-economic conditions. The primary risk associated with communication networks includes customer and information loss during promotional sales, with implications for commercial and marketing functions. Buhaug et al. (2023) discusses climate-driven risks to peace, while Tan et al. (2021) presents a blockchain-based Service Level Agreement model for Industry 4.0 to enhance service level control through data information.

M: Methodology decisions pertain to Supplier and Manufacturing functions related to Evaluation and Ranking as well as Operational Planning for decision-making. The primary risk involves service quality that can lead to inefficiency and increased production costs due to erroneous decisions. Utama et al. (2016) discuss Supplier Performance Evaluation methods within the Plastic Manufacturing Industry, while Deveci et al. (2020) propose a decision support system for sustainable urban transportation assessment and prioritization.

P: The Products Life Cycle encompasses the Distribution function alongside Hospital and Eyecare providers, focusing on customer sharing tendencies and demand forecasting. The primary risks are associated with product variety, single-source production, and the short life cycle of Eyeglass lenses due to expiration. Demand fluctuations, seasonality, and fulfillment errors significantly influence inventory, potentially leading to excess stock and disposal challenges owing to extended lead times. Palanivel and Suganya (2021) discusses a Partial backlogging inventory model that integrates price-dependent demand, time-varying holding costs, and quantity discounts, emphasizing the necessity of effective inventory management within the product cycle.

L: Logistic Management encompasses Manufacturing and Distribution functions, which are

linked to Digital Storage and Site Selection to meet global demand. The primary risk arises from information infrastructure failures and incompatibility of IT platforms among supply chain partners, affecting the significance of information across all supply chain functions. Additionally, product allocation to manufacturing is influenced by high inventory levels and elevated transportation costs. Shastri et al. (2014) discusses supply chain management involving two-level trade credit financing with demand influenced by selling price, under the impact of preservation technology supporting inventory operations.

E : Economic conditions influence hospital and eyecare provider operations, as well as supplier activities related to logistics and environmental protection. Feliciano et al. (2022) evaluate agricultural emissions alongside climate change strategies, while Pescaroli et al. (2023) discusses organizational resilience and climate adaptation in emergency management.

6. Conclusions and Recommendations

6.1 Conclusions

This research analyzes inventory and production factors in the eyeglass lens industry during global crises, emphasizing six domains: Safety Stock, Information Integration, Methodology Decision, Products Life Cycle, Logistic Management, and Economic Conditions. These domains are critical for inventory control and operational continuity during disruptions. The study employs path testing and structural equation modeling (SEM), revealing Information Integration as the predominant factor, with a standardized coefficient of 0.97, accounting for 75% of the variance in performance. This highlights the necessity of effective information flow for rapid response and resilience against crises. Logistic Management and Methodology Decision are also crucial, with standardized coefficients of 0.89, reflecting their importance in sustaining inventory efficiency and service levels. Safety Stock and Products Life Cycle have coefficients of 0.87, indicating their roles in managing stock levels and product expiration amidst volatility in the eyeglass sector. Economic Conditions, with a coefficient of 0.81, significantly influence inventory management strategies, particularly during global crises.

The proposed inventory management model offers insights to mitigate supply losses and enhance operational efficiency during global crises. This model, grounded in the SIMPLE framework, serves as a strategic guide for eyeglass industry firms to adapt inventory management to crisis challenges. Implementing this model enables stakeholders in the eyeglass lens supply chain to navigate global disruptions more adeptly, improving inventory control and resilience. In conclusion, the research highlights the necessity for adaptive inventory management strategies in crisis contexts. By improving information integration, logistics, methodology decisions, and addressing economic fluctuations, the eyeglass lens industry can bolster its ability to endure and recover from disruptions, ensuring continuity amidst global adversities.

6.2 Theoretical Contribution

The research enhances theoretical knowledge on inventory management and supply chain resilience by pinpointing critical performance factors during global crises. The SIMPLE framework serves as a structured model for crisis-related inventory control, thereby enriching supply chain risk management literature. By unifying these domains, the study underscores the interdependence of operational and external elements in inventory management during disruptions, presenting a comprehensive view of supply chain resilience. Information Integration is identified as the most significant factor, supporting theories that highlight the necessity of data flow in supply chains. This supports the Resource-Based View (RBV) by demonstrating that information-sharing capabilities are vital resources for enhancing resilience during disruptions. In conclusion, the theoretical contributions of this study deepen the comprehension of crisis-focused inventory management by validating the necessity of integrated

strategies that incorporate both internal operational dynamics and external economic factors. The insights gleaned from this study may inform future research aimed at formulating adaptive, cross-functional approaches to inventory management under uncertainty, thereby enriching the theoretical framework for supply chain resilience in crisis contexts.

6.3 Managerial Implication

The SIMPLE framework provides insights for enhancing inventory management and supply chain resilience amid global crises. It identifies critical factors including Information Integration, Logistic Management, Methodology Decision, Safety Stock, Product Life Cycle, and Economic Conditions, offering a model for improving crisis management strategies. The proposed framework empowers managers to proactively manage inventory during crises, bolstering operational resilience and customer service. This enables businesses to sustain continuity and recover efficiently once stability is restored.

6.4 Limitations & Suggestion for Future Study

This study provides a framework for inventory management during global crises but has limitations that suggest avenues for additional research. First, the study focuses on the eyeglass lens industry, which has distinct demand and supply chain challenges, limiting the generalizability of the SIMPLE framework to other sectors. Future research could explore the application of the SIMPLE framework in various industries like perishables, pharmaceuticals, or electronics to evaluate its versatility and efficacy. Second, this research analyzes inventory management during a specific crisis period, presenting a static perspective. Future studies could implement a longitudinal methodology to understand how the influence of these factors shifts over time and across different crisis phases, revealing the adaptive strategies organizations utilize during extended disruptions. Third, the research overlooks potential differences in supply chain resilience linked to geographical or economic factors, particularly between developed and emerging markets. Future investigations could assess the framework's relevance in varied regions, examining how local factors such as infrastructure and regulatory environments impact inventory and production during crises. Fourth, the study highlights Information Integration but does not address the impact of advanced technologies like AI, blockchain, or IoT on supply chain resilience. Future research could explore how the incorporation of these technologies within the SIMPLE framework can enhance inventory management, decision-making, and risk mitigation. Finally, the research minimally addresses how shifts in consumer demand during crises affect inventory and supply chain management. Given the significant behavioral changes crises induce, future studies could delve into demand forecasting and consumer behavior models to refine inventory strategies. By addressing these limitations, future research can advance the insights of this study, refining the SIMPLE framework for broader applicability across various contexts, crises, and technological environments.

References

Arnold, J. R. T. (2011). *Introduction to materials management* (7th ed.). Prentice Hall.

Associated Press. (2024, January 19). *Panama Canal Traffic Cut by More Than a Third Because of Drought*. <https://apnews.com/article/panama-canal-global-trade-routes-drought-climate-change-bd76a77825a2e8e751a24346f8fd54a9>

Becerra, P., Mula, J., & Sanchis, R. (2021). Green supply chain quantitative models for sustainable inventory management: A review. *Journal of Cleaner Production*, 328, 129544. <https://doi.org/10.1016/j.jclepro.2021.129544>

- Bowersox, D. J., Closs, D. J., & Cooper, M. B. (2013). *Supply chain logistics management* (4th ed.). McGraw-Hill.
- Buhaug, H., Benjaminsen, T. A., Gilmore, E. A., & Hendrix, C. S. (2023). Climate-driven risks to peace over the 21st century. *Climate Risk Management*, 39, 100471. <https://doi.org/10.1016/j.crm.2022.100471>
- Cachon, G. P., & Fisher, M. (2000). Supply chain inventory management and the value of shared information. *Management Science*, 46(8), 1032-1048.
- Chen, X., Liu, Y., & Zhao, X. (2023). Digital transformation in global supply chains: Impact on inventory management and operational resilience. *Journal of Operations Management*, 65(3), 212-225.
- Choi T.Y. (2007). Supplier-supplier relationships: why they matter. *Supply Chain Management Review*, 11(5), 51-56.
- Chopra, S., & Meindl, P. (2016). *Supply chain management: Strategy, planning, and operation* (6th ed.). Pearson.
- Christopher, M. (2011). *Logistics and supply chain management* (4th ed.). Pearson.
- Christopher, M., & Peck, H. (2004). Building the resilient supply chain. *The International Journal of Logistics Management*, 15(2), 1-14.
- Coyle, J. J., Langley, C. J., Novack, R. A., & Gibson, B. J. (2016). *Supply chain management: A logistics perspective* (10th ed.). Cengage Learning.
- Das, K. (2021) *Explained: How much did Suez Canal blockage cost world trade” India Today*. <https://www.indiatoday.in/business/story/explained-how-much-didsuez-canal-blockage-cost-world-trade-1785062-2021-03-30>
- Deveci, M., Mishra, A. R., Gokasar, I., Rani, P., Pamucar, D., & Özcan, E. (2023). A decision support system for assessing and prioritizing sustainable urban transportation in metaverse. *IEEE Transactions on Fuzzy Systems*, 31(2), 475–484. <https://doi.org/10.1109/TFUZZ.2022.3190613>
- Diamantopoulos, A. & Siguaw, J.A. (2000). *Introduction to LISREL: A guide for the uninitiated*. SAGE Publications, Inc.
- Dutta, S., Shah, H., Dasari, A., Singal, K., Harikeerthi, N. Y., & Talakola, Y. R. (2017). Optimizing inventory through ABC classification and demand forecasting. In *Proceedings of the 17th International Annual Conference of the American Society for Engineering Management*. Huntsville, USA.
- Feliciano, D., Recha, J., Ambaw, G., MacSween, K., Solomon, D., & Wollenberg, E. (2022). Assessment of agricultural emissions, climate change mitigation and adaptation practices in Ethiopia. *Climate Policy*, 22(4), 427–444. <https://doi.org/10.1080/14693062.2022.2028597>
- Godichaud, M. & Amodeo, L. (2019). EOQ models with stockouts for disassembly systems. *IFAC PapersOnLine*, 52(13), 1681-1686, doi: 10.1016/j.ifacol.2019.11.442.
- Goffin, R. D. (2007). Assessing the adequacy of structural equation models: Golden rules and editorial policies. *Personality and Individual Differences*, 42(5), 831–839. <https://doi.org/10.1016/j.paid.2006.09.019>
- Gunasekaran, A., & Ngai, E. W. T. (2004). Information systems in supply chain integration and management. *European Journal of Operational Research*, 159(2), 269-295.

Hair, J. Black, F. Babin, W. C. and Anderson, R. E. (2010). *Multivariate data analysis: A global perspective*. Upper Saddle River, NJ: Pearson Education, international.

Hamdy, A., Al-Awamry, A., & Mostafa, N. (2022). Warehousing 4.0: A proposed system of using Node-RED for applying Internet of Things in warehousing. *Sustainable Futures*, 4, 100069. <https://doi.org/10.1016/j.sfr.2022.100069>

Hasbullah, H. & Santoso, Y. (2020). Overstock improvement by combining forecasting, EOQ, and ROP. *Journal PASTI*, 14(3), 230-242. doi:10.22441/pasti.2020.v14i3.002.

Hopp, W. J., & Spearman, M. L. (2008). *Factory physics* (3rd ed.). Waveland Press.

Hu, L., & Bentler, P. M. (1999). Cutoff criteria for fit indexes in covariance structure analysis: Conventional criteria versus new alternatives. *Structural Equation Modeling: A Multidisciplinary Journal*, 6(1), 1–55. <https://doi.org/10.1080/10705519909540118>

Kelloway, E.K. (2015). *Using Mplus for Structural Equation Modeling: A Researcher's Guide*. Sage Publications

Khan, M.G. Huda, N.U. & Zaman, U.K.U. (2022). Smart Warehouse Management System: Architecture, Real-Time Implementation and Prototype Design. *Machines*, 10(2), 150. <https://doi.org/10.3390/machines10020150>

Kholil, M. (2023). Lean manufacturing analysis to reduce delays in the inflight entertainment service before departure check-in process. *The International Journal of Scientific and Academic Research*, 3(2), 13–23. <https://doi.org/10.54756/IJSAR.2023.V3.2.3.2>

Krzyzaniak, S. (2022). Optimization of the stock structure of a single stock item taking into account stock quantity constraints, using a Lagrange multiplier. *Logforum*, 18(2), 261–269. <https://doi.org/10.17270/J.LOG.2022.730>

Kumar, S., & Chandra, C. (2024). Resilient supply chain management: A systematic review. *International Journal of Production Economics*, 270, 114631.

Lambert, D. M., & Stock, J. R. (2001). *Strategic logistics management* (4th ed.). McGraw-Hill.

Law, A. M. (2014). *Simulation modeling and analysis* (5th ed.). McGraw-Hill.

Li, Y., & Zobel, C. W. (2024). Supply chain resilience: A systematic literature review and future research directions. *International Journal of Production Economics*, 270, 114632.

Liu, X., Chen, X., & Zhang, Y. (2023). Digital transformation in healthcare supply chains. *Journal of Operations Management*, 67(1), 23-35.

Lutfi, M. I., Haekal, J., Kholil, M., & Mu'min, R. (2022). The Integration Of Business Process Reengineering And Snell X's Enterprise Resource Planning For Efficiency And Effectiveness: A Case Study Of Cosmetics And Household Sub Sector Companies. *Res Militaris*, 12(4),1767-1772.

Mueller, R.O. (1996). *Confirmatory factor analysis in basic principles of structural equation modeling: An introduction to LISREL and EQS*. Springer-Verlag.

Mu'min, R., Haekal, J., Lutfi, M. I., Kholil, M., & Mohd Yunus, K. N. (2023). The Implementation Of Cloud Enterprise Resource Planning By Snell X In Manufacturing Process Strategy: A Case Study Of Skincare's Company. *Jurnal Penelitian dan Aplikasi System dan Teknik Industrial*, 17(1), 13-20.

Nahmias, S., & Olsen, T. L. (2015). *Production and operations analysis* (7th ed.). Waveland Press.

- Palanivel, M., & Suganya, M. (2021). Partial backlogging inventory model with price and stock level dependent demand, time varying holding cost and quantity discounts. *Journal of Management Analytics*, 9(1), 32–59. <https://doi.org/10.1080/23270012.2021.1887771>
- Pescaroli, G., Guida, K., Reynolds, J., Pulwarty, R. S., Linkov, I., & Alexander, D. E. (2023). Managing systemic risk in emergency management, organizational resilience and climate change adaptation. *Disaster Prevention and Management: An International Journal*, 32(1), 234–251.
- Proctor P. Reid, W. Dale Compton, Jerome H. Grossman, and Gary Fanjiang. (2005). *Building a Better Delivery System: A New Engineering/HealthCare Partnership*. <https://pubmed.ncbi.nlm.nih.gov/20669457/>
- Ropi, N. M., Hishamuddin, H., Wahab, D. A., & Saibani, N. (2021). Optimization models of remanufacturing uncertainties in closed-loop supply chains: A review. *IEEE Access*, 9, 160533–160551. <https://doi.org/10.1109/ACCESS.2021.3132096>
- Rossit, D.A., Tohme, F. & Frutos, M. (2019). A data-driven scheduling approach to smart manufacturing. *Journal of Industrial Information Integration*, 15, 69–79. <https://doi.org/10.1016/j.jii.2019.04.003>
- Rushton, A., Croucher, P., & Baker, P. (2017). *The handbook of logistics and distribution management* (6th ed.). Kogan Page.
- Shams, E., Ranjbari, Z., & Scagnelli, M. (2022). The imbalance of food and biofuel markets amid Ukraine-Russia crisis: A systems thinking perspective. *Biofuel Research Journal*, 9, 1640–1647.
- Shams, R., Gunasekaran, A., & Marimuthu, M. (2022). Supply chain risk management in global crises: Insights from COVID-19 and beyond. *Supply Chain Management: An International Journal*, 27(3), 307-323.
- Shao, X.F., Liu, W., Li, Y., Chaudhry, H.R. & Yue, X.G. (2021). Multistage implementation framework for smart supply chain management under industry 4.0. *Technological Forecasting and Social Change*, 162, 120354. <https://doi.org/10.1016/j.techfore.2020.120354>
- Shastri, A. S., Singh, R., Yadav, D., & Gupta, S. (2014). Supply chain management for two-level trade credit financing with selling price dependent demand under the effect of preservation technology. *Inderscience Enterprises Ltd*, 7(6), 695–718.
- Singh S.R. and Rana, K. (2020). Effect of inflation and variable holding cost on life time inventory model with multi variable demand and lost sales. *International Journal of Recent Technology and Engineering (IJRTE)*, 8(5), 2277-3878. DOI:10.35940/ijrte.E6249.018520
- Smith, R., & Johnson, M. (2023). Crisis management in global supply chains. *Supply Chain Management Review*, 57(2), 12-19.
- Stevenson, W. J. (2020). *Operations management* (14th ed.). McGraw-Hill.
- Suez Canal Blockage a Large Loss Event for Global Reinsurers. (2021). *Fitch Ratings*. <https://www.fitchratings.com/research/insurance/suez-canal-blockagelarge-loss-event-for-global-reinsurers-29-03-2021>.
- Swain, P., Mallick, C., Singh, T., Mishra, P. J., & Pattanayak, H. (2021). Formulation of an optimal ordering policy with generalised time-dependent demand, quadratic holding cost and partial backlogging. *Journal of Information and Optimization Sciences*, 42(5), 1163–1179. <https://doi.org/10.1080/02522667.2021.1938988>

- Swain, M., Singh, R., & Rana, V. (2021). Optimal ordering policy formulation under generalized time-dependent demand. *European Journal of Operational Research*, 295(1), 285-295.
- Tan, W., Zhu, H., Tan, J., Zhao, Y., Xu, L. D., & Guo, K. (2021). A novel service level agreement model using blockchain and smart contract for cloud manufacturing in industry 4.0. *Enterprise Information Systems*, 16(12). <https://doi.org/10.1080/17517575.2021.1939426>
- Torbacki, W., & Kijewska, K. (2019). Identifying key performance indicators to be used in Logistics 4.0 and Industry 4.0 for the needs of sustainable municipal logistics by means of the DEMATEL method. *Transportation Research Procedia*, 39, 534–543. <https://doi.org/10.1016/j.trpro.2019.06.055>
- Utama, D. M., Baroto, T., Ibrahim, M. F., & Widodo, D. S. (2016). Evaluation of supplier performance in plastic manufacturing industry: A case study. *Journal of Physics: Conference Series*, 1845, The International Conference on Industrial Automation, Smart Grid and its Application (ICIASGA), 4–5 November 2020, Jawa Timur, Indonesia.
- Wang, S., Zhang, J., & Huang, X. (2024). Crisis management in global supply chains: Lessons from COVID-19 and beyond. *Supply Chain Management: An International Journal*, 29(2), 134-150.
- Wang P., & Hill J.A., (2006). Recursive behavior of safety stock reduction: the effect of lead-time uncertainty. *Decision Sciences*, 37(2), 285-90.
- World Health Organization. (2021). *WHO COVID-19 situation dashboard*. WHO Health Emergency Dashboard.
- Xu Z., Elomri A., Kerbache L., and Omri A. el. (2020). Impacts of COVID-19 on Global Supply Chains: Facts and Perspectives. *IEEE Engineering Management Review*, 48(3), 153–166.
- Zhang, H., & Liu, L. (2023). Machine learning applications in inventory optimization: A comprehensive review. *Computers & Industrial Engineering*, 163, 107944.
- Zhou, H., & Benton, W. C. (2007). Supply chain practice and information sharing. *Journal of Operations Management*, 25(6), 1348-1364.
- Zoubek, M., & Šimon, M. (2021). A framework for a Logistics 4.0 maturity model with a specification for internal logistics. *MM Science Journal*, 2021, 4264–4274. https://doi.org/10.17973/MMSJ.2021_03_2020073
- Zsidisin G.A., Panelli, A. and Upton, R. (2000). Purchasing organization involvement in risk assessments, contingency plans, and risk management: an exploratory study. *Supply Chain Management: An International Journal*, 5(4), 187-198.
- Zsidisin, G. A., Ellram, L. M., Carter, J. R., & Cavinato, J. L. (2000). A review of supply risk management. *Journal of Supply Chain Management*, 36(4), 14-27.