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Leveraging Forecasting Model with Machine Learning Approach and Deploying Supply Chain Strategies to Revitalize Business Performance During the 2023 Economic Fall

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Abstract

The aftereffects of the COVID-19 epidemic highlighted the need for efficient data-driven approaches to tracking, comprehending, and mitigating its effects. This study examines the application of statistical forecasting model and inventory management strategies to revitalize business operations during the 2023 economic downturn. Before that, the SCOR Model and Failure Mode and Effect Analysis (FMEA) method are used in a consumer electronic and home appliance company to identify the key supply chain risk components those need to be addressed immediately. Despite such an economic fall, which never happened in previous years, achieving forecasting accuracy and supply assurance with optimized inventory is a long-standing issue. The company achieved a 54% oversell in the first half of 2023 by utilizing regression analysis with a statistical forecasting model, resulting in an additional revenue of $1.7M. Improvements in inventory management, including the deployment of a reorder model and inventory profiling, led to an 85% reduction in slow-paced inventory, a 65% reduction in air shipment costs, less CO2 emission, and optimized inventory levels across over 430 retail outlets. These strategies optimized resources and facilitated the successful and timely launch of new products. The case highlights how data-driven supply chain management can significantly enhance business performance in challenging economic environments.

Keywords
SCOR Model, Failure Mode and Effect Analysis (FMEA) Method, Regression Analysis, Statistical Forecasting, Re-order Model, After COVID Impact/Economic Downturn.

1. Introduction

In modern practices, Supply Chain Management (SCM) begins with customer requirement and ends with customer requirement fulfillment (Ahmed and Shuvro 2023). The supply chain is the active integration of business activities from original suppliers through end-users that provide services, products, and information to maximize customer value and achieve sustainable competitive advantage. The rise of the information technology revolution, economic globalization, and increased customer expectations have brought significant changes to supply chain management (SCM) (Tirkolaee et al. 2021).

The goal is to improve the long-term performance of each function and the supply chain overall by strategically coordinating the traditional business functions and techniques among these functions within a specific organization (Marinagi and Trivellas 2014).

Supply Chain (SC) components spread out through various departments generally work as entities where integrated effort is missing. If information flow is hampered across departments, price fluctuations, limited supplier resources, a disrupted planning process, and less supplier collaboration impacts business performance negatively. Here we have proposed a modernized supply chain process in Figure 1 and discussed all its vital stages including the Demand planning and fulfillment process.

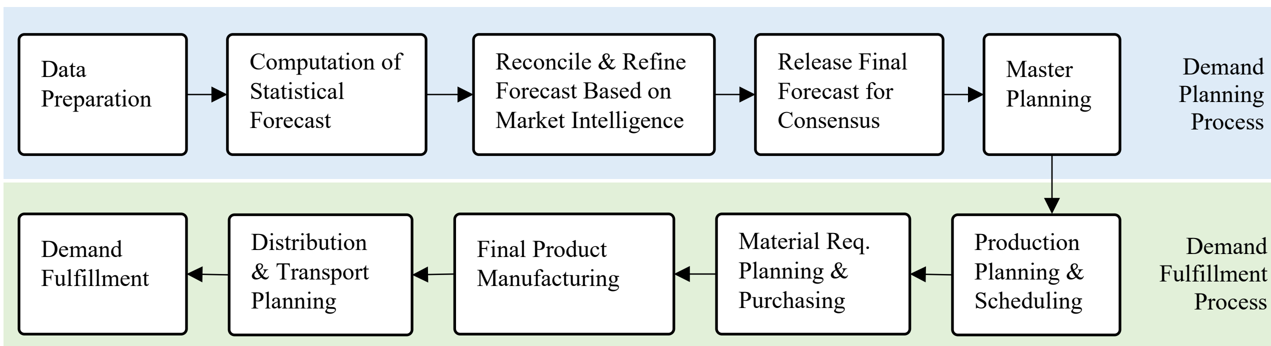


Figure 1. Demand Planning and Demand Fulfillment Process in Supply Chain

The demand planning and fulfillment process is very important in supply chain management to create a connection between forecasting, production, and delivery. Staring with gathering and preparing data by considering historical sale trends, market insights, and external factors to build a solid foundation (Fildes et al. 2008).

The demand fulfillment process starts with implementing the master plan into action. After production planning and scheduling, timelines and resources are allocated with tools like Material Requirements Planning (Gunasekaran et al. 2004). Procurement function ensures that raw materials are available at the right time by coordinating purchasing activities and minimizing variability (Lee et al. 1997). Raw materials are then transformed into finished goods through efficient manufacturing processes and rigorous quality checks (Womack et al., 1990).

For distribution and transport planning process, logistics teams work with optimizing transport routes to ensure timely deliveries (Rodrigue et al. 2016). The process ends by delivering the right products to the right place at the right time to meet customer expectations (Christopher 2016). This cohesive approach promotes collaboration across departments, mitigates supply chain risks, and enhances overall efficiency and responsiveness, aligning day-to-day operations with customer needs (Stadtler 2005).

Based on this process, we have developed a conceptual framework and hypotheses to design a model aimed at achieving operational advantages and driving positive business performance during the post-COVID-19 economic downturn. Furthermore, we applied the SCOR Model and the Failure Mode and Effect Analysis (FMEA) method company to identify and prioritize key supply chain risks to address economic challenges, achieving forecasting accuracy, supply assurance, and optimized inventory management.

2. Literature Review

The reviewed literatures are ranging from different fields to some different research streams: different techniques or strategies used in the area of supply chain. The key focus was to find how different supply chain and data science components are used to regenerate business performance during the post pandemic period. This paper also compared with other parameters like research gap for further analysis and area of contribution for quick insight. It is observed that the most of the papers did either an impact analysis or strategic modeling on a specific area. Below Table 1 shows the summary of the contributions of different papers where the contribution of this paper also highlighted.

Table 1. The contributions of different papers

Year	**Paper Title**	**Authors**	**Summary**	**Research Gap**	**Area of Contribution**
2020	Global Economic Effects of COVID-19: In Brief	Jackson, J.K., Weiss, M.A., Schwarzenberg, A.B., and Nelson, R.M.	Provides an overview of the immediate global economic impacts of COVID-19, emphasizing supply chain disruptions and unemployment.	Lacks detailed analysis of policy responses and their long-term effectiveness in economic recovery.	Immediate economic impact analysis
2021	Applying Regression Models For Covid-19 Analysis	Raja Kishor Duggirala	Explores the application of regression models to analyze trends and impacts of COVID-19, focusing on health and economic factors.	Limited analysis on sector-specific economic impacts and practical implementation of regression insights.	Statistical modeling for pandemic trend analysis
2021	After-effects of the COVID-19 Pandemic: Prospects for Medium-Term Economic Damage	Barrett, M.P., Das, M.S., Magistretti, G., Pugacheva, E., and Wingender, M.P.	Assesses the medium-term economic consequences of the pandemic, including labor market shifts and fiscal impacts.	Insufficient focus on long-term structural economic changes and varying impacts across industries.	Medium-term economic forecasting
2021	Supply Chain Integration Enables Resilience, Flexibility, and Innovation to Improve Business Performance in COVID-19 Era	(Authors not specified)	Investigates how supply chain integration enhances resilience, flexibility, and innovation, thereby improving business performance during COVID-19.	Limited focus on industry-specific applications and long-term sustainability impacts.	Supply chain integration strategies during disruptions.
2022	The Economic Impact of COVID-19 Around the World	Martin, F.M., Sánchez, J.M., and Wilkinson, O.	Investigates the global economic effects of COVID-19, highlighting disparities across countries and regions.	Lacks detailed analysis of sector-specific recovery trajectories and post-pandemic economic resilience.	Global economic analysis and disparity insights
2022	Considering Economic Indicators and Dynamic Channel Interactions to Conduct Sales Forecasting for Retail Sectors	Wang, C.H.	Develops a sales forecasting model for retail sectors by incorporating economic indicators and dynamic channel interactions.	Does not address the impact of unpredictable pandemic-related variables on retail sector forecasting.	Sales forecasting for retail during economic disruptions
2022	Creating Supply Chain Resilience During and Post-COVID-19 Outbreak: The Organizational Ambidexterity Perspective	Ocicka, B., Mierzejewska, W., & Brzeziński, J.	Explores the role of organizational ambidexterity in building supply chain resilience during and after the COVID-19 pandemic.	Needs empirical validation across diverse industries and regions.	Organizational strategies for enhancing supply chain resilience.
2024	Analyzing the Varied Impact of COVID-19 on Stock Markets: A Comparative Study of Low-and High-Infection-Rate Countries	Teitler Regev, S., and Tavor, T.	Compares stock market performance in countries with varying COVID-19 infection rates, analyzing market volatility and recovery trends.	Limited exploration of the underlying factors driving market resilience or vulnerability.	Stock market performance during crises
2024	Analyzing Resilience and Legality in Post-Pandemic Sustainable Supply Chain Management: A Systematic Literature Review	Gupta, N., Gunawan, I., & Kamineni, R.	Examines the integration of leanness, agility, and resilience in developing sustainable supply chains, particularly in Australian civil infrastructure projects.	Lacks empirical studies validating proposed frameworks in real-world settings.	Frameworks for sustainable and resilient supply chains
2024	**This Paper**	K. M. S. Ahmed, J. N. Joti, M. S. Raiyan	The study explores the use of statistical forecasting models and other SC strategies to revitalize business performance during the 2023 economic downturn.	The study lacks a comprehensive discussion of the proposed strategies across different industries and global regions.	Data-driven SC management, statistical forecasting, inventory optimization, re-order & safety stock model, environmental sustainability and resource allocation

3. Conceptual framework and hypotheses

The conceptual framework for the investigation is displayed in Figure 2 below. The framework states that a total of six SCM Strategic Practices will influence organizational performance through direct effects and operational benefits. The six strategic practices include waste/slow-moving stock management, logistical optimization, information or forecast sharing, strategic planning, and strategic negotiation. (Rasi et al. 2016) (Li et al. 2006)

The hypotheses developed for this study are as follows:

H1: SCM Strategic Practices directly and positively affects organizational performance of the company.
H2: Competitive Advantage is positively related to organizational performance of the company.
H3: SCM Strategic Practices directly and positively affects competitive advantage of the company

SCM strategic practices can be defined as the set of activities in an organization to ensure effective supply chain management. Different type of SCM strategic practices are discussed in details in the following paragraphs.

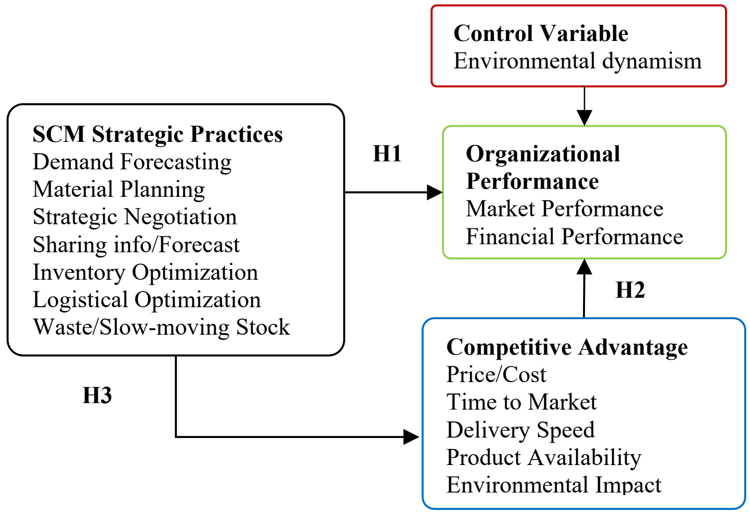


Figure 2. Research framework

3.1. SCM strategic practices

Strategic Planning: Strategic planning involves designing long-term supply chain goals and aligning them with business objectives. It ensures that the supply chain is resilient and can adapt to market changes. This process includes evaluating internal and external environments, setting key performance indicators (KPIs), and identifying risks and opportunities. Strategic planning enables businesses to build sustainable supply chain models that support agility and innovation (Chopra et al. 2016).

Strategic Negotiation: Strategic negotiation focuses on building partnerships with suppliers and stakeholders to secure favorable terms while ensuring quality and sustainability. This involves leveraging data, understanding market dynamics, and creating win-win scenarios that promote long-term collaboration. Effective negotiation strategies can reduce costs, improve supply chain resilience, and enhance supplier relationships (Cousins et al. 2004)

Sharing Information/Forecast: Sharing real-time data and forecasts between supply chain partners improves transparency and decision-making, reducing the bullwhip effect. It allows for better synchronization of production and inventory management across the supply chain. Collaborative forecasting not only enhances demand planning accuracy but also builds trust among partners by promoting accountability and data-driven strategies (Lee et al. 1997)

Customer Satisfaction: Ensuring customer satisfaction is critical by delivering products and services on time, in the right quantity, and in optimal condition. This involves understanding customer needs, providing seamless communication, and consistently exceeding service expectations. Companies with high customer satisfaction levels often experience increased loyalty, repeat business, and competitive advantage (Christopher 2016).

Logistical Optimization: Logistical optimization focuses on improving transportation routes, reducing costs, and ensuring timely deliveries. This involves leveraging advanced tools like AI and IoT to monitor and enhance logistics performance. Efficient logistical operations reduce delays, cut down fuel consumption, and minimize overall supply chain costs, contributing to greater sustainability (Rodrigue 2016).

Waste/Slow-moving Stock Management: Effective inventory management practices, such as lean management, aim to reduce waste and address slow-moving inventory issues. This involves identifying non-performing inventory, analyzing demand patterns, and implementing Just-in-Time (JIT) principles. Reducing slow-moving stock not only minimizes holding costs but also improves cash flow and operational efficiency (Womack 1990).

3.2. Control Variable

Dynamism occurs when decision-makers are unable to predict future events using the information available to them. Highly dynamic environments pose significant challenges for manufacturers, making it increasingly difficult to achieve superior performance as the level of environmental dynamism rises. Scholars such as (Anderson and Tushman 2001) consider environmental dynamism to be one of the most critical competitive factors influencing the survival of business units. Given its potential effect on performance, we incorporated it as a control variable in our analysis.

3. Research Procedure

This flowchart describes a structured research methodology for risk analysis in supply chain management, integrating the SCOR Model and FMEA. First of all, observe the real situation to identify inefficiencies and risks, guided by the SCOR framework for assessing the performance of a supply chain. Extensive literature review is conducted to present the base for the research study, and then comes the formulation of specific objectives, usually related to the identification and mitigation of risk. Information is gathered regarding the research study from the stakeholders or through interviews or observations; SCOR proceeds to appraise the reliability and cost issues, while FMEA considers the severity, occurrence, and detection of risks. The data processed further calculates Risk Priority Numbers for prioritizing critical issues. Next, the analysis and discussion identify the main risks and inefficiencies, match them against SCOR and FMEA insights, and suggest ways of improvement. The research concludes by summarizing its findings and strategies for improving supply chain resilience and performance. This approach is supported by prior research, including (Huang et al. 2004) on SCOR's application, (Stamatis 2003) on FMEA, and Supply Chain Council (2012) guidelines that point out the combined effectiveness of these methodologies in improving supply chain processes (Figure 3).

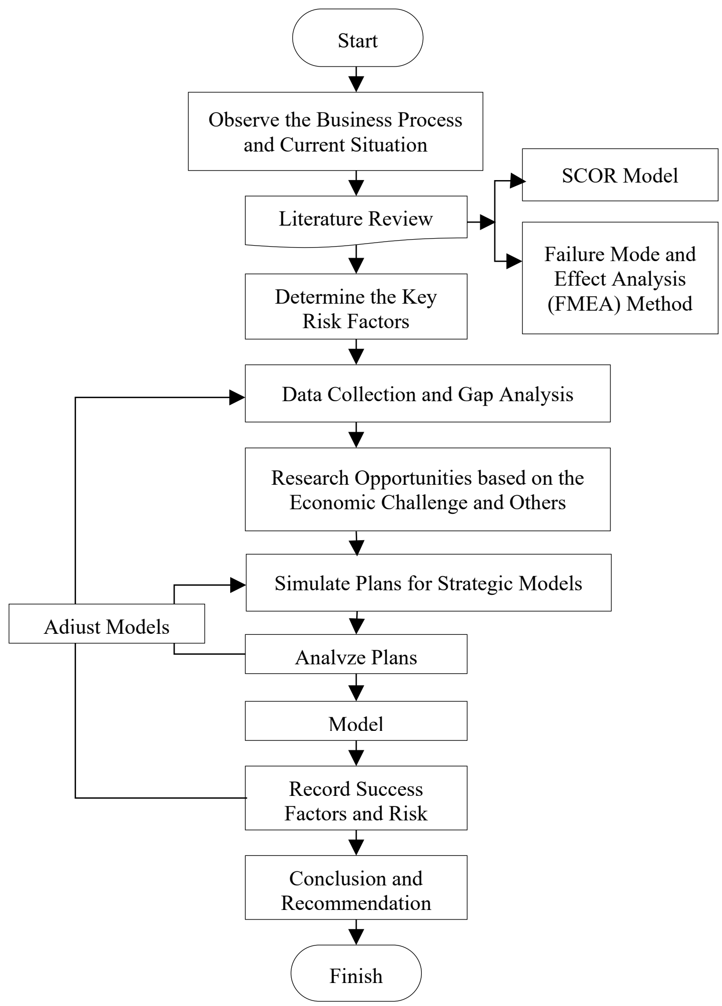


Figure 3. Research methodology

4. SCOR Model and Failure Mode and Effect Analysis (FMEA) Method

To identify the critical supply chain components those should be addressed immediately and to ensue performance from it we went through a brief literature review process. As a result, Failure Mode and Effect Analysis Method was applied based on the critical components found through SCOR model. (Ariyanti and Andika 2016)

5.1 SCOR Model

Supply Chain Operations Reference Model is a comprehensive framework used to analyze, evaluate, and improve supply chain performance. The model provides standardized terminology and a structured approach for organizations to measure and enhance supply chain efficiency and effectiveness. The SCOR model organizes supply chain activities into six primary processes:

Plan: Activities related to planning supply chain resources and aligning them with demand. Examples: demand forecasting, inventory planning, and capacity management.
Source: Processes for procuring goods and services needed for production. Examples: supplier selection, purchasing, and supplier performance monitoring.
Make: Encompasses production and manufacturing processes. Examples: production scheduling, quality control, and packaging.
Deliver: Focuses on order fulfillment and the logistics of delivering products to customers. Examples: warehousing, transportation, and distribution management.
Return: Addresses reverse logistics, including returns of defective or excess products. Examples: product recall, warranty handling, and recycling.
Enable: Support processes that facilitate the core supply chain activities. Examples: data management, compliance, and risk assessment

5.2 FMEA Method

Failure Mode and Effect Analysis method is a systematic, proactive approach for identifying and evaluating potential failures in a product, process, design, or system. It is widely used in various industries to enhance reliability, improve safety, and ensure quality.

The FMEA method and the SCOR model approach was established in Table 2, after conducting a thorough analysis in a company record/data. In the case of FMEA, the Risk Priority Number (RPN) is utilized to prioritize the risks associated with failure modes (Wang et al., 2009). The RPN is determined by using the following formula to prioritize failure modes for corrective action:

$$RPN = \text{Severity } (S) \times \text{Occurrence } (O) \times \text{Detection } (D) \quad (1)$$

RSV is determined by using the following formula to prioritize risks:

$$RSV = \text{Severity } (S) \times \text{Occurrence } (O) \quad (2)$$

The identified risks were evaluated based on their severity, likelihood of occurrence, and detection capability. Subsequently, the Risk Priority Number (RPN) and Risk Score Value (RSV) were calculated using formulas (1) and (2), respectively. The outcomes of these calculations are presented in Table 3.

To identify and evaluate the critical supply chain risk factors, a combination of Pareto Chart and Scatterplot analysis was employed, utilizing calculated Risk Priority Numbers (RPN) and Risk Severity Values (RSV). The Pareto Chart, generated using Minitab software, served as the foundation for applying the 80/20 principle, highlighting the most impactful risk factors. Scatterplots were also developed in Minitab by plotting all RPN and RSV values and determining interpolated reference lines derived from the Pareto analysis. As illustrated in Figure 2, the analysis revealed four key risks located in Quadrant 1, which should be prioritized for developing effective mitigation strategies and control measures.

Table 2. Risk Identification for Plan, Source, Make, Delivery, and Return Process.

Process	**Code**	**Risk Factors**
Plan	P1	The impact of volatile and uncertain (VUCA) macroeconomic conditions on demand forecasting accuracy.
	P2	Risks arising from regulatory and environmental changes impacting supply chain planning.
	P3	Competitive pressure from new business strategies adopted by competitors.
	P4	Disruptions caused by sudden technological advancements outpacing current capabilities.
	P5	Accumulation of slow-moving inventory and obsolete stock due to low or no demand.
	P6	Shifts in consumer preferences leading to forecast inaccuracies and demand uncertainty.
Source	S1	Disruptions in product sourcing due to changes in government regulations.
	S2	Incidences of defective, missing, or low-quality parts and components from suppliers.
	S3	Supplier production capacity constraints causing delays in fulfilling orders.
	S4	Shortages in base materials at the supplier end impacting the supply chain.
	S5	Delays in shipment caused by supplier-side or logistics partner issues.
	S6	Prolonged material in-house lead times affecting downstream operations.
Make	M1	Disruptions in manufacturing caused by machine breakdowns and equipment failures.
	M2	Deviations between planned and actual production outputs at the SKU level.
	M3	Production disruption due to shortages of raw materials.
	M4	Shortages in skilled or unskilled manpower disrupting production schedules.
	M5	Limitations in production capacity restricting the ability to meet demand.
	M6	Delays in third-party manufacturing processes impacting overall timelines.
	M7	Avoidable raw material wastage or imbalance leading to inefficiencies in production.
Delivery	D1	Underutilization of logistics capacity leading to increased costs and inefficiencies.
	D2	Shortages of labor for transportation and distribution activities.
	D3	Product damages resulting from poor handling during transit and delivery.
	D4	Re-distribution processes impacting service levels.
	D5	Shortages of logistics resources (vehicles, carriers, etc.) causing delivery delays.
Return	R1	Delays in customer service processes impacting product returns and resolution times.
	R2	Unavailability of spare parts critical to servicing and repair operations.
	R3	Damages to parts and components during the warranty period leading to customer dissatisfaction.

The first quadrant consists of 4 risks consisting of supply chain process that occurs, for example the risk in the make process with code M3 regarding production disruption due to shortages of raw materials. The next example is the risk from the plan process with code P5 regarding accumulation of slow-moving inventory and obsolete stock due to low or no demand. The risks above are sorted by the largest RPN value, so risk control starts from code P1, D4, P5, and M3. The second quadrant, located at the top left of the scatterplot, represents risks that occur frequently but have minimal impact on the company's operations. Consequently, the risks in this quadrant are not considered a priority for mitigation. In our analysis, no risks were identified within this zone.

The third quadrant located at the bottom left represents a problem that does not often occur so that companies will tend to ignore the risks contained in the third quadrant (Table 3). The third quadrant consists of 23 risks consisting of every supply chain process that occurs, for example the risk in the source process with M6 code, namely Delays in third-party manufacturing processes impacting overall timelines. The next example is the risk of the delivery process with code M7 regarding avoidable raw material wastage or imbalance leading to inefficiencies in production. The risks above are sorted by the largest RPN value, so risk control starts from code M6, M2, S4, S3, S5, M7, M4, D2, R1, M3, D3, D5, S6, R2, P6, P3, S2, P2, S1, M5, D4, R3, P4 (Figure 3- Figure 8).

Table 3. RPN and RSV Score.

Process	**Code**	**S**	**O**	**D**	**RPN**	**RSV**
Plan	P1	8	6	7	336	48
	P2	7	2	5	70	14
	P3	3	2	6	36	6
	P4	5	2	7	70	10
	P5	7	7	6	294	49
	P6	6	3	4	72	18
Source	S1	8	1	8	64	8
	S2	7	2	5	70	14
	S3	6	6	5	180	36
	S4	6	5	6	180	30
	S5	6	5	5	150	30
	S6	7	5	2	70	35
Make	M1	7	5	6	210	35
	M2	5	5	4	100	25
	M3	8	7	5	280	56
	M4	5	4	6	120	20
	M5	6	3	3	54	18
	M6	7	5	7	245	35
	M7	7	5	4	140	35
Delivery	D1	6	5	4	120	30
	D2	4	4	6	96	16
	D3	4	2	6	48	8
	D4	7	6	7	294	42
	D5	4	4	6	96	16
Return	R1	6	3	6	108	18
	R2	3	5	5	75	15
	R3	2	3	8	48	6

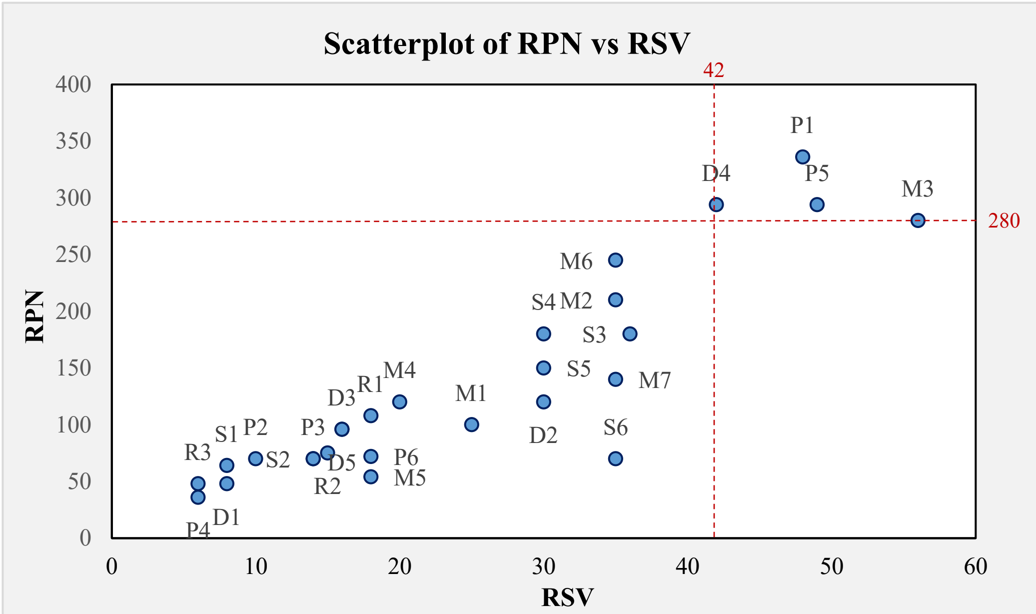


Figure 4. RPN vs RSV Scatterplot

5.4 Improvement Frameworks

After identifying the critical risk factors, opportunities were searched for solving the issues and strategic models were proposed based economic factors and others. The strategic plans for strategic models are as follows:

Strategy for P1 - Applying Machine Learning technique to establish Statistical Forecasting Model.
Strategy for P5 - Setting an aggressive goal for improvement in resource optimization.
Strategy for M3 - Deploying Re-Order Model to reduce material crisis and air shipment cost.
Strategy for D4 - Shop-wise Inventory Profiling Model to ensure the right SKU at the right place.

6. Case Study

The proposed framework was implemented in a multinational consumer electronic and home appliance company to revitalize business performance during the 2023 economic fall. During the COVID period the company struggled to keep its growth trajectory. But after the pandemic period, most of the companies in this business sector faced a recession due to the economic downturn. There were a high demand vs sales actualization gap, high season-end or year-end inventory and slow-moving inventory challenge, additional air-freight cost due to raw-material shortage etc. Considering the situation, the proposed breakthrough models, like Statistical Forecasting Model, Re-order model etc. were implemented to counter the aftereffect of COVID pandemic and to increase the supply chain surplus significantly.

6.1 Applying machine learning technique to establish statistical forecasting model to revitalize business performance

In retail business if you want to ensure supply assurance with optimized inventory. Then a best-fitting forecasting model and strategic allocation model should be the high priority. The product (Side-by-Side Refrigerator) for which we developed the statistical forecasting model has a high seasonal effect on sales trend. To predict right demand forecast for better supply management, we went for two classical time series forecasting techniques.

1. Seasonal ARIMA
2. Linear forecasting with Seasonal Trend

After analyzing the last 5 business years' data and using machine learning technique a Seasonal Forecasting Model was achieved which promised 88% accuracy in the following year in Figure 6. The model also promised higher business opportunities. But the only fear was the current economic downturn which never happened in past 5 years. This product is the most profitable category in that particular product segment. To predict the future forecast deviation, we used linear regression analysis for inflation rate vs forecast deviation. The analysis shows a very strong relationship of forecast deviation with the increment of inflation rate in Figure 5.

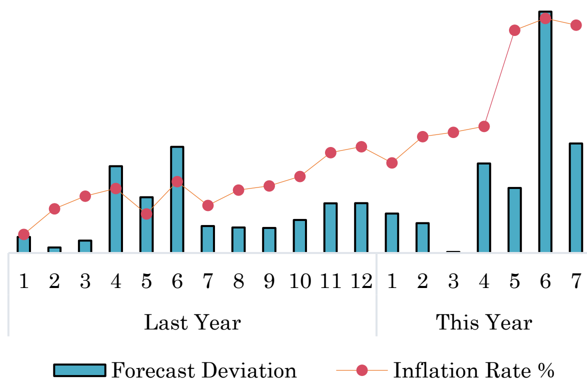


Figure 5. Linear Regression Analysis

Our estimated regression model $\hat{y} = a + bx$

Based on Figure 5, an adjusted statistical forecast Figure 6 was considered which was 76% higher than the original sales plan in H1 2023. The additional supply was initiated based on this higher projection. The end of the story, in Q1 102% oversell and in Q2 21% oversell than the sales plan. Figure 7. Forecasting Accuracy: Q1 99%, 95%, 88% and in Q2 72%, 44%, 86%. The reason for the deviation in Q2 is the supply shortage due to the country's dollar crisis situation (LC delay) in Figure 7.

Inflation rate% vs Forecast Deviation:

A very strong positive relationship is visible between these two parameters.

As Q2 is peak season, that's why deviation level is comparatively high.
But in off-season Q1, Q3, Q4, the deviation is relatively low.

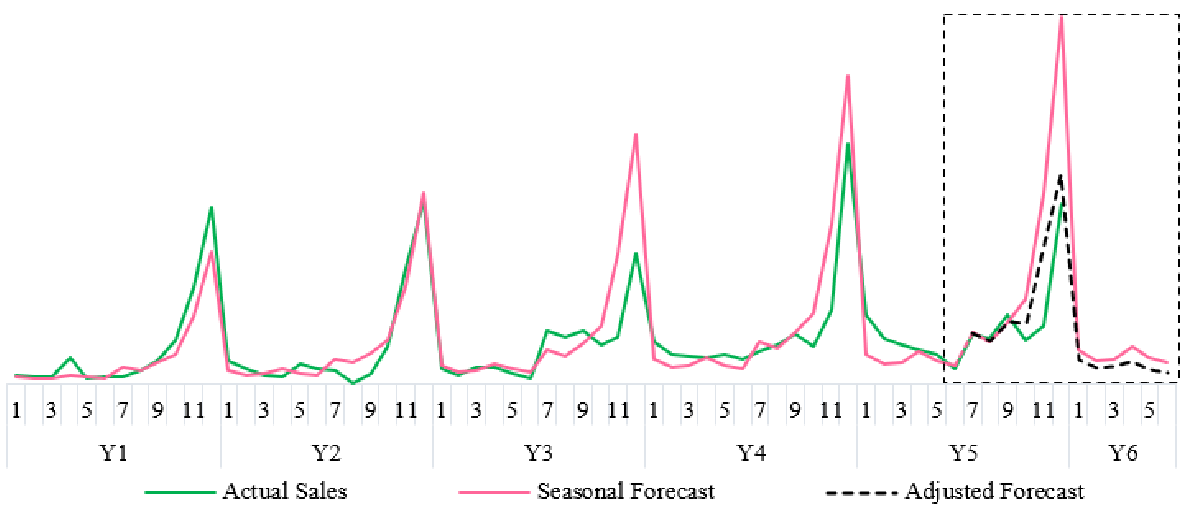


Figure 6. Statistical Forecasting Model and Adjustment

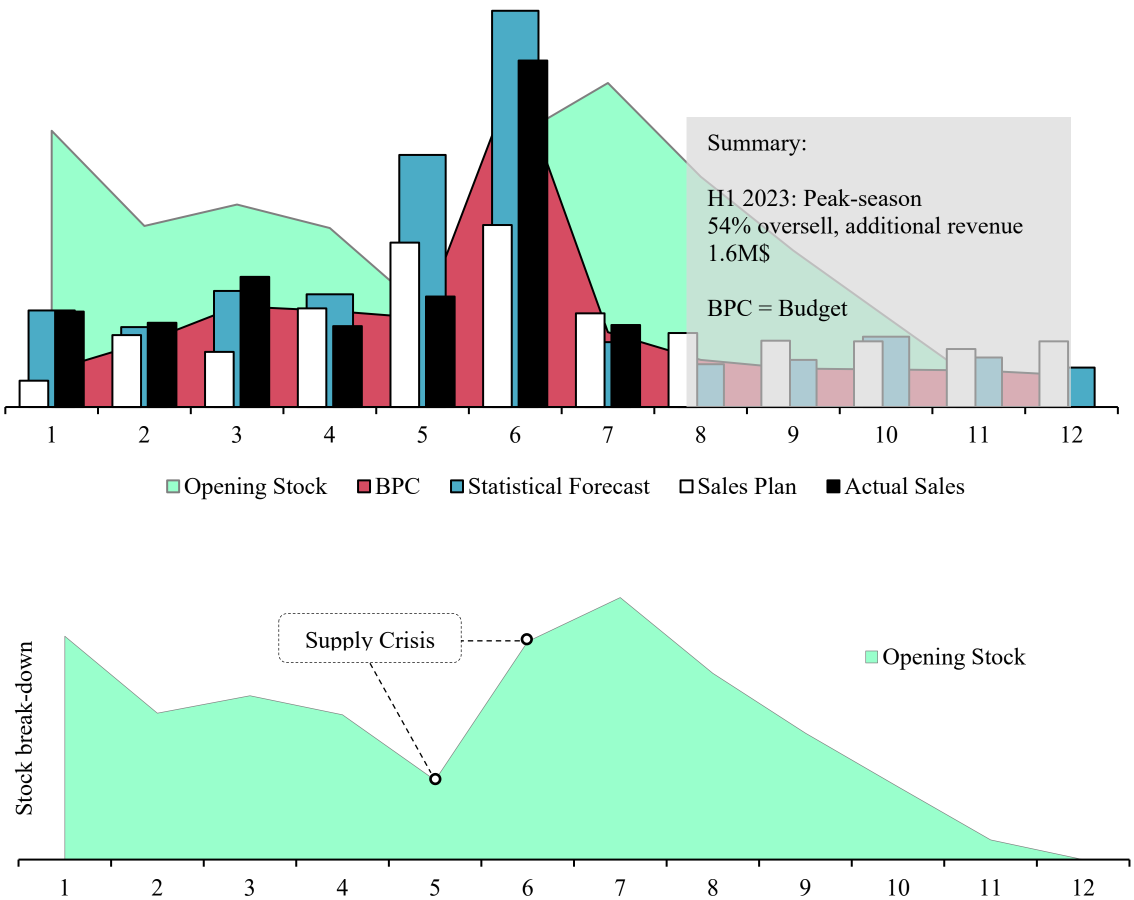


Figure 7. Demand vs Supply for H1 2023 with opening stock break-down

6.2 Setting an aggressive goal for improvement in resource optimization

After receiving the next year Demand projection from marketing team for all categories, the supply, purchase and production requirement plan were prepared for SKU-wise consensus demand planning. We already standardized item name uniqueness in all categories which is mandatory to get accurate information for data analysis and for software implementation. From the analysis it was found that around 44K units were slow-paced and no demand stock which were around 41% (Figure 8) of year opening stock of that particular category. The formulas are as follows:

Slow-paced stock-1 : if current stock > sum of next 6 months' demand…………………….…. (3)
Slow-paced stock-2 : if current stock > 6 x monthly avg. of last year actual sales………….…. (4)
No demand stock : if there is no demand against current stock.……….……………………..…. (5)

The total value of the slow-moving stock was around 13.5 M$. The below action plan were taken to reduce the total slow-moving quantity within the season.

- Further purchase was on hold of slow-moving SKUs.
- The in-transit stocks were cancelled after the agreement with suppliers and rest quantities were added to the reduction plan.
- Demand no. was collected for the No Demand SKUs stocks.
- Area wise stock holding was identified with suitable insight to set sales target accordingly.
- Week-wise, month-wise, sales target was set with clear reduction visibility after the alignment with marketing and sales team.
- Final slow-moving stock reduction target was 56K units.

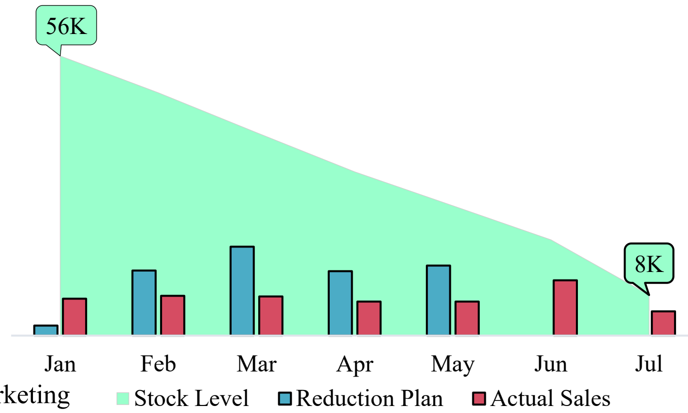


Figure 8. Slow-moving stock reduction

Finally, slow-moving stock reduced by 85% (Figure 8) and a better space utilization and resource optimization achieved. It also helped to reduce purchase 22%, production 9% and inventory holding cost by 32.5%. As a result, inventory days improved from 151D to 106D (Figure 9). In Y4 (Figure 9) to achieve avg. monthly sales 18K only 54K avg. monthly stock was maintained whereas in Y1 it was 5 times more than the sales.

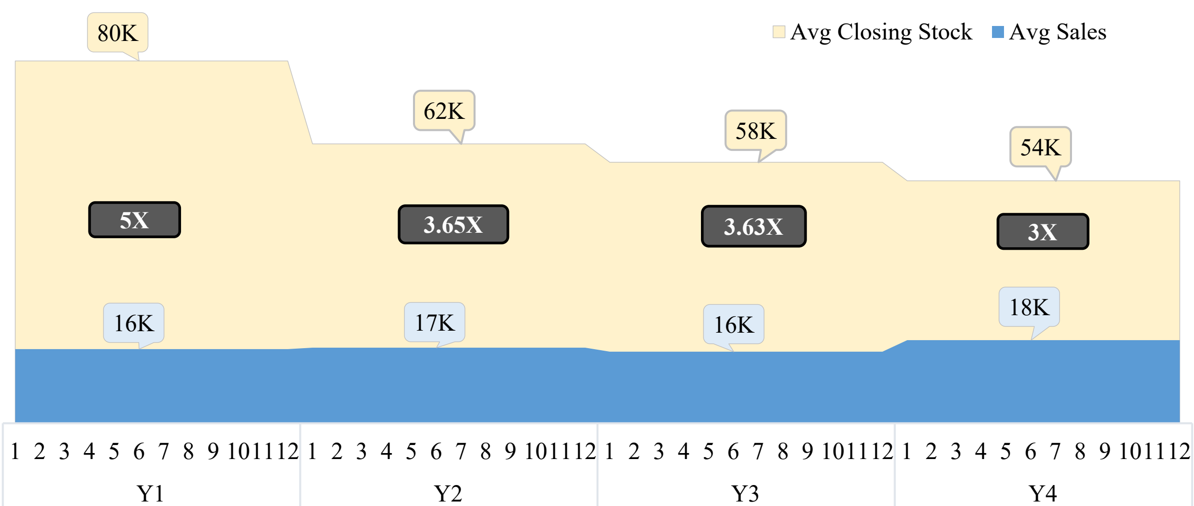


Figure 9. Year-year avg. sales/month vs avg. closing stock/month

6.3 Deploying Re-Order Model to reduce material crisis and air shipment cost

After starting the own manufacturing project, company faced a huge challenge to ensure on-time material arrival. Year 2022 was successful for launching few new Refrigerator projects. But there was a huge air shipment cost. Because project lead time was short and supply chain had to ensure 250+ materials, from 40+ suppliers, from 5 different countries where shipment lead time varies from 70days to 140days.

In year 2023 company aimed to launch three more Refrigerator project by Q1 2023. By deploying Re-order cycle, all the raw-materials were secured one month ahead and the project was successfully launched by Q1 2023. Besides on-time material arrival, Re-order cycle management also helped significantly to reduce air-shipment cost in 2023 and compared to 2022 65% air shipment cost reduced (Figure 10). To support the UN Sustainable Development Goals (SDGs) it also reduced CO_2 emission as air freight produces around 10 times more CO_2 than transportation by ship. Due to country's forex challenges (LC opening delay), few air shipments happened to secure the production and supply in peak season. Otherwise sales performance would have been significantly impacted.

Formulas to apply Re-Order Model are as follows:

Re-order point (ROP) = Lead-time demand (LTD) + Safety Stock (SS)
= Lead-time x Avg. demand + SS
= $LT \times D_{avg} + SS$ …………………………………………… (5)

Safety Stock (SS) = (Max. daily demand x Max lead-time) - (Avg. daily demand x Avg. lead-time)
= $(D_{max} \times LT_{max}) - (D_{avg} \times LT_{avg})$ ……………………………… (6)

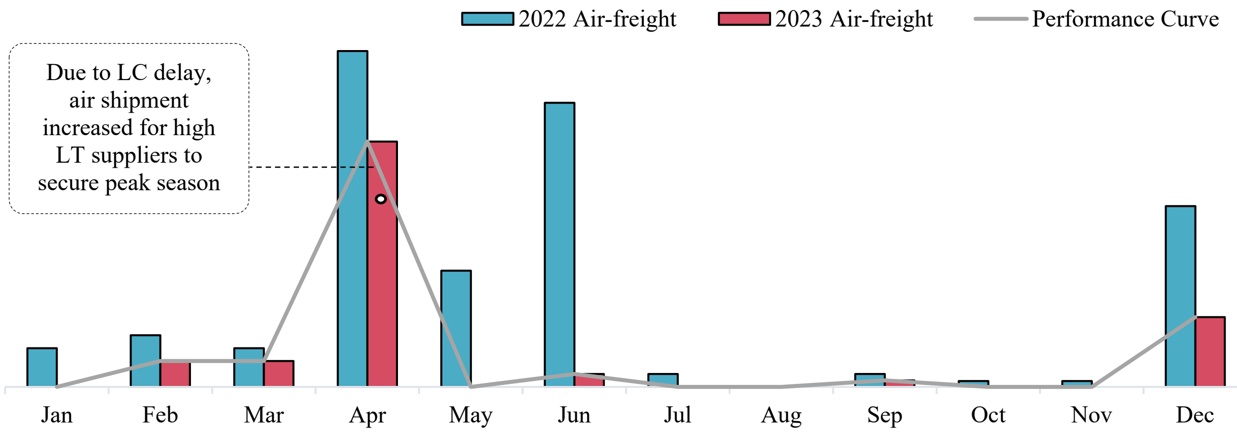
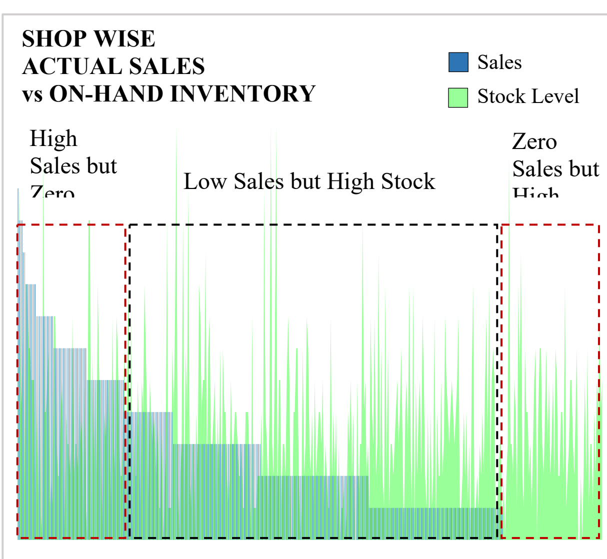


Figure 10. Air freight reduction performance

6.4 Shop-wise Inventory Profiling Model to ensure right SKU at right place

As the company has more than 430+ shops, so to ensure better supply assurance with optimized inventory, a right Inventory Allocation Model was always a high priority. Because this will ensure right SKU at right place at right time. As a result, higher sales opportunity will be increased. So in 2023, as a first step, using the Supply vs. Sales Matrix (Figure 11) shop wise inventory profiling was introduced (Figure 12) to answer below questions for high selling SKUs in different seasons/quarters:

- The area/shops where sales is high but stock level is low
- The area/shops where sales is low but stock level is high



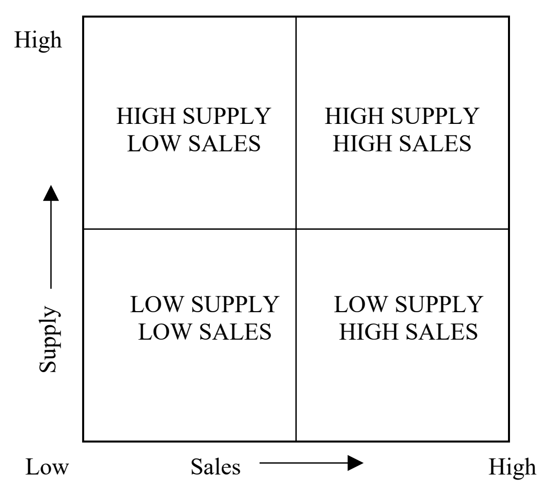


Figure 11. Supply vs. Sales Matrix

Figure 12. Shop-wise Inventory Profiling

Findings:
- 110 shops holding 38% of total stock contributing only 6% of total sales
- 14 shops contributing 26% of total sales, but avg. stock per shop near to zero.

Based on the finding, the stock allocation strategy was prepared. This model helped to reduce slow-paced or aged inventory and re-distribution cost by allocating stock at right selling zone/area. Using this insight, an allocation model can be introduced with the help of unsupervised machine learning techniques.

5. Results and discussion

In summary, the Statistical Forecasting Model to reduce forecast deviation, Re-Order Model to reduce material crisis and air-shipment, inventory optimization through slow-moving stock reduction and inventory profiling model not only addressed the persistent losses but also propelled the company to counter the post pandemic situation. This success underscores the efficacy of strategic supply chain management in fostering resilience and profitability amid complex environmental challenges. Below Table 4, summaries all the components and its limitations where different strategies as per opportunities were set to gain operational performance. By prioritizing strategic approach to the identified risk factors, a long-term sustainable business model was achieved to gain competitive advantages.

Table 4. Organizational performance through SCM strategic practices and competitive advantage

Associated Risks	Strategy	Company Benefit	UN SDGs Alignment	Result
Economic fall	Regression analysis with demand deviation Vs. inflation rate	- 54% oversell - Additional revenue 1.7 million USD - Right prediction of actual demand	- Goal 12: Responsible Consumption and Production - Goal 13: Climate Action	- All these strategic approach helped company largely to secure a significant business growth, 615% in 2023 compared to 2022. - In 2023, there was 5% negative growth of this consumer electronic and home appliance industry, but company made 2% growth in the market.
Economic fall and In-transit RM	- Demand no adjustment - Area-wise slow-paced stock identify - Identify area-wise high selling opportunity of particular SKUs - Collaboration with supplier to cut open order or delay the shipment plan	- Inventory Days reduced from 151D to 106D - Slow-moving stock reduced by 85% - Purchase reduced by 22%, production by 9% and inventory holding cost by 32.5%	- Goal 12: Responsible Consumption and Production - Goal 13: Climate Action	
- Forex crisis - LC opening delay - Single Supplier Source	- Advance production without LC based on LC sharing guarantee letter - Forecast sharing - Order visibility - Business transparency - Regular collaboration meeting	- On-time project launch - Supply increased by 10% - 65% air-freight reduced - Less CO2 emission	- Goal 12: Responsible Consumption and Production - Goal 13: Climate Action	
- 430+ shops - 1300+ SKUs	- Only High selling or High value SKUs - Develop Supply vs Sales Matrix	- Right SKU at Right Place at Right Time - Less Re-distribution, less CO2 emission - Less opportunity of slow-moving stock - Supply assurance with optimized inventory	- Goal 12: Responsible Consumption and Production - Goal 13: Climate Action	

Supply Chain Components	**Limitations**	**Opportunity**
Planning	High demand deviation	Statistical Forecasting Model
Inventory	High Inventory Days	- Slow-moving and no demand stock identification and reduction - Priority on purchasing and producing high selling SKUs
Manufacturing	- Production Disruption - Project launching delay - Air-shipment due to RM crisis	Introduction of Re-order point and Safety Stock Model
Distribution	No inventory allocation strategy	Introduction of Allocation Model

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