Building What-If Simulation to Improve Inventory Control by using Logistic Data in Sales & Distribution Area

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Abstract

This study discusses the challenges faced by businesses in managing their inventory, particularly in the context of sales and distribution, where demand can be difficult to forecast accurately. The author suggest that what-if simulations can help businesses optimize their inventory control processes and reduce inventory costs by providing insights into how different scenarios may arise. The study focuses on the use of logistic data to build what-if simulations, leveraging data such as order history and supply chain data to develop models that can predict future demand and inventory levels.

The paper highlights the benefits of using what-if simulations to improve inventory control, including increased accuracy in demand forecasting, better resource allocation, and improved customer satisfaction. The author presume that the use of what-if simulations can be an effective tool for businesses in the sales and distribution area to optimize their inventory control processes, reduce costs, and improve overall efficiency.

Keywords: supply chain, what-if simulation, business intelligence, inventory management, data analytics

1. Introduction

In today's fast-paced and highly competitive business environment, effective inventory control is a critical component of supply chain management. Efficient inventory management helps organizations optimize their resources, minimize costs, and ensure customer satisfaction by maintaining an appropriate balance between stock availability and capital investment. One of the most significant challenges that businesses face is making accurate predictions about inventory demand and determining the optimal inventory levels to avoid stockouts or excess inventory. In this context, the use of logistic data in the sales and distribution area offers a valuable opportunity to improve inventory control and decision-making.

The primary motivation behind building a what-if simulation for inventory control is to enhance the decision-making process by providing a robust and data-driven tool that allows organizations to explore various scenarios, assess their impacts on inventory levels, and identify optimal strategies for managing inventory. By leveraging logistic data from sales and distribution, the what-if simulation aims to account for factors such as seasonality, demand fluctuations, lead times, and supplier reliability, thus enabling a more comprehensive and accurate analysis of inventory control strategies.

Based on this motivation, this study will raise this problem as research question: *How can what-if simulations be used to improve supply chain sustainability and minimize the negative impact of logistics operations (such as increased cost and delayed deliveries)?*

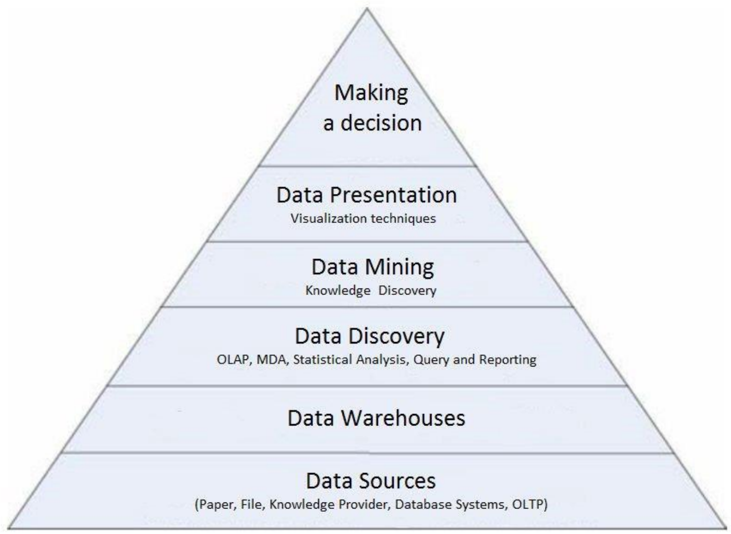

Figure 1. phases of building what-if simulation model

Several benefits can be derived from implementing a what-if simulation for inventory control. These include:

- Improved Forecast Accuracy: By incorporating logistic data from the sales and distribution area, the what-if simulation can generate more accurate forecasts, enabling organizations to better anticipate demand and adjust inventory levels accordingly.
- Enhanced Decision-Making: The simulation allows decision-makers to explore various scenarios and their potential impacts on inventory control, thus promoting informed and data-driven decision-making.
- Cost Reduction: By identifying optimal inventory levels and avoiding stockouts or excess inventory, organizations can minimize carrying, stock-out, and obsolescence costs.
- Increased Customer Satisfaction: Efficient inventory control ensures that products are available when customers need them, reducing the likelihood of lost sales and enhancing overall customer satisfaction.

- Agility and Adaptability: The what-if simulation enables organizations to quickly adapt to changing market conditions and customer needs by evaluating the potential impacts of various inventory control strategies and selecting the most suitable approach.

In conclusion, building a what-if simulation to improve inventory control by using logistic data in sales and distribution is a promising approach that can help organizations optimize their inventory management processes, reduce costs, and enhance customer satisfaction. By enabling data-driven decision-making and facilitating the exploration of various scenarios, the what-if simulation can serve as a valuable tool for organizations striving to excel in today's dynamic and competitive business landscape.

2. Literature Review

This study will review the recent literature on what-if simulations for improving inventory control by leveraging logistic data in the sales and distribution area. The focus is on studies published in 2019 and beyond that have explored the use of simulations, data analytics, and machine learning techniques to enhance inventory management.

A. Data-Driven Approaches for Inventory Control

Data-driven approaches have gained significant attention in inventory control literature. (Gaur and Pachori, 2020, pp.139) proposed a machine learning-based demand forecasting model using logistic data to optimize inventory management decisions. Their study demonstrated the potential of data-driven techniques for improving forecast accuracy and inventory control performance.

Another study is from (Bai et al, 2020, pp.58) which focused on optimizing inventory control in the retail supply chain by employing data-driven methods, including machine learning and data mining techniques. The study showed that utilizing data-driven approaches for inventory control could significantly reduce inventory costs and improve customer satisfaction in the retail sector.

These authors emphasize the importance of accurate demand forecasting for effective inventory control and discuss the potential advantages of utilizing ML approaches to address this challenge. The paper examines various ML methods, such as regression techniques, artificial neural networks, support vector machines, and ensemble methods, and highlights their applications in demand forecasting. By comparing the performance of these techniques in various studies, the authors demonstrate the superiority of ML methods over traditional statistical approaches in terms of accuracy and adaptability.

Moreover, the papers discuss the challenges and limitations associated with the application of ML techniques to demand forecasting, including issues related to data quality, feature selection, model interpretability, and computational complexity. The authors also identify opportunities for future research in this area, such as the integration of ML with optimization techniques, the development of hybrid models that combine multiple ML methods, and the application of deep learning techniques to handle complex and large-scale datasets.

In conclusion, these related works offer valuable insights into the current state of research on ML-based demand forecasting for inventory management and highlight the potential of these techniques for improving forecast accuracy and inventory control performance. Their review serves as a foundation for further exploration and development of novel ML approaches to address inventory management challenges.

B. Simulation and Optimization Techniques

Simulation and optimization techniques play a crucial role in inventory management by (Wang et al, 2020, pp.96), the authors developed a what-if simulation framework for inventory control and used a multi-objective optimization algorithm to identify optimal inventory policies.

The other study is proposed by (Aghazadeh and Ameri, 2020, pp.58), which proposed a simulation-based what-if analysis framework to identify and mitigate supply chain risks in a responsive manner. Contribution of the framework is demonstrating the effectiveness of what-if analysis in improving supply chain performance by minimizing risks and enhancing decision-making.

Another study is proposed by (Ivanov et al, 2020, pp.58) and (Zhong, Y, 2019, pp.9), which aimed to explore the impact of digital technology, including what-if simulations, on the ripple effect and supply chain risk analytics in the context of Industry 4.0. The study showed that leveraging digital technologies, such as what-if simulations, could enhance supply chain risk analytics and improve inventory control practices.

These studies propose a novel framework for inventory control that combines simulation and optimization techniques to address the trade-offs between conflicting objectives, such as minimizing costs and maximizing customer satisfaction. The authors acknowledge the complexity and uncertainty inherent in inventory management, as well as the need for an approach that can balance multiple objectives simultaneously.

The proposed framework consists of two main components: a simulation model that captures the dynamics of inventory control and a multi-objective optimization algorithm that identifies optimal inventory policies considering the trade-offs between competing objectives. The simulation model is designed to represent various aspects of inventory control, such as demand uncertainty, lead times, and replenishment policies, while the optimization algorithm is used to search for the best inventory policies that satisfy the multiple objectives.

In conclusion, these authors present a simulation-optimization framework that addresses the challenges of multi-objective trade-offs in inventory control. By integrating simulation and optimization techniques, the proposed framework allows decision-makers to explore various inventory policies and their potential impacts on multiple objectives, thereby enabling more informed and balanced decision-making in inventory management.

C. Integration of Sales and Distribution Data

The integration of sales and distribution data has been recognized as a key factor in improving inventory control. (Khatab and Ait-Kadi, 2020, pp.140) and (Barykin, S ,2021, pp.20) developed a simulation-based approach that incorporated logistic data from sales and distribution to optimize inventory levels and reduce costs. Their study demonstrated the effectiveness of using real-time sales data in inventory management and highlighted the importance of data integration.

This paper proposes a real-time simulation-based optimization approach to address the challenges of inventory control in the context of humanitarian supply chains, which are characterized by high levels of uncertainty and variability in demand, lead times, and available resources.

The authors develop a simulation model that captures the dynamic behaviour of a humanitarian supply chain, including the interactions between various components, such as suppliers, transportation, and distribution centres. The model is designed to incorporate real-time data from sales and distribution, which allows for continuous updates and adjustments to the inventory control policies in response to changing conditions. An optimization algorithm is then used to search for the best inventory policies that minimize total costs while ensuring an adequate level of service to the affected population.

In conclusion, the study presents a novel real-time simulation-based optimization approach for inventory control under uncertainties in humanitarian supply chains. By incorporating real-time data from sales and distribution, the proposed approach enables more accurate and adaptive inventory management, leading to improved performance and better service to the affected population.

D. Machine Learning for Inventory Control

Recent studies have explored the potential of machine learning for inventory control. For example, (Liu et al, 2020, pp.281) proposed a deep learning-based demand forecasting model for inventory management, which significantly improved forecast accuracy and inventory performance. Additionally, (Sharma et al, 2021, 59) developed a machine learning-based what-if simulation for inventory control, demonstrating the effectiveness of machine learning algorithms for scenario analysis and decision-making. The authors propose a two-step approach that involves pre-processing the time series data and then applying LSTM and CNN models for forecasting. The pre-processing step is designed to address challenges such as data non-stationarity and seasonality, while the deep learning models can capture complex patterns and relationships in the data. The proposed approach is evaluated on multiple datasets, including both synthetic and real-world inventory management data. The results of the study indicate that the deep learning models, particularly the LSTM, outperform traditional time series and machine learning methods in terms of forecasting accuracy. The improved accuracy leads to better inventory control performance, including reduced stock-outs and lower inventory holding costs.

In conclusion, this paper presents a compelling case for the application of deep learning techniques, specifically LSTM and CNN, for demand forecasting in inventory management. Their research demonstrates the potential of these models to improve forecast accuracy and inventory control performance, paving the way for further exploration and development of deep learning techniques in this domain.

In summary, recent literature emphasizes the importance of data-driven approaches, simulation and optimization techniques, sales and distribution data integration. Building what-if simulations that leverage logistic data in the sales and distribution area can significantly enhance inventory management by enabling accurate demand forecasting, scenario analysis, and informed decision-making. Future research in this area could explore the development of novel simulation frameworks and machine learning techniques tailored to specific industry contexts and inventory control challenges.

3. Research Method & Specification

The research parameters that are required to comprehend and justify the appropriate research process and instruments for sourcing, collecting, analysing, and interpreting the research data are explained in this chapter. Consequently, this chapter assisted the researcher in comprehending and defining various research methods and tools in order to select the most suitable one to address the research objectives. This chapter discusses the researcher's ethics, limitations of the research, and philosophy, approach, design, techniques, and methodology methods for data sampling, collection, and analysis.

A. Research Method

This study will follow CRISP-DM procedure as Data Mining Approach, as shown in Figure 2.

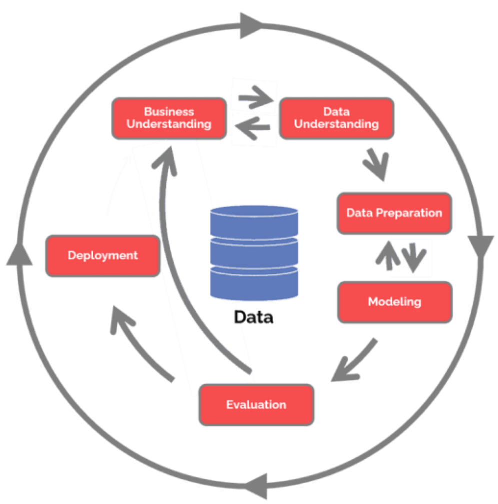

Figure 2. CRISP-DM Methodology

CRISP-DM, which stands for Cross-Industry Standard Process for Data Mining, is a widely adopted methodology for data mining projects. It provides a structured and systematic approach to guide data mining practitioners through the entire lifecycle of a project, from understanding the business problem to deploying the final model. CRISP-DM can be applied to various industries and types of data mining tasks, making it a popular framework for data-driven projects. The CRISP-DM methodology consists of six main phases:

- Business Understanding: Understand the business objectives and requirements related to inventory control in the sales and distribution area. Identify the key performance indicators (KPIs) for inventory management, such as inventory holding costs, stockouts, and order fulfillment rates. Define the goals of the what-if simulation, such as exploring different inventory policies, analyzing the impact of demand variability, or evaluating the benefits of incorporating new data sources.
- Data Understanding: Collect relevant logistic data, such as historical sales records, inventory levels, customer demand patterns, and lead times. Explore the data to identify trends, seasonality, and correlations between variables that may influence inventory control decisions. Assess the quality and completeness of the data, identifying any issues that need to be addressed during the data preparation phase.
- Data Preparation: Clean, preprocess, and transform the logistic data to make it suitable for use in the what-if simulation model. This may involve handling missing values, outliers, or inconsistencies, as well as aggregating data at the appropriate level of granularity (e.g., daily, weekly, or monthly). Select the relevant features and variables for the simulation model, considering their potential impact on inventory control decisions and performance.
- Modeling: In the modeling phase, a variety of data mining algorithms and techniques are used to create models that can fulfill business goals. The what-if simulation model for inventory control is created by incorporating the logistic data and relevant variables identified in the previous phases.
- Evaluation : Based on previous phase, this study should answer the research question and related key points, as follows :
    - Assess results: Do the models meet the requirements for business success? Which ones should this study approve for the business objectives?
    - Method of review: Examine the completed tasks. Did anything go unnoticed? Did each step go as planned? Summarize findings and make any necessary corrections.
    - Decide following stages: Make a decision about whether to move on to deployment, continue iterating, or start new projects based on the three previous tasks.
- Deployment : All of the actions that make a software system available for use are referred to as software deployment. As a result, "deployment" ought to be understood as a general procedure that must be tailored to meet particular requirements or characteristics.

B. Research Resources

This study will use following tools and technologies to bring the research to completion :

- Microsoft Power BI
- Microsoft SQL Server
- Microsoft Excel

And following dataset will be used for the purpose of finishing this project:

Constante, Fabian; Silva, Fernando; Pereira, António (2019), “DataCo SMART SUPPLY CHAIN FOR BIG DATA ANALYSIS”, Mendeley Data, V5, doi: 10.17632/8gx2fvg2k6.5

C. Evaluation

These will be evaluated for the purpose of project completeness:

- Model Validation: Before deploying the what-if simulation model, validate its performance using a holdout dataset or historical data not used during model development. This validation process ensures that the model is accurate and robust enough to provide meaningful insights for inventory control decisions.
- Performance Metrics: Select appropriate performance metrics to evaluate the effectiveness of the what-if simulation model. These metrics may include inventory holding costs, stockout rates, order fulfillment rates, and service levels. Comparing the performance of different inventory policies or scenarios using these metrics will help identify the most effective strategies for inventory control.
- Scenario Analysis: Conduct scenario analyses using the what-if simulation model to explore different inventory control strategies, demand patterns, lead times, and other factors that may influence inventory performance. Evaluate the impact of these scenarios on the chosen performance metrics to understand the potential risks, benefits, and trade-offs associated with each strategy.

D. Ethical Considerations of the Research

Because there is no human related participant in the study, thus there will be no major ethical consideration in this research.

E. Project Plan

Project: Building What-If Simulation to Improve Inventory Control by using Logistic Data in Sales & Distribution Area

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Project start date: 22/05/2023

Milestone marker: 1

Scrolling increment: 0

Milestone description	Progress	Start	Days
Project kickoff			
Outline the Project Objective	100%	22/05/2023	1
Research (will be ongoing phase during the whole Project Lifecycle)	20%	23/05/2023	
Requirement Gathering			
Collect Data Source & KPI	30%	23/05/2023	5
Define Reporting Needs & User Role		28/05/2023	4
Data Source Identification			
Identify the relevant data sources needed for the project		01/06/2023	7
Data Integration or ETL Phase			
Extract		08/06/2023	3
Transform		11/06/2023	3
Load		14/06/2023	3
Data Storage & Modeling			
Determine the optimal data storage solution		17/06/2023	5
Design the data model, including tables, relationships, and indexes		22/06/2023	5
Data Quality & Validation			
Ensure data quality by validating, cleaning, and transforming the data		27/06/2023	2
BI Tool Selection			
Evaluate and choose the appropriate BI tool(s) for the project		29/06/2023	2
BI Tool Configuration			
Configure the selected BI tool, including setting up data connections, user roles, and security settings.		01/07/2023	2
Dashboard and report development			
Design and create dashboards, reports, and visualizations		03/07/2023	15
Testing			
Conduct thorough testing of the BI solution, including functionality and performance		18/07/2023	5
Deployment			
Deploy the BI solution to the production environment, ensuring a smooth transition and minimal disruption		23/07/2023	5
Project closure			
Document the lessons learned, conduct a final project review, and celebrate the project's completion		28/07/2023	1

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