

CHAPTER 3

RESEARCH METHODOLOGY

3.1 Introduction

This chapter outlines the methods and procedures used in conducting the research. It details the research approach, design, population and sample, tools and models used, data collection procedures, data analysis techniques, and ethical considerations to ensure the study's validity and reliability.

3.2 Research Approach

Quantitative:

The study adopts a quantitative research approach to analyze historical inventory and sales data. Quantitative methods are used to develop, test, and evaluate predictive models for delay and inventory shortage forecasting.

3.3 Research Design

The research follows a predictive and analytical design, focusing on time-series forecasting and machine learning techniques. The study evaluates model performance using key metrics such as accuracy, mean squared error (MSE), and root mean squared error (RMSE) to assess the effectiveness of the proposed solutions.

3.4 Population and Sample

Population:

The population consists of supply chain data, including inventory levels, sales records, transportation times, and supplier reliability metrics from a sports equipment supply chain.

Sample:

A sample of historical data covering a three-year period is extracted for analysis. This includes records with seasonal demand fluctuations, transportation delays, and stock replenishment patterns.

3.5 Instrumentation

Tools:

- Python (with Jupyter Notebook): Used for implementing predictive models.
- Tableau/Power BI: Used for visualizing insights and results.

Models:

- **ARIMA:** For traditional time-series forecasting.
- **SARIMA:** To account for seasonality in time-series data.
- **XGBoost:** For machine learning-based regression and prediction.
- **LSTM:** For handling sequential and long-term dependencies in data.

Datasets:

Historical inventory and sales records that include variables such as transportation times, seasonal demand, and supplier reliability.

Justification:

These tools and models are widely recognized and effective for analyzing large datasets and forecasting supply chain events.

3.6 Data Collection Procedure

Steps:

1. Collect historical data from suppliers and internal databases, including sales, inventory levels, and delivery times.
2. Preprocess the data to address missing values, outliers, and anomalies and to adjust for seasonality.
3. Conduct exploratory data analysis (EDA) to identify trends, patterns, and correlations in the data.
4. Split the data into training and testing sets for model evaluation.
5. Train and test ARIMA, SARIMA, XGBoost, and LSTM models on the preprocessed data to forecast delays and inventory shortages.

3.7 Data Analysis

3.7.1 Analysis Technique:

- Time-series analysis for ARIMA and SARIMA models.
- Regression and classification techniques for XGBoost.
- Sequential data analysis for LSTM models.

3.7.2 Software:

Python for implementing and analyzing models, and Tableau/Power BI for visualizing results.

3.7.3 Unit of Analysis:

The unit of analysis is the supply chain transaction or event, such as a shipment delay or stockout event.

3.8 Validity, Reliability, and Ethical Considerations

Validity:

- Internal validity is ensured by using robust statistical methods and cleaning the dataset to remove biases.
- Model validation is performed using cross-validation techniques and a separate testing dataset.

Reliability:

- The models are tested on different timeframes within the dataset to ensure reproducibility.
- Results are compared across multiple model types to confirm consistency.

Ethical Considerations:

- Data anonymity is maintained to protect supplier and consumer information.
- The study adheres to ethical guidelines for data usage and transparency, ensuring that all data handling processes comply with privacy regulations.

3.9 Research Planning

The research is planned in stages, starting with data collection and preprocessing, followed by EDA, model training, evaluation, and result interpretation. Clear timelines and milestones are set to ensure the project stays on track.

3.10 Chapter Summary

This chapter detailed the quantitative research approach, predictive research design, and methods for data collection, analysis, and validation. It also addressed ethical considerations and outlined the tools and techniques used to ensure the study's reliability and accuracy.