



**PREDICTIVE MODELING FOR SALES FORECASTING: AN EMPIRICAL
STUDY OF SS SYSTEM IN A UPS MANUFACTURING INDUSTRY**

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Cite This Article: V. Satishkumar & S. Sweata, "Predictive Modeling for Sales Forecasting: an Empirical Study of SS System in a UPS Manufacturing Industry", Indo American Journal of Multidisciplinary Research and Review, Volume 10, Issue 1, January - June, Page Number 27-31, 2026.

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Type of Review: Peer Reviewed as per |C|O|P|E| Guidance.

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DOI: <https://doi.org/10.5281/zenodo.18708547>

Abstract:

This study examines the application of statistical forecasting methods to improve sales prediction accuracy for SS Systems, a small-to-medium UPS manufacturing enterprise in Coimbatore with an annual turnover of ₹3 crore. Traditional intuition-based forecasting methods, prevalent among Indian SMEs, often result in inventory mismatches and production inefficiencies.

Through analysis of five years of sales data (2020-2024), the research compares multiple forecasting techniques, including Moving Average, Exponential Smoothing, Linear Regression, and ARIMA models. Key findings reveal that ARIMA achieved superior accuracy (MAPE = 1.9%) compared to traditional methods (approximately 20% MAPE). Correlation analysis identified strong relationships between sales performance and external factors, including Tamil Nadu GDP ($r = 0.978$), power outages ($r = -0.966$), and government green energy subsidies ($r = 0.977$).

The study demonstrates that resource-constrained SMEs can achieve significant forecasting improvements using accessible tools such as Excel and SPSS, along with secondary data, potentially reducing inventory costs by 20% and improving order fulfillment by 15%. Results indicate that Solar UPS products showed exceptional growth (32.8% CAGR), driven substantially by a 161% increase in government renewable energy subsidies during the study period.

Key Words: Sales Forecasting, Predictive Modeling, ARIMA, SME Analytics, UPS Manufacturing, Statistical Forecasting, Government Subsidies, Time Series Analysis, Inventory Optimization.

Introduction:

Sales forecasting accuracy directly impacts the operational efficiency and competitive positioning of manufacturing enterprises. For small and medium enterprises (SMEs) operating in India's industrial sector, the challenge intensifies due to limited access to sophisticated analytical tools, constrained technical expertise, and insufficient historical data infrastructure (Gupta, 2025; Singh, 2024). Despite these limitations, accurate demand prediction remains critical for production planning, inventory management, resource allocation, and strategic decision-making.

The Indian UPS manufacturing sector exemplifies this challenge, operating at the intersection of infrastructure development, power sector dynamics, economic growth patterns, and evolving government renewable energy policies. SS Systems, a Coimbatore-based manufacturer with 25 years of operational experience, represents a typical SME facing demand uncertainty while relying predominantly on experience-based forecasting approaches that frequently fail to capture market trends, seasonal variations, and external economic influences.

Recent technological developments have democratized access to analytical tools, enabling SMEs to leverage statistical methods without prohibitive investment (Pandey & Shah, 2024). Concurrently, the availability of secondary data from government sources, industry reports, and regional economic indicators provides opportunities for SMEs to enhance forecasting capabilities despite internal data limitations. However, practical demonstrations of such implementations within resource-constrained SME contexts remain limited in academic literature.

This research addresses the gap between theoretical forecasting methodologies and practical SME application by systematically documenting the implementation of accessible statistical techniques using secondary data sources. The study evaluates multiple forecasting approaches, quantifies external demand drivers, and demonstrates actionable strategies for inventory optimization and production planning suitable for similar manufacturing enterprises.

Objectives of the Study:

- To analyze trends, seasonality, and cyclical patterns in SS Systems' sales performance across product categories and market segments.
- To assess the influence of external factors (economic indicators, power infrastructure, government policies, and competitive pricing) on UPS sales fluctuations.
- To develop and validate predictive models for future sales forecasting using time series and regression techniques.
- To evaluate comparative model accuracy through statistical error metrics (MAPE, MAE, RMSE).
- To provide actionable recommendations for inventory optimization, production planning, and strategic resource allocation.
- To compare the effectiveness of traditional intuition-based forecasting with statistical forecasting methodologies.

Review of Literature:

Forecasting Methods for SMEs:

Sharma and Patel (2025) demonstrated that ARIMA and Exponential Smoothing models significantly improved forecast accuracy for small-scale electronics firms compared to manual estimation methods. Their findings emphasized the importance of model selection based on data characteristics and organizational constraints. Similarly, Singh (2024) argued that SMEs benefit most from simple, interpretable models rather than complex machine learning approaches requiring extensive datasets and technical infrastructure.

Thompson and Nair (2024) compared various forecasting models for SMEs with limited historical data, recommending ensemble methods that combine simple statistical techniques with market trend analysis. Their research highlighted that hybrid approaches often outperform single-method implementations, particularly in volatile market conditions. Nayak and Thomas (2025) corroborated these findings in the consumer electronics sector, showing that combined Moving Average and Regression models achieved superior quarterly demand prediction accuracy.

External Factors in Manufacturing Forecasting:

Wang and Li (2025) demonstrated that integrating external economic indicators into sales forecasting models significantly improved prediction accuracy for manufacturing firms. Their study emphasized the importance of identifying relevant macroeconomic variables specific to industry contexts. Kumar and Jain (2024) specifically examined UPS sales patterns, revealing seasonal peaks influenced by power outage patterns and monsoon-related infrastructure challenges in India.

Krishnan and Iyer (2024) investigated demand patterns in the Indian UPS market, identifying seasonal trends linked to industrial expansion cycles with practical applications for small-scale manufacturers. Choudhury (2023) analyzed regional variations in power supply impacts on UPS demand, providing insights for manufacturers regarding geographic market segmentation strategies.

Policy Impacts and Renewable Energy:

Rao and Pillai (2023) analyzed relationships between India's power sector reforms and UPS market demand, providing manufacturers with insights regarding policy-driven demand fluctuations. Their research emphasized the importance of monitoring regulatory changes to improve demand forecasting accuracy. Mehta and Sharma (2022) examined digitalization trends and work-from-home patterns, demonstrating how pandemic-driven behavioral changes created new demand segments requiring different predictive approaches.

SME Implementation Challenges:

Chakraborty and Bose (2024) studied predictive modeling adoption in Indian SMEs, concluding that perceived ease of use and cost-effectiveness primarily drive implementation decisions. Patil (2021) identified cost barriers preventing SMEs from adopting complex forecasting software and advocated for graduated implementation strategies beginning with spreadsheet-based methods.

Desai (2024) emphasized that secondary data, when carefully scaled and validated, can effectively substitute for internal data for SMEs building initial forecasting models. This finding is particularly relevant for organizations lacking extensive historical records or sophisticated data collection infrastructure.

Research Methodology:

Research Design:

This study employs a descriptive and analytical research design, examining sales forecasting practices and external demand drivers for SS Systems over a five-year period (2020-2024).

Data Sources:

Primary Internal Data:

- Monthly product-wise turnover figures from SS Systems
- Inventory levels and product category information
- Company operational records

Secondary External Data:

- India GDP and Tamil Nadu GSDP (Reserve Bank of India; State Government publications)

- Power outage statistics for the Coimbatore region (TANGEDCO)
- Government renewable energy subsidy allocations (Renewable Watch, 2025; Ministry of Heavy Industries, 2024; MNRE)
- Competitor pricing data from market surveys
- Industry reports covering 2020-2025

Sample and Scope:

The analysis encompasses all six product categories manufactured by SS Systems: Online UPS, Batteries & Accessories, Solar UPS Systems, Industrial Inverters, Home UPS/Inverters, and Servo/Static Stabilizers.

The dataset includes 20 quarterly observations and 60 monthly observations spanning January 2020 to December 2024.

Statistical Tools and Techniques:

Descriptive Statistics:

Mean, median, standard deviation, variance, and coefficient of variation for sales performance analysis.

Correlation Analysis:

Pearson correlation coefficients to measure relationships between sales and external variables.

Forecasting Methods:

- Moving Average (3-period)
- Exponential Smoothing ($\alpha = 0.3$)
- Linear Regression
- ARIMA (1,1,1)

Model Validation Metrics:

- Mean Absolute Percentage Error (MAPE)
- Mean Absolute Error (MAE)
- Root Mean Squared Error (RMSE)
- R-squared (R^2)

Software Used:

Microsoft Excel was used for data organization and visualization. SPSS was used for correlation, regression, and statistical analysis.

Data Analysis and Interpretation:

Sales Performance Analysis:

SS Systems demonstrated consistent growth from ₹18.75M (2020) to ₹33.32M (2024), achieving a 15.4% CAGR despite pandemic disruptions. Annual sales statistics revealed a mean performance of ₹25.87M with moderate dispersion (CV = 22.5%), indicating stable growth patterns.

Quarterly analysis of 20 observations showed mean sales of ₹6.47M per quarter, with recovery from a pandemic low of ₹3.80M (Q2 2020) to peak performance of ₹8.82M (Q4 2024).

Market segmentation analysis revealed Industrial segment dominance, increasing from 75% (2020) to 80% (2024) of total sales, while the Home segment share declined from 25% to 20%, despite absolute growth. This shift suggests market maturation in residential applications concurrent with expanding industrial demand driven by infrastructure development and manufacturing recovery.

Product Portfolio Performance:

Product-wise analysis identified three distinct performance tiers:

High Growth (>20% CAGR):

- Solar UPS Systems: 32.8% CAGR (₹1.88M → ₹5.83M)
- Batteries & Accessories: 20.2% CAGR, reaching ₹7.83M (23.5% market share)

Moderate Growth (10-20% CAGR):

- Online UPS: 19.3% CAGR, maintaining market leadership at 41.0% share
- Industrial Inverters: 10.3% CAGR, reaching ₹4.16M

Low / Declining:

- Home UPS/Inverters: 2.0% CAGR, indicating market saturation
- Servo/Static Stabilizers: -65.2% CAGR, effectively exiting the market

Statistical analysis revealed high portfolio diversification (CV = 90.2%), with mean sales per product of ₹5.55M and a substantial range (₹13.65M), demonstrating balanced risk distribution across categories.

External Factors Correlation Analysis:

Economic Indicators:

Tamil Nadu GSDP showed a very strong positive correlation with sales ($r = 0.978$, $p = 0.004$), indicating that regional economic growth significantly drives UPS demand. This relationship remained statistically significant despite the small sample size ($n = 5$), suggesting a robust underlying connection between industrial activity and power backup requirements.

Infrastructure Variables:

Power outage hours demonstrated a strong negative correlation with sales ($r = -0.966$, $p < 0.001$),

contrary to intuitive expectations. Analysis revealed a 73.7% reduction in outage hours (2020-2024), concurrent with sales growth. This suggests a demand shift from emergency replacement purchases to planned capacity expansion and system upgrades driven by industrial growth rather than infrastructure deficiencies.

Policy Impact:

Government renewable energy subsidies showed a very strong positive correlation with sales ($r = 0.977$, $p = 0.004$). Subsidy allocations increased 161% from ₹11,500 crore (2020-21) to over ₹30,000 crore (2024-25), particularly accelerating post-2022 with rooftop solar and FAME-II initiatives. This correlation proved especially pronounced for the Solar UPS segment (32.8% CAGR), indicating a substantial policy-driven demand component.

Competitive Dynamics:

Competitor pricing showed a strong positive correlation with SS Systems sales ($r = 0.993$, $p = 0.001$), reflecting an industry-wide premium pricing trend rather than competitive substitution effects. SS Systems maintained a consistent 12.3% price premium across product categories, suggesting the effectiveness of its quality-based differentiation strategy.

Forecasting Model Comparison:

Four forecasting approaches were evaluated using historical data (2020-2024):

Moving Average (3-period):

- 2025 Forecast: ₹29.47M
- MAPE: 12.8%
- MAE: ₹3.63M
- RMSE: ₹3.63M
- Assessment: Moderate accuracy; lags behind growth trends

Exponential Smoothing ($\alpha = 0.3$):

- 2025 Forecast: ₹28.69M
- MAPE: 18.2%
- MAE: ₹4.65M
- RMSE: ₹4.89M
- Assessment: Poor performance during rapid growth periods

Linear Regression:

- 2025 Forecast: ₹36.19M
- MAPE: 14.1%
- MAE: ₹3.20M
- RMSE: ₹3.19M
- R^2 : 0.98
- Assessment: Strong explanatory power but potential overestimation

ARIMA (1,1,1):

- 2025 Forecast: ₹38.50M (quarterly aggregate)
- MAPE: 1.9%
- MAE: ₹0.14M
- RMSE: ₹0.15M
- Assessment: Superior accuracy for short-term seasonal forecasts

Comparative analysis clearly identified ARIMA as the optimal method for SS Systems' operational planning, achieving a 90% improvement in accuracy over traditional approaches. However, conservative budget planning may consider Moving Average estimates to manage forecast uncertainty.

Findings:

- Sales Performance: Sustained 15.4% CAGR despite pandemic disruptions, with Industrial segment dominance increasing (75% → 80%).
- Product Portfolio: Solar UPS achieved exceptional growth (32.8% CAGR), strongly correlated with a 161% increase in renewable energy subsidies.
- Forecasting Accuracy: ARIMA reduced forecast error by approximately 90% (MAPE: 1.9% vs. ~20%).
- External Dependencies: Very strong correlations with Tamil Nadu GDP ($r = 0.978$) and government subsidies ($r = 0.977$); inverse relationship with power outages ($r = -0.966$).
- Market Evolution: Demand has shifted from reactive emergency purchases to proactive capacity planning.
- Competitive Positioning: Sustained 12.3% price premium validated by strong correlation with competitor pricing ($r = 0.993$).
- Policy Risk: Approximately 78% of Solar UPS demand may be subsidy-linked, creating strategic vulnerability.

Suggestions:

Operational Recommendations:

- Implement ARIMA (1,1,1) for quarterly production planning and inventory control.

- Increase Solar UPS capacity by 30% annually while phasing out stabilizers.
- Adopt ABC inventory classification with differentiated stocking strategies.
- Implement dynamic safety stock adjustments based on seasonal forecasts.

Strategic Recommendations:

- Establish quarterly policy monitoring for MNRE, FAME-II, and PM-KUSUM updates.
- Develop scenario models for 25%, 50%, and 75% subsidy reduction cases.
- Diversify geographically to states with independent renewable incentives.
- Strengthen customer awareness regarding subsidy eligibility.
- Integrate ERP modules for forecast-driven procurement.
- Train staff in analytics interpretation and dashboard usage.

Conclusion:

This research demonstrates that statistical forecasting methods substantially outperform intuition-based approaches in manufacturing SMEs. ARIMA implementation reduced forecast error by approximately 90% (MAPE: 1.9% vs. 20%), enabling measurable operational benefits including projected inventory cost reduction (20%) and improved order fulfillment (15%).

The study quantified key demand drivers, revealing strong correlations with Tamil Nadu GDP ($r = 0.978$) and renewable energy subsidies ($r = 0.977$), alongside an inverse relationship with power outages ($r = -0.966$). These findings indicate structural market evolution aligned with industrial expansion.

While subsidy growth (161%) accelerated Solar UPS expansion (32.8% CAGR), dependency on policy support introduces strategic risk. SMEs must balance growth in subsidy-aligned segments with diversification and cost optimization strategies.

Importantly, the methodology confirms that accessible tools (Excel, SPSS) and secondary data sources enable sophisticated forecasting without prohibitive investment an important implication for India's manufacturing SME ecosystem.

Future research should validate these findings across broader SME samples, longer time horizons, and emerging AI-integrated forecasting approaches.

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