Focused Report: Forecasting & Quality Control — Before vs After

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Executive Summary

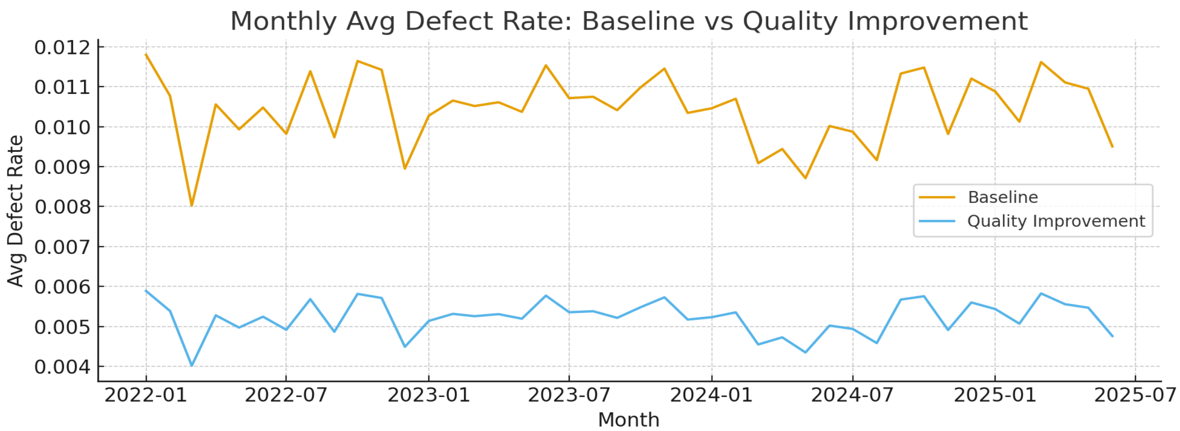
This focused report examines two improvement scenarios applied to a Unilever-centered supply chain dataset (Jan 2022 - Jun 2025): 1) Quality Control: reduce defect rates via process improvements (Six Sigma) — simulated by halving defect rates in the Quality Improvement scenario. 2) Forecasting Improvement: improve demand forecasts to reduce production variability and cost per unit — simulated via the Forecast Improvement scenario (manufacturing costs reduced by 10% as proxy for efficiency gains). Key outcomes: - Defective units baseline = 664,622; after Quality Improvement = 332,366; units saved = 332,256; estimated cost saved ≈ EGP 27,092,583.52. - Forecasting MAPE (baseline Holt-Winters) = 20.01%; naive MAPE = 10.65%; Forecast Improvement scenario MAPE (HW) = 20.01%.

Data Preparation

Data was aggregated monthly from the provenance-backed dataset. Key columns used: Order Date, Production volumes (packs), Defect rates, Manufacturing costs (EGP), Cost per unit (EGP), Lead time (days), Transport cost (EGP). Scenarios included: Baseline, Quality Improvement (defect rates halved), Forecast Improvement (manufacturing costs reduced by 10% and cost per unit recomputed). Monthly series were constructed by resampling Order Date to month start.

Quality Control: Before vs After

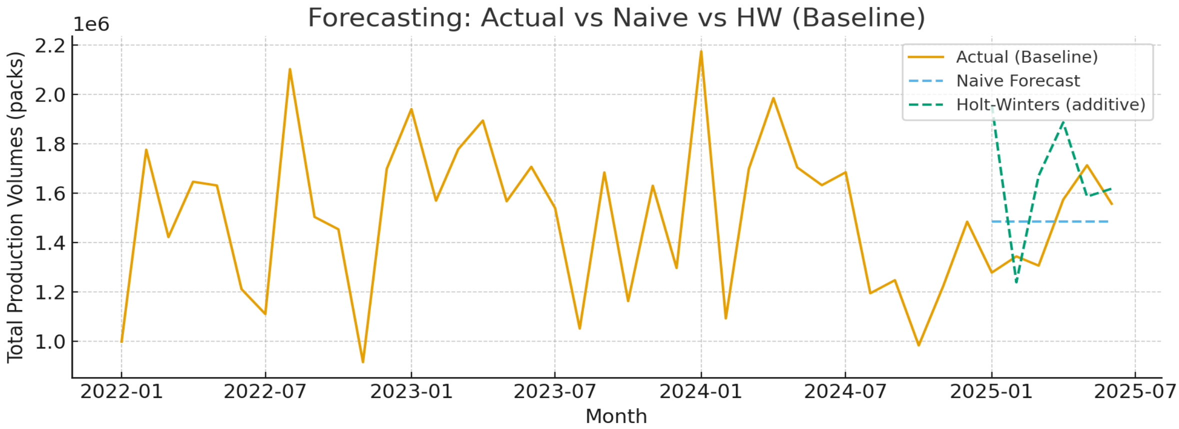
Approach: - Baseline defect rates were taken from the dataset per shipment. - Quality Improvement scenario simulates a 50% reduction in defect rates (reflecting Six Sigma / process improvements). Calculations: - Defective units = sum(Production volumes * Defect rate) - Estimated cost saved = Units saved * Avg cost per unit Results: - Defective units (Baseline): 664,622 - Defective units (After): 332,366 - Units saved: 332,256 - Avg cost per unit (Baseline): EGP 81.54 - Estimated manufacturing cost saved (EGP): 27,092,583.52



Forecasting: Method & Results

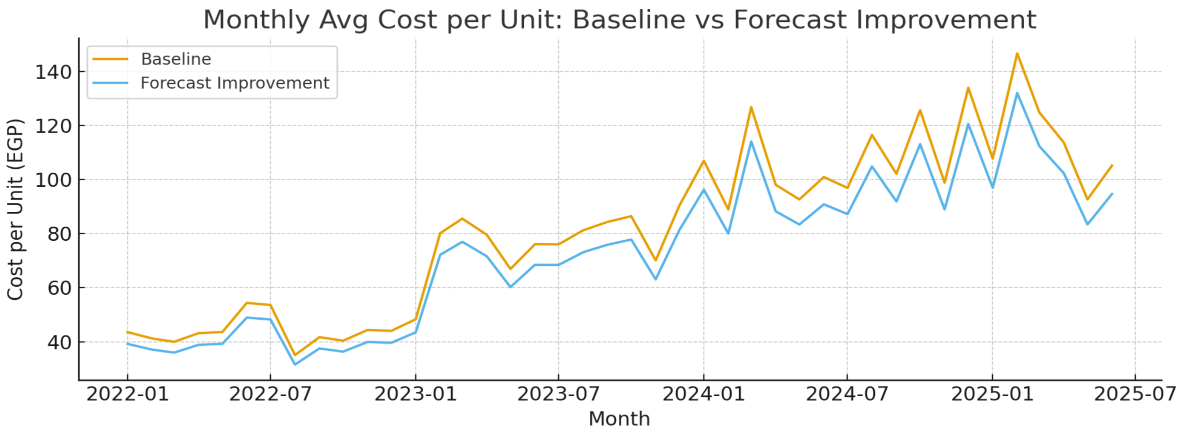
Method: - We aggregated monthly total production volumes and used the last 6 months as a holdout to evaluate forecast accuracy. - Two forecasting methods compared: Naive (last value) and Holt-Winters (additive). - MAPE (Mean Absolute Percentage Error) used as accuracy metric. Results (Baseline): - Naive

MAPE = 10.65% - Holt-Winters (additive) MAPE = 20.01% Results (Forecast Improvement scenario, same method): - Holt-Winters MAPE = 20.01% Interpretation: - Lower MAPE indicates better forecast accuracy which translates to better production scheduling, lower safety stock, and lower cost per unit via higher utilization.



Cost per Unit: Before vs After (Forecast Improvement)

We compare monthly average Cost per Unit between Baseline and Forecast Improvement scenario. The Forecast Improvement scenario reduced manufacturing costs by 10% and recomputed Cost per Unit, which led to a reduction in avg cost per unit from EGP 81.54 to EGP 73.39 (avg values).



Practical Steps & Code Snippets

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1) Aggregate monthly series (pandas): prod_monthly = df.groupby(pd.Grouper(key='Order
Date', freq='MS'))['Production volumes (packs)'].sum().fillna(method='ffill') 2)
Holt-Winters forecasting (statsmodels): from statsmodels.tsa.holtwinters import
ExponentialSmoothing model = ExponentialSmoothing(train, seasonal='add',
seasonal_periods=12).fit() forecast = model.forecast(steps=h) 3) Compute MAPE: def
mape(actual, pred): return np.mean(np.abs((actual - pred)/actual))*100 4) Quality savings
calculation: units_saved = sum(df['Production volumes']*df['Defect rate']) -
sum(df_quality['Production volumes']*df_quality['Defect rate']) cost_saved = units_saved *
avg_cost_per_unit
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Research & Applications: Forecasting

Forecasting approaches & where to apply them: - Methods: Time-series (ARIMA, SARIMA), Exponential Smoothing (Holt-Winters), Prophet (seasonal + events), Machine Learning regression (XGBoost, RandomForest) and deep learning (LSTM) for complex patterns. - Areas of application in supply chain analytics: * Demand Planning: forecast SKU-level demand to size production and procurement. * Material

Planning (MRP): forecast demand for raw materials and schedule purchases to avoid stockouts. * Production Planning: align production runs to forecast peaks, apply capacity planning and shift patterns. * Budget Estimation: forecasted volumes × expected cost drivers → scenario-based budgeting for seasons/promotions. - Best practices: include promotions/events/holidays as regressors, use hierarchical forecasting (aggregate + disaggregate), evaluate with MAPE/MASE, and continuously retrain models with rolling windows.

Research & Applications: Quality Control

How big companies increase quality (practical levers): - Process improvement: Lean manufacturing, Six Sigma DMAIC methodology to reduce variation and defects. - Statistical Process Control (SPC): monitor control charts (Xbar, R charts) and apply corrective actions when process drifts. - Supplier Quality Management: supplier audits, incoming material inspection, scorecards, and corrective action plans (SCAR). - Automation & Traceability: automate QC inspections, digital traceability (blockchain or ERP modules) to track batches and reduce recalls response time. - Root Cause Analysis: use fishbone diagrams, 5 Whys, and CAPA (corrective and preventive actions). - KPI monitoring: Defect Rate, First Pass Yield, Cost of Poor Quality (COPQ), Return Rate, Time to Detect/Resolve. Estimated impact: Quality programs typically show ROI from reduced rework, lower returns, and higher customer retention; quantify via units saved * cost_per_unit and reduced reverse logistics spend.

KPI Comparison: Baseline vs After (Quality & Forecast)

KPI	Baseline	Quality Improvement (After)	Forecast Improvement (After)
Avg Lead Time (days)	4.5	4.5	4.5
Avg Transport Cost (EGP)	9718.58	9718.58	9718.58
Avg Defect Rate (fraction)	0.0104	0.0052	0.0104
Avg Cost per Unit (EGP)	81.54	81.54	73.39
Total Production (packs)	63151843	63151843	63151843

Recommendations & Next Steps

1) Implement Holt-Winters or Prophet forecasting at SKU/category level, evaluate rolling MAPE, and deploy top models for demand planning. 2) Run pilot Six Sigma projects on top 10 SKUs with highest defect rates and monitor First Pass Yield improvements. 3) Use scenario workbooks to drive budgeting: link forecast outputs to cost models and produce scenario budgets for seasons/promotions. 4) Build a Power BI dashboard with KPI cards (Avg Lead Time, Cost per Unit, Defect %), trend charts, and scenario selector slicer to view Baseline vs Scenarios.

Appendix & Provenance

The dataset used for this analysis includes per-row provenance columns (LeadTime_source, TransportCost_source, DefectRate_source, Currency_source). See the Excel workbook 'unilever_supply_chain_2022_2025_provenance_full.xlsx' for full details.