From Data to Strategy: Machine Learning for Identifying Risk Patterns in Amazon's Operations

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Abstract—*This thesis proposes a shift from binary incident classification to probabilistic risk forecasting within Amazon's European operations. Focusing on High-Value Goods (HVG), the research utilizes DeepAR (AutoRegressive Recurrent Networks) to model sparse, non-linear theft patterns. By leveraging static covariates for cold-start scaling and optimizing for P95 tail-risk calibration, this study aims to provide Finance and Operations with a quantitative basis for dynamic resource allocation and protocol escalation.*

keywords—*Probabilistic Forecasting, DeepAR, Tail Risk, Distributed Training, MLOps*

1. Context

As a research intern within Amazon's Finance Analytics team, I identified a gap in how operational risk was modeled for SEV1&2 incidents. Traditional reporting focused on retrospective variance analysis, failing to capture the predictive intermittent volatility of theft during high-velocity events like product launches. This project aims to transition the strategy from reactive reporting to proactive, probabilistic risk quantification, allowing the EMEA S&LP Team to deploy resources based on statistical confidence intervals rather than static schedules.

2. Action Plan - Definitive

1. **Precedent Analysis Data Audit:** Review internal cost allocation practices and audit the "Positive-Unlabeled" bias in security reports vs. inventory reconciliation logs. ✓
2. **Feature Engineering Covariate Selection:** Construct static covariates (Warehouse SqFt) to handle scale differences and dynamic covariates (Launch Dates) to capture seasonality. ✓
3. **Model Implementation (DeepAR)**
   - 3.1. Defining the Probabilistic Loss Function (Negative Binomial Likelihood)
   - 3.2. Distributed Training Setup (TensorFlow `MirroredStrategy`)
   - 3.3. Pipeline Optimization (SageMaker Pipe Mode Implementation)
   - 3.4. Training the Global Model across EU regions
4. **Validation Calibration:**
   - 4.1. Backtesting P50, P90, and P95 forecasts against actuals.
   - 4.2. Calculating Interval Coverage (Calibration) to verify 95% of ground truth falls within bounds.
   - 4.3. Benchmarking training latency (Scalability Validation).
5. **Synthesis:** Compile findings on "Tail Risk" quantification and its impact on financial reserve planning.

3. Thesis Abstract - Definitive

In this thesis, we implement a DeepAR probabilistic forecasting framework to quantify operational theft risk within Amazon's European logistics network. By shifting from deterministic prediction to probabilistic inference, we address the challenge of modeling sparse, high-impact events. The research demonstrates that leveraging global learning via static covariates and optimizing for tail-risk calibration (P95) improves resource allocation efficiency compared to traditional regression or classification methods.

4. Access and Visibility

As stipulated by Ca' Foscari University of Venice[1] Comma IV.I, this thesis will be subject to an embargo period of 36 months following its submission. During this time, the document will not be publicly accessible. This measure ensures the confidentiality of proprietary data.