

Explainable AI for Risk-Aware Inventory Planning

A Scenario-Based Tactical Framework for Industrial Spare Parts

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Key Topics

- Explainable AI (XAI)
- Inventory Management
- Risk-Aware Planning
- Industrial Spare Parts
- Supply Chain Decision Support

“Better prediction accuracy does not automatically create better operational decisions.”

The Problem

Why Spare Parts Inventory Is Difficult

Industrial spare-parts planning is highly complex because demand is:

- irregular,
- unpredictable,
- and failure driven.

Traditional inventory systems struggle with:

- unexpected equipment breakdowns,
 - supply disruptions,
 - long lead times,
 - and volatile demand patterns.
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Common Business Risks

- Production downtime
 - Emergency procurement costs
 - Overstocking
 - Capital lock-in
 - Poor service levels
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Core Challenge

Companies need inventory decisions that are:

- accurate,
- transparent,
- and resilient under uncertainty.

Limitations of Traditional Models

Why Classical Inventory Models Are No Longer Enough

Traditional models such as:

- EOQ,
- Reorder Point Models,
- Base Stock Policies

work well under stable conditions.

But modern supply chains are not stable.

Main Limitations

Assumption of predictable demand

Weak handling of extreme disruptions

Limited risk awareness

Poor adaptability to changing environments

Result

Inventory decisions become reactive instead of resilient.

The Role of AI

How AI Improves Inventory Planning

Artificial Intelligence and Machine Learning can:

- improve demand forecasting,
 - detect hidden patterns,
 - adapt to changing conditions,
 - and optimize inventory parameters dynamically.
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AI Applications

- Predictive analytics
 - Machine learning forecasting
 - Reinforcement learning
 - Real-time inventory optimization
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The Problem With AI

Many AI systems operate as **black boxes**.

Managers often receive recommendations without understanding:

- why decisions were made,
- what risks exist,
- or how reliable outputs are.

Why Explainable AI (XAI) Matters

From Black Box AI to Transparent Decision Support

Explainable AI (XAI) helps decision makers understand:

- why predictions are generated,
 - what factors influence outcomes,
 - and how decisions change under different scenarios.
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XAI Supports

Transparency

Trust

Accountability

Human-AI collaboration

Better risk evaluation

Key Insight

Explainability becomes valuable only when it directly supports operational decisions such as:

- safety stock adjustments,
- reorder point calibration,
- and service-level management.

Proposed Framework

Scenario-Based Explainable AI Framework

Layer 1 — Data & Knowledge

- Historical demand
- Operational data
- Maintenance records
- Risk indicators

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Layer 2 — AI & Explainability

- Forecasting models
- AI predictions
- Explainability outputs
- Decision interpretation

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Layer 3 — Scenario Simulation

- Risk scenarios
- Stress testing
- Tactical inventory evaluation
- Decision comparison

Objective

Support inventory decisions that are:

- risk-aware,
- explainable,
- and operationally practical.

Key Findings

Main Research Findings

1. Forecast Accuracy Alone Is Not Enough

Better forecasts do not automatically create better inventory decisions.

2. Explainability Improves Decision Quality

XAI helps planners:

- validate recommendations,
 - identify trade-offs,
 - and improve confidence in AI outputs.
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3. Scenario-Based Planning Improves Resilience

Testing decisions across multiple future scenarios improves:

- robustness,
 - service stability,
 - and risk preparedness.
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4. Human Judgment Remains Critical

AI should support decision makers — not replace them.

Conclusion

Conclusion

Modern supply chains require inventory systems that are:

- intelligent,
- transparent,
- and resilient under uncertainty.

This research proposes a framework that combines:

- classical inventory logic,
- AI forecasting,
- explainable AI,
- and scenario-based risk analysis.

Future Direction

The next step is empirical implementation and real-world testing of explainable AI systems in industrial inventory environments.