SIMULATION-BASED STUDY ON ENHANCING LOGISTICS EFFICIENCY USING A DIGITAL TWIN MODEL: A CASE OF POTA GLOBAL LOGISTICS

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ABSTRACT:

In today's technology-driven logistics environment, efficiency, visibility, and resilience are critical success factors. This research examines the role of Digital Twin Technology in enhancing logistics performance within POTA Global Logistics Pvt. Ltd**.**, an integrated logistics company in India. Using a simulation-based approach, the study explores how virtual replicas of logistics operations can improve decision-making, reduce disruptions, and optimize key performance indicators (KPIs). Data was collected from 50 logistics professionals using structured questionnaires, analyzed through SPSS. Results show that while POTA maintains standardized performance monitoring, real-time data integration and adaptability require improvement. The study concludes that the implementation of a Digital Twin Model enables proactive decision-making, cost efficiency, and predictive logistics management aligned with Industry 4.0 and Sustainable Development Goals (SDGs 9 & 12).

KEYWORDS:

Digital Twin, Logistics Efficiency, Simulation, Supply Chain, Predictive Analytics, Industry 4.0.

INTRODUCTION:

The logistics industry is undergoing a technological revolution, driven by digitalization, automation, and data analytics. Among emerging technologies, the Digital Twina virtual model of real-world systems offers powerful opportunities to simulate logistics operations and predict performance outcomes.This study titled "A Simulation-Based Study on Enhancing Logistics Efficiency Using a Digital Twin Model: A Case of POTA Global Logistics Pvt. Ltd." investigates how adopting Digital Twin technology can improve operational efficiency and resilience in logistics management. The study also aligns with the United Nations Sustainable Development Goals, promoting innovation and sustainability in industrial systems.

OBJECTIVES:

1. To design and implement a digital twin model for monitoring logistics performance.
2. To assess adaptability and responsiveness under stress scenarios.
3. To analyse the effect of real-time data integration on decision-making.

REVIEW OF LITERATURE:

- Tao et al. (2019) defined Digital Twins as interactive models for real-time optimization in manufacturing.

- Ivanov et al. (2020) highlighted their role in resilient supply chains, enabling disruption simulations.
- Min (2021) and Mourtzis&Doukas (2018) recognized Digital Twins as tools for logistics network optimization and visibility.

RESEARCH METHODOLOGY:

The research follows a descriptive and analytical design supported by simulation modelling.

- Data Source: Primary data from 50 respondents at POTA Global Logistics; secondary data from reports and policy documents.
- Sampling: Purposive sampling targeting logistics and IT professionals.
- Tools Used: SPSS 26.0 for statistical testing (t-test, ANOVA, MANOVA, regression).
- Variables:
  - Independent: Type of logistics process, real-time data integration, disruption type.
  - Dependent: KPI performance, adaptability, decision-making effectiveness.

DATA ANALYSIS AND INTERPRETATION:

a. Descriptive Findings:

Option	Description	Percentage (%)
A	Real-time visualization of logistics operations	42.0
B	Predictive analytics for demand and delays	32.0
C	End-to-end process automation	16.0
D	Performance monitoring and optimization	10.0

Interpretation:

- 42% of respondents viewed real-time visualization as the main purpose of the digital twin.
- 44% preferred integrating inventory and transport operations.
- ERP and WMS systems were identified as key data sources.

b. ANOVA and MANOVA Results:

ANOVA Results for Adaptability Under Stress Scenarios

Source	Sum of Squares	df	F	Sig.
Between Groups	1.376	2	1.729	0.189
Within Groups	18.704	47	-	-

Interpretation:

No significant difference was found in KPI monitoring across disruption scenarios ($p > 0.05$), indicating stable monitoring practices.However, MANOVA revealed thatperceptions of data system integration vary across logistics domains transportation and warehousing systems prioritize ERP data, while last-mile delivery emphasizes IoT inputs.

c. Regression Analysis:

Regression Analysis on Decision-Making Effectiveness

Predictor	B	Std. Error	t	Sig.
Constant	2.615	0.488	5.357	0.000
Types of Real-Time Data	-0.088	0.152	-0.574	0.569
Systems Feeding Data	-0.127	0.178	-0.712	0.480

Interpretation:

Real-time data types and systems did not significantly predict decision-making effectiveness ($p > 0.05$), showing that current data integration systems have limited strategic impact.

FINDINGS:

- Digital Twin models are viewed as essential for real-time visibility and predictive analytics.
- POTA relies on ERP/WMS systems but lacks integrated real-time data adoption.
- KPI frameworks are consistent but require adaptive updates under stress conditions.
- The digital twin approach can identify inefficiencies and support data-driven decisions.

SUGGESTIONS:

1. **Implement full-scale Digital Twin integration** across all logistics operations.
2. **Adopt IoT-based real-time data** for predictive analytics and risk assessment.
3. **Upgrade to cloud-based platforms** (Azure Digital Twins, AWS IoT TwinMaker).
4. **Conduct periodic KPI reviews** to align with simulation outcomes.
5. **Develop employee training programs** on digital systems and data analytics.
6. **Include sustainability metrics** (fuel efficiency, emissions) in simulation dashboards.

CONCLUSION:

This study demonstrates that Digital Twin technology can revolutionize logistics management by providing simulation-based insights and predictive control. While POTA Global Logistics exhibits strong operational systems, improvements in data integration and automation can further enhance responsiveness and cost efficiency.
Digital Twin implementation enables a shift from reactive operations to predictive and prescriptive logistics, ensuring long-term resilience, sustainability, and competitive advantage.

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