

Optimizing Africa's Semiconductor Supply Chains Through AI-Powered Predictive Logistics and Anomaly Detection

Imah Avwerosuo

Bishop Benson Idahosa University Benin City

ABSTRACT

Africa's entry into the global semiconductor value chain is gathering momentum. Countries such as South Africa, Kenya, Morocco, Egypt, and Rwanda are beginning to establish design hubs, assembly and packaging plants, and logistics corridors that connect them to global markets. Yet, the continent's semiconductor supply chains face significant structural challenges. Long lead times, fragmented logistics networks, unpredictable border delays, volatile demand, and limited end-to-end visibility are persistent obstacles. Unlike other industries, semiconductor manufacturing depends on highly precise, time-sensitive movements of materials and components. A single delayed shipment of packaged ICs or wafers can halt production lines worth millions of dollars.

To address these challenges, African semiconductor stakeholders are turning to artificial intelligence—specifically, predictive logistics and anomaly detection. By embedding these technologies into their supply chain operations, African chipmakers, OSAT facilities, logistics providers, and policymakers can move from reactive problem-solving to proactive decision-making, dramatically increasing reliability, efficiency, and resilience.

Keywords: Africa; semiconductor value chain; supply chain resilience; predictive logistics; artificial intelligence; anomaly detection; manufacturing efficiency; logistics networks.

International Journal of Technology, Management and Humanities (2025)

DOI: 10.21590/ijtmh.11.04.01

INTRODUCTION

The Unique Challenges of Semiconductor Logistics

Semiconductor supply chains are unlike any other. They involve thousands of components, from wafers and resists to substrates and lead frames, all moving through multi-step processes that require precise timing. The value density is extremely high, and the manufacturing cycle is unforgiving of disruptions. Delays at ports, shifts in temperature or humidity, or anomalies in shipping routes can result in significant yield losses or missed customer commitments. Moreover, many African logistics networks are still developing digital maturity. This makes real-time visibility across multiple actors—manufacturers, carriers, customs, and distributors—particularly difficult to achieve.

AI offers a way to overcome these constraints without relying solely on massive infrastructure projects. Predictive logistics can forecast delays before they happen, allowing planners to reroute shipments, adjust schedules, or increase buffer stock intelligently. Anomaly detection can identify subtle irregularities in shipment conditions, manufacturing cycle times, or order patterns, flagging problems early

Corresponding Author: Imah Avwerosuo, Bishop Benson Idahosa University Benin City, e-mail: sadenze@yahoo.com

How to cite this article: Avwerosuo, I. (2025). Optimizing Africa's Semiconductor Supply Chains Through AI-Powered Predictive Logistics and Anomaly Detection. *International Journal of Technology, Management and Humanities*, 11(4), 1-4.

Source of support: Nil

Conflict of interest: None

enough to prevent waste and disruptions.

Building the Data Foundation

For AI to work effectively, supply chains must first establish a strong data backbone. This begins with capturing operational and logistics data—GPS signals, shipment events, port dwell times, customs clearance records, and IoT sensor data on temperature and humidity. Manufacturing and order data, including work-in-progress timestamps, yields, and customer bookings, are equally critical. External information such as weather conditions, port congestion levels, or public holidays can enrich predictive models. This data should flow into a modern architecture: a message bus to handle real-

time feeds, a data lake to store historical information, and a feature store that powers machine learning models. With this foundation, African semiconductor actors can build predictive systems that learn from past disruptions and adapt to new patterns over time.

Predictive Logistics: Anticipating Problems Before They Occur

The first major application of AI is predictive logistics. Machine learning models can be trained to estimate arrival times with remarkable accuracy, factoring in lane characteristics, carrier history, port congestion, weather, and customs performance. Instead of relying on static schedules, companies can generate probabilistic ETAs—showing, for example, a 70% chance of a shipment being delayed by 36 hours due to heavy rainfall in Johannesburg combined with congestion at Cape Town port.

Beyond ETA predictions, AI can recommend optimal modes and routes based on cost, carbon intensity, and risk. For example, suppose a sea freight shipment is projected to miss a critical production deadline. In that case, the system can propose switching to air freight and automatically initiate a tender with approved carriers. Multi-echelon inventory optimization algorithms can also determine where to position safety stock across hubs and factories, using predicted transit times and demand variability.

Detecting Anomalies Before They Become Disruptions

The second major application is anomaly detection. Semiconductor materials are often moisture-sensitive, and exposure beyond certain thresholds can ruin entire lots. By using sensor data and unsupervised learning techniques—such as isolation forests or deep autoencoders—companies can detect abnormal temperature or humidity levels in real time and take action, such as triggering re-baking protocols or quarantining lots before they enter production.

Anomaly detection also applies to manufacturing cycle times and commercial patterns. Sudden deviations in work-in-progress durations may indicate machine malfunctions or procedural errors. Unusual order requests or shipment splits might flag planning errors or emerging demand shocks. By spotting these anomalies early, organizations can respond before the issues cascade downstream.

Implementing AI in the African Context

Africa's logistics environment presents unique implementation opportunities and challenges. Free-trade corridors such as the Tanger-Med hub in Morocco, the Durban-Gauteng corridor in South Africa, and the Mombasa-Nairobi route in Kenya are ideal starting points for pilot projects. These corridors handle regular semiconductor-related volumes and connect to major air cargo hubs such as Johannesburg, Addis Ababa, Nairobi, and Casablanca. Partnering with regional logistics providers that can supply consistent data streams

is essential.

Resilience must also be built into the models themselves. Given variations in power supply and connectivity, IoT devices should be equipped with local buffering and store-and-forward capabilities. Customs procedures differ across jurisdictions, so AI systems must be flexible enough to incorporate regulatory nuances and clearance timelines for each country.

Governance, Security, and Measurable Impact

Successful AI deployments require more than models. Companies must establish robust governance frameworks to manage data quality, model versioning, access controls, and compliance with standards such as JEDEC for moisture-sensitive devices. Cybersecurity measures, including device authentication and encrypted event records, are essential to protect supply chain integrity.

The impact of predictive logistics and anomaly detection can be significant. Companies can expect to improve on-time delivery by 5–15%, reduce average port dwell times by up to 30%, and cut expedite costs by as much as 35%. Quality improvements through early detection of environmental excursions can protect yields and reduce waste. Overall, these technologies can offer a payback period of less than a year for logistics networks with moderate volumes.

A Roadmap for Rapid Adoption

African semiconductor players do not need to embark on multi-year transformation programs to benefit from AI. A 90-day roadmap can deliver tangible results. In the first two weeks, companies can select priority logistics lanes and establish baseline performance metrics. Over the next month, they can integrate data from a few carriers and deploy initial ETA and anomaly detection models. In the final phase, these systems can be connected to operational dashboards and decision playbooks, allowing human planners to act on AI insights. Once proven on a few lanes, the approach can scale to broader networks.

CONCLUSION

Africa stands at the threshold of a new era in semiconductor manufacturing and trade. By embracing AI-powered predictive logistics and anomaly detection, the continent can build supply chains that are not only more efficient but also more resilient to disruption. Rather than waiting for infrastructure to catch up, African semiconductor ecosystems can leapfrog legacy systems, positioning themselves as reliable partners in the global chip industry. The combination of data, intelligence, and decisive action can transform Africa's semiconductor supply chains from vulnerable to visionary.

REFERENCES

- [1] Khan, M. M. (2025). Leveraging Artificial Intelligence to Enhance Supply Chain Resilience: The Promising Role of AI. *Management*, 17(1), 99-120.



- [2] Chickermane, H. (2025). How Machine Learning and Generative AI Are Enabling the Autonomous Supply Chain. In *Supply Chain Transformation Through Generative AI and Machine Learning* (pp. 1-28). IGI Global Scientific Publishing.
- [3] Pham, H., & Bris, P. (2025). AI in Supply Chain: Techniques, Applications, Real-World Cases and Benefits under SCOR Framework. *Operations and Supply Chain Management: An International Journal*, 18(2), 300-316.
- [4] Srinivasarao, L. B. (2025). Technological Solutions: AI, Blockchain, and Real-Time Monitoring: The Role of AI in Identifying and Countering Disinformation. In *Mass Media and Impact of Fake News on Supply Chains* (pp. 239-264). IGI Global Scientific Publishing.
- [5] Ohuei, E. A., & Aji, I. S. (2025). Robotic Systems and Intelligent Maintenance Strategies for Enhanced Manufacturing Efficiency. *International Journal of Innovative Science and Research Technology*, 10(7), 1160-1176.
- [6] Shaik, Kamal Mohammed Najeeb. (2025). SDN-based detection and mitigation of botnet traffic in large-scale networks. *World Journal of Advanced Research and Reviews*. 10.30574/wjarr.2025.25.2.0686.
- [7] Ashraf, M. S., Akuthota, V., Prapty, F. T., Sultana, S., Riad, J. A., Ghosh, C. R., ... & Anwar, A. S. (2025, April). Hybrid Q-Learning with VLMs Reasoning Features. In *2025 3rd International Conference on Artificial Intelligence and Machine Learning Applications Theme: Healthcare and Internet of Things (AIMLA)* (pp. 1-6). IEEE.
- [8] Arefin, N. T. Z. S. (2025). Future-Proofing Healthcare: The Role of AI and Blockchain in Data Security.
- [9] Shuvo, M. R., Debnath, R., Hasan, N., Nazara, R., Rahman, F. N., Riad, M. J. A., & Roy, P. (2025, February). Exploring Religions and Cross-Cultural Sensitivities in Conversational AI. In *2025 International Conference on Artificial Intelligence and Data Engineering (AIDE)* (pp. 629-636). IEEE.
- [10] Arefin, M. A. O. S. (2025). Advancements in AI-Enhanced OCT Imaging for Early Disease Detection and Prevention in Aging Populations.
- [11] Sultana, S., Akuthota, V., Subarna, J., Fuad, M. M., Riad, M. J. A., Islam, M. S., ... & Ashraf, M. S. (2025, June). Multi-Vision LVLMs Model Ensemble for Gold Jewelry Authenticity Verification. In *2025 International Conference on Computing Technologies (ICOCT)* (pp. 1-6). IEEE.
- [12] Arefin, S., & Zannat, N. T. (2025). Securing AI in Global Health Research: A Framework for Cross-Border Data Collaboration. *Clinical Medicine And Health Research Journal*, 5(02), 1187-1193.
- [13] Riad, M. J. A., Roy, P., Shuvo, M. R., Hasan, N., Das, S., Ayin, F. J., ... & Rahman, M. M. (2025, January). Fine-Tuning Large Language Models for Regional Dialect Comprehended Question answering in Bangla. In *2025 IEEE International Students' Conference on Electrical, Electronics and Computer Science (SCEECS)* (pp. 1-6). IEEE.
- [14] Arefin, N. T. Z. S. (2025). AI vs Cyber Threats: Real-World Case Studies on Securing Healthcare Data.
- [15] Azmi, S. K. (2025). Voronoi partitioning for secure zone isolation in software-defined cyber perimeters. *Global Journal of Engineering and Technology Advances*, 24(03), 431-441.
- [16] Shaik, Kamal Mohammed Najeeb. (2025). Secure Routing in SDN-Enabled 5G Networks: A Trust-Based Model. *International Journal for Research Publication and Seminar*. 16. 10.36676/jrps.v16.i3.292.
- [17] Almazrouei, K. M. K., Kotb, R., Salem, O. A., Oussaid, A. M., Al-Awlaqi, A. M., & Mamdouh, H. (2025). Knowledge, Attitude and Practice towards Pre-Marital Screening and Consultations among a sample of students in Abu Dhabi, the United Arab Emirates: A Cross-Sectional Study.
- [18] Ojuri, M. A. (2025). Ethical AI and QA-Driven Cybersecurity Risk Mitigation for Critical Infrastructure. *Euro Vantage journals of Artificial intelligence*, 2(1), 60-75.
- [19] Mansur, S. (2025). AI Literacy as a Foundation for Digital Citizenship in Education. *JOURNAL OF TEACHER EDUCATION AND RESEARCH*, 20(01), 5-12.
- [20] Rahman, M. M. (2025). Generational Diversity and Inclusion: HRM Challenges and Opportunities in Multigenerational Workforces.
- [21] Azmi, S. K. (2025). Hypergraph-Based Data Sharding for Scalable Blockchain Storage in Enterprise IT Systems.
- [22] Prior, M. (2025). The Diaspora: Survival, Sacrifices, and the Misunderstood Heartbeat Of Africa: An analysis of migration, remittances, and identity across Nigeria, Ghana, and Togo. *International Journal of Technology, Management and Humanities*, 11(03), 26-28.
- [23] Karamchand, G. ZERO TRUST SECURITY ARCHITECTURE: A PARADIGM SHIFT IN CYBERSECURITY FOR THE DIGITAL AGE. *Journal ID*, 2145, 6523.
- [24] Gupta, N. (2025). The Rise of AI Copilots: Redefining Human-Machine Collaboration in Knowledge Work. *International Journal of Humanities and Information Technology*, 7(03).
- [25] Sanusi, B. O. (2025). Smart Infrastructure: Leveraging IoT and AI for Predictive Maintenance in Urban Facilities. *SAMRIDDHI: A Journal of Physical Sciences, Engineering and Technology*, 17(02), 26-37.
- [26] Aramide, Oluwatosin. (2025). AI AND CYBERWARFARE. *Journal of Tianjin University Science and Technology*. 58. 10.5281/zenodo.16948349.
- [27] Vethachalam, S. (2025). Cybersecurity automation: Enhancing incident response and threat mitigation.
- [28] Ojuri, M. A. (2025). Quality Metrics for Cybersecurity Testing: Defining Benchmarks for Secure Code. *Well Testing Journal*, 34(S3), 786-801.
- [29] Lima, S. A., Rahman, M. M., & Hoque, M. I. Leveraging HRM practices to foster inclusive leadership and advance gender diversity in US tech organizations.
- [30] Sanusi, B. Design and Construction of Hospitals: Integrating Civil Engineering with Healthcare Facility Requirements.
- [31] Shaik, Kamal Mohammed Najeeb. (2025). Next-Generation Firewalls: Beyond Traditional Perimeter Defense. *International Journal For Multidisciplinary Research*. 7. 10.36948/ijfmr.2025.v07i04.51775.
- [32] Bilchenko, N. (2025). Fragile Global Chain: How Frozen Berries Are Becoming a Matter of National Security. *DME Journal of Management*, 6(01).
- [33] Karamchandz, G. (2025). Secure and Privacy-Preserving Data Migration Techniques in Cloud Ecosystems. *Journal of Data Analysis and Critical Management*, 1(02), 67-78.
- [34] Oni, B. A., Adebayo, I. A., Ojo, V. O., & Nkansah, C. (2025). Insight into Underground Hydrogen Storage in Aquifers: Current Status, Modeling, Economic Approaches and Future Outlook. *Energy & Fuels*.
- [35] Karamchand, Gopalakrishna & Aramide, Oluwatosin. (2025). AI AND CYBERWARFARE. *Journal of Tianjin University Science and Technology*. 58. 10.5281/zenodo.16948349.
- [36] Azmi, S. K. Bott-Cher Cohomology For Modeling Secure

- Software Update Cascades In Iot Networks.
- [37] Lima, S. A., & Rahman, M. M. (2025). Neurodiversity at Work: Hrm Strategies for Creating Equitable and Supportive Tech Workplaces. *Well Testing Journal*, 34(S3), 245-250.
- [38] Samuel, A. J. (2025). Predictive AI for Supply Chain Management: Addressing Vulnerabilities to Cyber-Physical Attacks. *Well Testing Journal*, 34(S2), 185-202.
- [39] Azmi, S. K. Retrieval-Augmented Requirements: Using RAG To Elicit, Trace, And Validate Requirements From Enterprise Knowledge Bases.
- [40] SANUSI, B. O. (2025). LEVERAGING CIVIL ENGINEERING AND DATA ANALYTICS FOR ECONOMIC GROWTH: A CASE STUDY ON SUPPLY CHAIN OPTIMIZATION IN SPORTS FACILITY RENOVATIONS. *MULTIDISCIPLINARY JOURNAL OF ENGINEERING, TECHNOLOGY AND SCIENCES*, 2(1).
- [41] Azmi, S. K. (2025). Kirigami-Inspired Data Sharding for Secure Distributed Data Processing in Cloud Environments.
- [42] Sachar, D. (2025, May). Enhanced Machine Learning Approaches for Network Intrusion and Anomaly Detection. In 2025 Systems and Information Engineering Design Symposium (SIEDS) (pp. 426-431). IEEE.
- [43] Azmi, S. K. (2021). Riemannian Flow Analysis for Secure Software Dependency Resolution in Microservices Architectures. *Well Testing Journal*, 30(2), 66-80.
- [44] Sachar, D. (2025, May). Optimizing Transaction Fraud Detection: A Comparative Study of Nature-Inspired Algorithms for Feature Selection. In 2025 Systems and Information Engineering Design Symposium (SIEDS) (pp. 392-397). IEEE.
- [45] Almazrouei, K. M. K., Kotb, R., Salem, O. A., Oussaid, A. M., Al-Awlaqi, A. M., & Mamdouh, H. (2025). Knowledge, Attitude and Practice towards Pre-Marital Screening and Consultations among a sample of students in Abu Dhabi, the United Arab Emirates: A Cross-Sectional Study.
- [46] Kumar, K. (2025). Cross-Asset Correlation Shifts in Crisis Periods: A Framework for Portfolio Hedging. *Journal of Data Analysis and Critical Management*, 1(01), 40-51.
- [47] Azmi, S. K. Zero-Trust Architectures Integrated With Blockchain For Secure Multi-Party Computation In Decentralized Finance.
- [48] Karamchand, G. (2025). AI-Optimized Network Function Virtualization Security in Cloud Infrastructure. *International Journal of Humanities and Information Technology*, 7(03), 01-12.
- [49] Gade, S., Kholpe, B. M., Paikrao, U. B., & Kumbhar, G. J. (2025). Enriching redistribution of power in EV Charging Stations through Deep learning. *International Journal of Scientific Research in Modern Science and Technology*, 4(1), 29-45.
- [50] Azmi, S. K. (2021). Spin-Orbit Coupling in Hardware-Based Data Obfuscation for Tamper-Proof Cyber Data Vaults. *Well Testing Journal*, 30(1), 140-154.

