Abstract

The accelerating pace of digital transformation has made the adoption of Artificial Intelligence (AI) a strategic imperative in data-intensive and time-critical industries such as air cargo. However, the sector's operational complexity, stringent regulatory environment, and fragmented stakeholder ecosystem have resulted in slow and uneven diffusion of AI initiatives. At the same time, global discourse is shifting from the efficiency-centric orientation of Industry 4.0 toward the human-centric paradigm of Industry 5.0, emphasizing ethical oversight, transparency, trust, and workforce inclusivity in AI-driven transformation. Against this backdrop, this thesis investigates how the Indian air cargo industry can transition from isolated AI deployments toward a scalable and sustainable adoption of both AI and Human-Centric Artificial Intelligence (HCAI), balancing operational efficiency with human-centric sustainability. Anchored in an extended Technology–Organization–Environment (TOE+) framework incorporating Human-Social dimensions, the study adopts a five-phase hybrid multi-criteria decision-making (MCDM) methodology integrating Fuzzy Delphi, Fuzzy DEMATEL, Analytic Hierarchy Process (AHP), Fuzzy TOPSIS, and sensitivity analysis. Through an extensive literature review and expert-informed Fuzzy Delphi analysis, the study identifies and validates AI barriers and enablers, and HCAI barriers and enablers spanning technological, organizational, environmental, and human-social domains. The findings reveal that persistent technological deficiencies such as poor data quality and inadequate infrastructure, organizational gaps including lack of top management commitment and strategic roadmaps, and human-social challenges such as fear of job displacement and lack of trust in AI collectively constrain adoption, while enablers such as real-time visibility, automation, leadership support, ethical oversight, stakeholder collaboration, and human-in-the-loop design offer significant transformative potential. Using Fuzzy DEMATEL, the study uncovers the causal structure of these factors, showing that data quality, leadership commitment, digital infrastructure, ethical governance, trust-building, and AI talent availability function as root-causal drivers shaping downstream outcomes such as resistance to change and stakeholder disengagement. Building on these insights, AHP-based prioritisation highlights the most critical barriers and enablers for both AI and HCAI, which are subsequently translated into implementation strategies and evaluated using Fuzzy TOPSIS with sensitivity analysis. Strategies such as establishing AI steering committees, upgrading digital infrastructure, deploying real-time analytics platforms, creating ethical oversight mechanisms, and embedding human-in-the-loop workflows consistently emerge as robust across multiple decision scenarios. By integrating causal analysis, prioritisation, and strategy evaluation within a unified TOE+ framework, this thesis advances theory by reframing HCAI as an evolutionary extension of AI adoption, contributes methodologically by operationalizing human-centric principles within a hybrid MCDM pipeline, and provides actionable decision support for industry leaders, technology vendors, and policymakers to align AI-driven efficiency gains with the ethical, social, and sustainability imperatives of Industry 5.0.

Keywords**:**
Artificial Intelligence (AI); Human-Centric Artificial Intelligence (HCAI); Industry 4.0; Industry 5.0; Air Cargo Industry; Digital Transformation; Technology–Organization–Environment (TOE) Framework; Human-Social (HS) Factors; Fuzzy Delphi; Fuzzy DEMATEL; Analytic Hierarchy Process (AHP); Fuzzy TOPSIS; Multi-Criteria Decision-Making (MCDM); Causal Modelling; Strategy Prioritisation; Sensitivity Analysis; Ethical AI; Organizational Readiness; Stakeholder Engagement; Sustainable Innovation.