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Quantitative and Qualitative Implications of AI Adoption for HRM in Last-Mile E-Commerce Delivery: A Systematic Review

Ionel Bostan^{1,*}, Alunica Morariu¹, Cristina Mihaela Lazăr²

¹Faculty of Law and Administrative Sciences, Ștefan cel Mare University, 720229 Suceava, Romania

²Faculty of Economic Sciences, Ovidius University, 900527 Constanța, Romania

*Correspondence: ionel.bostan@fdsa.usv.ro; ionel_bostan@yahoo.com (Ionel Bostan)

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Abstract

This systematic review examines the managerial implications of Artificial Intelligence (AI) adoption in last-mile e-commerce delivery, with a particular focus on human resource management (HRM). Based on 200 Web of Science–indexed studies (2013–2025), the evidence confirms substantial operational gains, including improvements in delivery speed (+15–32%), cost savings (+8–25%), fleet utilization (+10–18%), and workforce-allocation accuracy (+12–20%). However, qualitative findings also reveal challenges related to job redesign, surveillance pressures, shifts in employee motivation, and workplace inclusion. The review introduces an integrated framework that bridges logistics and HRM, highlighting the trade-offs between efficiency and employee well-being. For managers, successful implementation depends on a human-centered approach to AI adoption, transparent performance metrics, and workforce upskilling, while policymakers must ensure context-sensitive governance.

Keywords: artificial intelligence; e-commerce; last-mile delivery; human resource management; algorithmic management; workforce transformation and impacts

JEL: L81, L86, M12, M15, O33

1. Introduction

Artificial Intelligence (AI) has rapidly emerged as a transformative force across economic sectors, reshaping organizational processes and redefining the relationship between technology and human labor. Within the sphere of e-commerce, last-mile delivery has been particularly affected, given its complex requirements for speed, accuracy, and customer satisfaction (Ivanov et al., 2019; Köhler and Pizzol, 2020). The integration of AI tools—ranging from machine learning algorithms to computer vision systems and predictive analytics—has redefined both the quantitative performance indicators of delivery systems and the qualitative experiences of the workers managing these operations. As can be expected, the “last mile” represents the final stage of the supply chain, often generating more than 50% of total logistics costs (Savelsbergh and Van Woensel, 2016), a situation that justifies the adoption of traditional optimization strategies—focused on routing, scheduling, and resource allocation—enhanced through AI applications. For instance, deep reinforcement learning enables dynamic rerouting in real time (Ghaderi et al., 2022; Moreno-Saavedra et al., 2024), while computer vision systems reduce errors in parcel identification (Heng et al., 2023; Lu et al., 2024). It is important to emphasize that, quantitatively, these innovations translate into measurable efficiency gains; however, the adoption of AI simultaneously introduces new challenges for human resource management (HRM), such as algorithmic scheduling, intensi-

fied monitoring, and workforce polarization. From a human resource perspective, AI-driven last-mile operations have triggered a paradigm shift, with algorithmic management now influencing recruitment, training, performance evaluation, and even employee well-being (Meijerink and Bondarouk, 2023). In this regard, while some studies highlight positive outcomes, such as reduced workload through automation or increased transparency in performance metrics (Budhwar et al., 2022), others emphasize negative effects, including stress, job insecurity, and the perceived loss of autonomy (Chen et al., 2021; Meijerink et al., 2021; Veen et al., 2020). This duality highlights the importance of examining both quantitative and qualitative implications in an integrated framework.

Although prior research has expanded significantly, the Eastern European and Romanian contexts remain underexplored. This gap is not only empirical, but also conceptual and managerial. Beyond being merely underexplored, Central and Eastern European (CEE) economies exhibit structural and institutional characteristics that render AI adoption in last-mile delivery managerially distinct from more frequently studied contexts such as the United States or China. The legacy of post-socialist labor relations continues to shape managerial authority, employee trust, and perceptions of technological control, often resulting in heightened sensitivity to algorithmic surveillance and performance monitoring. At the same time, labor markets in the region are characterized by persistent dualities between



formal employment and informal or semi-formal arrangements, particularly in logistics and platform-mediated delivery services.

Moreover, infrastructural fragmentation—ranging from uneven transport networks to limited digital integration across urban and peripheral areas—constrains the scalability of AI-based routing and workforce optimization systems. While European Union integration has strengthened regulatory alignment through instruments such as General Data Protection Regulation (GDPR) and emerging AI governance frameworks, implementation capacity and enforcement remain uneven across new and old member states. As a result, managers in CEE last-mile delivery firms face a complex balancing act: leveraging AI to improve efficiency and competitiveness while navigating regulatory uncertainty, workforce vulnerability, and historically rooted skepticism toward automated managerial control. Embedding this regional specificity is essential for advancing context-sensitive insights relevant to the readership of the *Journal of East European Management Studies*.

In these regions, e-commerce logistics often coexist with infrastructural deficits, regulatory ambiguities, and informal labor markets, which shape AI adoption in distinctive ways. Addressing this blind spot is essential if scholarship is to move beyond global generalizations and capture the diversity of local experiences.

Despite the growing academic interest in AI adoption within logistics and HRM, the literature remains fragmented. Most logistics-oriented studies concentrate on operational efficiency, while HRM-focused works explore employee experiences. Few studies explicitly bridge the two perspectives (Chau et al., 2025; Jayakarthika et al., 2024). As a result, there is limited understanding of how efficiency gains relate to workforce dynamics in last-mile e-commerce delivery. To address this gap, the present study conducts a systematic review of 200 Web of Science-indexed articles published between 2013 and 2025, a period that captures both the early experimentation with AI tools in logistics and their rapid expansion during and after the COVID-19 pandemic. The review follows the Preferred Reporting Items for Systematic Reviews and Meta-Analyses (PRISMA) 2020 guidelines, ensuring rigorous methods and transparency in the identification, screening, eligibility, and inclusion of studies. The contribution of this paper is threefold: (i) it offers a systematic synthesis of AI's dual implications in last-mile delivery, encompassing operational and workforce outcomes; (ii) it identifies cross-cutting patterns—such as efficiency-well-being trade-offs and skill polarization—that transcend disciplinary boundaries; (iii) it provides managerial and policy recommendations to align AI-driven innovation with sustainable HRM practices.

In terms of structure, this article has been organized as follows: Section 2 outlines the materials and meth-

ods, including the systematic review protocol; Section 3 presents the results, organized into quantitative and qualitative themes; Section 4 discusses the findings in light of prior research and theoretical frameworks; Section 5 concludes with several final insights, also highlighting the implications for scholars, practitioners, and policymakers.

2. Materials and Methods

We employ a Systematic Literature Review (SLR) to identify, evaluate, and synthesize existing research on the quantitative and qualitative implications of AI adoption for HRM in last-mile e-commerce delivery. The SLR methodology was chosen because it offers a transparent, reproducible approach for integrating diverse both empirical and conceptual studies, thereby enabling the derivation of comprehensive insights (Denyer and Tranfield, 2009; Snyder, 2019; Tranfield et al., 2003). Compared to narrative reviews, which may be susceptible to selection bias, the SLR ensures that the resulting synthesis reflects the breadth and depth of current knowledge in both logistics and HRM domains.

The review follows the PRISMA guidelines (Page et al., 2021), widely recognized in social sciences and management research for ensuring methodological transparency and rigor. The PRISMA framework was applied in successive stages of identification, screening, eligibility assessment, and final inclusion, which are presented in detail in the Results section through the flow diagram. The literature search was conducted between January and March 2025 in the Web of Science (WoS) Core Collection, selected for its comprehensive coverage of high-impact journals relevant to logistics, HRM, operations research, and information systems. The search strategy combined Boolean operators, wildcards, and proximity searches.

Representative search strings included terms such as “artificial intelligence”, “machine learning”, “deep learning”, “algorithmic management”, and “predictive analytics”, combined with HRM-related keywords such as “recruitment”, “performance management” or “workforce management”, and logistics-specific terms like “last-mile delivery”, “e-commerce delivery”, “crowdshipping” or “urban logistics”. The time frame was restricted to 2013–2025 to capture both the early experimentation with AI in commercial logistics and its rapid expansion during and after the COVID-19 pandemic. It should be noted that the term ‘artificial intelligence’ encompasses heterogeneous technological stages over the reviewed period, ranging from early rule-based and optimization systems to more advanced machine learning and deep learning applications; the analysis therefore adopts a narrative synthesis approach that accounts for this evolution rather than treating AI as a uniform construct.

Only English-language publications were considered, with inclusion limited to journal articles indexed in WoS, consistent with the preference of highly prestigious jour-

nals for high-quality scholarly sources. Eligibility was determined based on clear inclusion and exclusion criteria.

The review considered only journal articles explicitly addressing AI technologies in last-mile delivery and/or HRM practices, whether empirical studies, theoretical works, or review papers, provided they contained sufficient methodological foundations. Publications reporting either quantitative performance metrics, qualitative workforce insights, or both, were retained. Studies focusing exclusively on AI outside the logistics context, articles addressing HRM without technological components, as well as works lacking sufficient methodological detail were excluded. The initial search identified 3142 records. After removing 512 duplicates, 2630 unique records remained, which were screened at the title and abstract level, resulting in the exclusion of 1945 articles that did not meet the inclusion criteria. A total of 685 articles were then subjected to full-text review, which led to the exclusion of 485 papers due to insufficiently rigorous methods, lack of relevance, or inadequate focus on the intersection of AI, HRM, and last-mile delivery. Ultimately, 200 studies were retained for data extraction and synthesis. Of these, 104 focused primarily on logistics and operations, 96 centered on HRM and organizational behavior, while 28 explicitly bridged both domains.

Data were extracted using a standardized template that captured bibliographic details, geographic scope, industry context, the AI technologies applied (machine learning, deep reinforcement learning, computer vision, Natural Language Processing (NLP), predictive analytics, hybrid AI–IoT), the HRM dimensions addressed (recruitment, training, scheduling, performance evaluation, well-being), quantitative performance indicators (delivery times, cost per parcel, error rates, fleet utilization), qualitative workforce outcomes (job satisfaction, autonomy, skill development, ethical issues), and methodological design (case studies, surveys, simulations, or mixed methods). Particular attention was paid to the geographical provenance of the reviewed studies in order to assess the extent to which CEE contexts are represented in the existing literature. This focus responds directly to calls within management research for greater contextual sensitivity, especially in transition economies where institutional, cultural, and labor-market dynamics differ markedly from those of advanced Western economies. By systematically mapping the regional distribution of studies, the review not only synthesizes substantive findings but also empirically substantiates the relative marginalization of CEE perspectives in AI-driven logistics and HRM research.

To structure and analyze the data, thematic coding was performed using NVivo 14 (version 14; Lumivero; Denver, Colorado, USA), enabling the identification of higher-order categories such as operational efficiency and performance gains, workforce transformation and skill requirements, employee experience and well-being, and ethics, governance, and algorithmic accountability. To ensure ro-

bustness, each study was evaluated through a five-point quality appraisal framework adapted from the Critical Appraisal Skills Programme (CASP), assessing clarity of research aims, appropriateness of methodology, rigor of data collection and analysis, transparency in reporting, and relevance to the review objectives. Articles scoring below three out of five were excluded, which led to the removal of twelve borderline studies.

The synthesis of findings combined quantitative and qualitative approaches. Quantitative data, such as improvements in delivery speed, costs, or fleet utilization, were normalized to percentage values wherever possible to allow for comparison across studies. When statistical heterogeneity was high ($I^2 > 75\%$), results were narratively summarized rather than pooled.

Qualitative synthesis relied on thematic analysis to highlight recurring patterns related to workforce experiences, including perceptions of autonomy, job satisfaction, or fairness. This dual approach ensured that both measurable operational outcomes and experiential workforce consequences were integrated, providing a balanced evidence base for the conceptual framework discussed in the following sections.

3. Results

The final corpus analyzed in this review comprises 200 articles published between 2013 and 2025, all indexed in Web of Science. For descriptive purposes, the studies were grouped according to their dominant thematic orientation. Specifically, 104 studies (52%) were classified as primarily logistics/operations-oriented, while 96 studies (48%) were classified as primarily HRM/organizational behavior-oriented. A subset of 28 studies, included within these two primary categories, explicitly connected both domains by simultaneously addressing operational and workforce implications of AI adoption. Thus, the 28 studies represent cross-cutting contributions within the corpus, not an additional category (Barykin et al., 2021; Cameron et al., 2023; Fenwick et al., 2024; Gong et al., 2025; Hiebl, 2023; Le and Fan, 2024; Nawaz et al., 2024; Palos-Sánchez et al., 2022; Pedrami and Vaezi, 2026); the total therefore remains 200. The academic profile of the corpus is reflected in the average impact factor of 6.2 (2024 JCR), which indicates a high level of scholarly visibility. Among the most frequently represented outlets are Sustainability, Computers & Industrial Engineering, HRM Review, Transportation Research Part E, and the Journal of Business Research. A temporal analysis of publication trends reveals a marked increase in scholarly output from 2018 onwards, with a steep acceleration during the COVID-19 pandemic (2020–2022), when e-commerce volumes expanded significantly worldwide (Alliou et al., 2024; Chu et al., 2023). As illustrated in Fig. 1, annual publications increased from 4 in 2013 to a peak of 33 in 2024, followed by 32 publications in 2025.

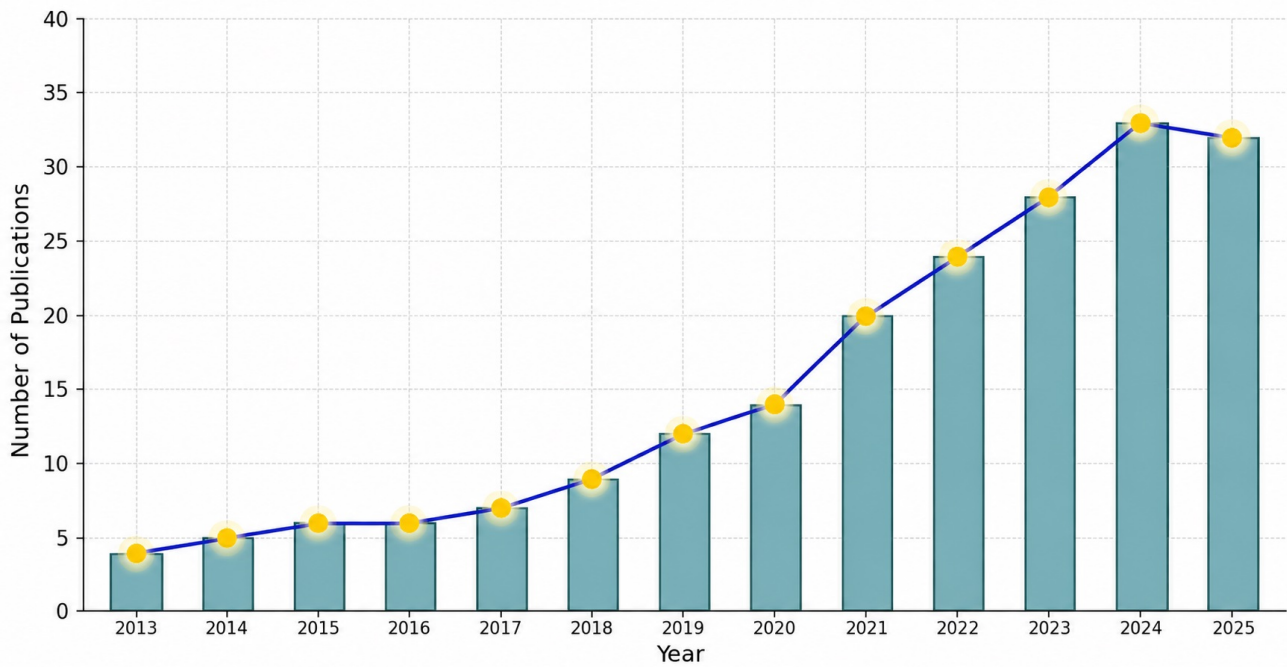


Fig. 1. Annual publication trends (2013–2025).

Table 1. Distribution of articles by region and sector (N = 200).

Region/Country group	No. of studies (%)	Main sectoral focus
China	54 (27%)	Courier delivery (AI routing, fleet management); food delivery platforms
United States	42 (21%)	E-commerce logistics, gig-platform workforce, predictive HRM analytics
United Kingdom	18 (9%)	Urban microhubs, parcel lockers, employee well-being studies
Germany	14 (7%)	Supply chain AI, automation ethics, warehouse robotics
India	12 (6%)	Grocery delivery, gig-economy workforce, algorithmic management
European Union (Other)	32 (16%)	Cross-border logistics, HRM digitalization, sustainability frameworks
Rest of Asia-Pacific	16 (8%)	Smart city delivery, IoT–AI integration
Latin America	6 (3%)	Platform-based gig delivery, informal workforce transitions
Africa	6 (3%)	E-commerce emergence, workforce adaptation, infrastructural challenges

Note: Distribution based on the 200 articles (100%) selected in this review. Regional classification reflects the first author’s institutional affiliation, while sectoral classification reflects the study’s thematic orientation. HRM, human resource management; AI, Artificial Intelligence.

The annual distribution shown in Fig. 1 sums to the final review corpus of 200 studies.

Beyond this temporal growth, the corpus also demonstrates a distinctive geographic and sectoral distribution. As shown in Table 1, the majority of studies originate from China, the United States, and Europe, while contributions from Latin America and Africa remain limited.

A closer examination of the category labelled “European Union (Other)” reveals that only a small fraction of these studies explicitly address CEE countries, including Poland, Romania, Hungary, and the Czech Republic. The majority instead focus on Western and Northern European contexts, where digital infrastructure maturity, regulatory enforcement, and institutional trust are comparatively stronger. This imbalance highlights a substantive research gap: despite facing distinct managerial and workforce chal-

lenges, CEE economies remain largely absent from empirical and conceptual analyses of AI adoption in last-mile delivery. The finding reinforces the need for regionally grounded management research that moves beyond aggregated European perspectives.

Sectoral segmentation mirrors this geographic distribution. Courier and parcel delivery represents the dominant field of application (46%), followed by grocery and food delivery (18%), omnichannel retail logistics (14%), urban freight microhubs and lockers (12%), and gig-platform delivery (10%). Each of these sectors displays distinct HRM challenges: While courier companies are often characterized by unionized labor relations, platform-based gig operators face persistent debates over worker classification, retention, and contractual precarity. With respect to the technologies applied, the 200 studies identify a broad spectrum

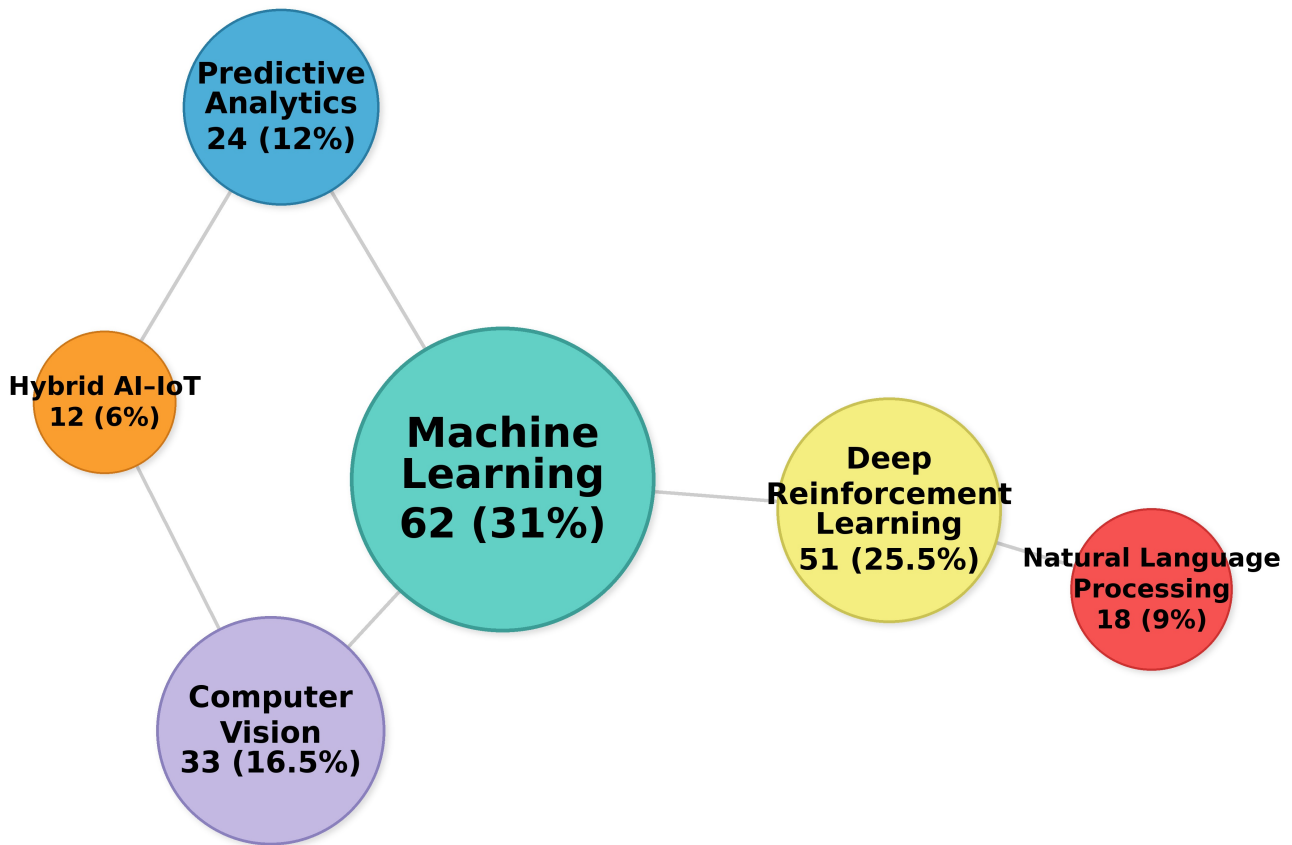


Fig. 2. Conceptual visualization of AI technology categories and thematic intersections.

of AI tools classified into six major categories. Machine learning is the most frequently applied technology (62 studies), mainly for demand forecasting, parcel volume prediction, and workforce allocation. Deep reinforcement learning appears in 51 studies, with a strong focus on routing and dispatch optimization through real-time adjustments. Computer vision is featured in 33 studies, primarily for automated package recognition and damage detection, while natural language processing is applied in 18 studies to support customer-facing communication such as chatbots and automated notifications. Predictive analytics, highlighted in 24 studies, is used for HRM purposes including talent sourcing, attrition prediction, and performance evaluation. Finally, 12 studies address hybrid AI-IoT systems, integrating sensor data with intelligent algorithms for fleet management and worker safety. While the logistics-oriented contributions emphasize efficiency metrics, the HRM-oriented works focus particularly on predictive analytics and algorithmic performance evaluation.

Fig. 2 provides a conceptual bubble-chart visualization summarizing the main AI technology categories identified in the reviewed literature and their intersections with logistics, HRM, and governance themes.

The quantitative evidence provided by the literature consistently indicates substantial operational improvements linked to AI implementation. Delivery times are reported

to decrease by 15–32% following the introduction of AI-based routing optimization (El Amrani et al., 2025; Kumar, 2025), while cost efficiency improves through per-delivery reductions between 8–25% (Cannas et al., 2024; Chen et al., 2024; Shuaibu et al., 2025). Fleet utilization has been shown to increase by 10–18% as a result of AI-driven scheduling, and computer vision has reduced misdelivery rates by 40–60% (Giuffrida et al., 2022). From a workforce management perspective, predictive demand models have improved shift planning accuracy by 12–20% (Soleimani et al., 2025). Algorithmic scheduling has lowered overtime hours by 10–15%, while AI-assisted training allocation has improved onboarding efficiency by 22% (Behrendt et al., 2022; Venugopal et al., 2024). The consolidated effects of these quantitative contributions are summarized in Table 2, which underscores consistent gains in speed, cost efficiency, and allocation accuracy.

Beyond measurable performance metrics, the qualitative analysis reveals four recurrent themes that highlight the organizational and workforce-level consequences of AI adoption. First, job redesign and skill transformation emerge as central issues, since AI displaces repetitive tasks but increases the demand for tech-enabled roles, making digital upskilling a critical requirement (Rodgers et al., 2023). Second, employee autonomy is often reduced through heightened algorithmic surveillance, as Global Po-

Table 2. Quantitative effects of AI adoption in last-mile delivery and HRM.

Quantitative effect	Indicators/Metrics used	Representative findings (Range)
Delivery time reduction	Average delivery time (minutes), % improvement	15–32% faster delivery after AI-based route optimization
Cost efficiency	Cost per parcel, total delivery cost savings (%)	8–25% reduction in per-delivery costs
Fleet utilization	Vehicle utilization rate (%), trips per vehicle/day	10–18% improvement in utilization efficiency
Error minimization	Misdelivery rate (%), package recognition accuracy	40–60% fewer errors via computer vision systems
Labor allocation accuracy	Forecast vs. actual workforce needs (% accuracy)	12–20% better alignment of staffing with demand
Overtime reduction	Overtime hours per worker, % decrease	10–15% decline in overtime hours due to algorithmic scheduling
Onboarding & training gains	Time-to-productivity, training efficiency (%)	22% faster onboarding via data-driven training allocation

Table 3. Qualitative effects of AI adoption in last-mile HRM.

Qualitative effect	Indicators/Dimensions used	Representative insights
Job redesign & skill transformation	New digital roles, demand for upskilling, automation of repetitive tasks	AI shifts workforce toward tech-enabled functions; digital skill gaps remain significant
Employee autonomy & surveillance	Level of task discretion, monitoring intensity, GPS/dashboards	Mixed outcomes: reduced uncertainty in assignments, but higher surveillance and centralization of control
Job satisfaction & motivation	Perceived fairness, recognition, engagement levels	Transparent metrics boost recognition; risks of depersonalization and stress reported
Ethical & Inclusion Concerns	Bias in recruitment algorithms, fairness in evaluation, inclusion of vulnerable groups	Algorithmic bias persists, especially in gig-delivery platforms; risk of marginalizing certain worker groups

Note: GPS refers to the Global Positioning System, a satellite-based technology used in last-mile delivery to track vehicle routes, worker location, and delivery progress in real time.

sitioning System (GPS) tracking and digital dashboards centralize managerial control (Vignola et al., 2023; Yuan et al., 2023; Zhou et al., 2023). Third, job satisfaction and motivation show a mixed picture: while transparent metrics allow more objective recognition of high performance, risks of depersonalization and reduced discretion remain significant (Bujold et al., 2022; Capasso et al., 2024; Yuan et al., 2023). Finally, ethical and inclusion concerns persist, as algorithmic recruitment and evaluation systems frequently replicate existing biases, disproportionately disadvantaging women, minorities, or gig workers (Lang et al., 2023; Parent-Rocheleau and Parker, 2022). The synthesis of these qualitative themes is presented in Table 3, which highlights how efficiency gains are often accompanied by costs in terms of autonomy, inclusiveness, and satisfaction.

Integrating the quantitative and qualitative evidence leads to three cross-cutting insights. First, there is a consistent efficiency–well-being trade-off, whereby operational gains often come at the expense of perceived autonomy and job satisfaction. Second, the findings reveal clear tendencies toward skill polarization, with high-skill digital roles expanding while low-skill manual positions decline. Importantly, skill polarization should be understood not merely as an HRM issue but as a systemic organiza-

tional challenge. The effectiveness of AI adoption is contingent upon an organization’s digital drive and the presence of a supportive digital culture that enables technology to translate into broad-based innovation performance. In the absence of such a culture, AI tends to reinforce existing inequalities, benefiting a small group of highly skilled specialists while marginalizing frontline delivery workers. This dynamic risks undermining organizational learning and long-term innovation capacity, particularly in small and medium-sized enterprises (SMEs) prevalent across Central and Eastern Europe.

Third, managerial mediation plays a decisive role: organizations with strong HRM practices manage to integrate AI as a supportive tool rather than a strict control mechanism, thereby mitigating adverse effects. These cross-cutting insights are summarized in Table 4, which consolidates the evidence across domains.

Finally, the review process itself is summarized in the PRISMA flow diagram presented in Fig. 3.

Out of the 3142 records initially identified, 512 duplicates were removed, leaving 2630 unique entries. Screening of titles and abstracts eliminated 1945 records, while the subsequent full-text review of 685 studies led to the exclusion of 485 items that did not meet methodological or

Table 4. Cross-cutting themes emerging from the SLR.

Theme	Quantitative evidence	Qualitative evidence
Efficiency–Well-being trade-offs	Delivery time ↓15–32%; cost per parcel ↓8–25%	Reports of reduced autonomy, increased monitoring
Skill polarization	Higher demand for data science, route optimization skills	Decline in low-skill, manual delivery tasks
Managerial mediation	Improved labor allocation accuracy (↑12–20%)	Mitigated negative effects where AI is framed as support tool

Note: The symbols ↑ and ↓ indicate the direction of change in the reported indicators. ↑ denotes an increase or improvement, such as higher labor allocation accuracy, while ↓ denotes a decrease or reduction, such as shorter delivery time or lower cost per parcel. SLR, Systematic Literature Review.

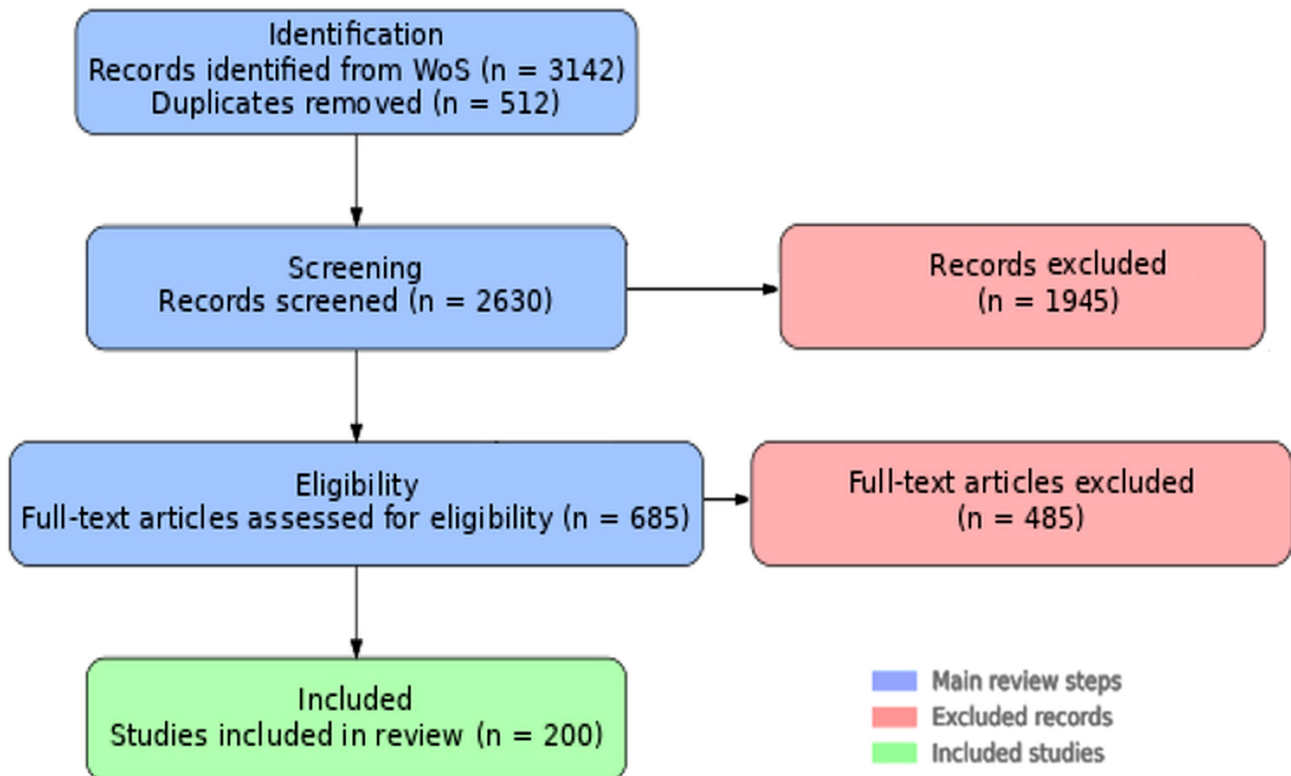


Fig. 3. PRISMA flow diagram. PRISMA, Preferred Reporting Items for Systematic Reviews and Meta-Analyses.

thematic requirements. The final synthesis, therefore, rests on 200 studies that provide the basis for the quantitative and qualitative analyses outlined above.

4. Discussion

The findings of this systematic review resonate with, yet also expand upon, prior scholarship in both logistics and HRM. Earlier reviews of AI in logistics (Lalla-Ruiz and Mes, 2025; Richey et al., 2023) emphasized the technical dimension of efficiency—improved routing, predictive demand forecasting, and error minimization. Conversely, reviews in HRM (Budhwar et al., 2023; Cabiddu et al., 2022) largely focused on algorithmic management, job redesign, and worker well-being. Our synthesis demonstrates that AI in last-mile e-commerce delivery cannot be fully under-

stood if logistics and HRM are treated in isolation. The operational efficiency gains—delivery time reductions of up to 32% or cost savings of up to 25%—are tightly interwoven with workforce outcomes such as reduced autonomy, intensified monitoring, and shifting skill demands. The theoretical alignment of these findings is best captured by the sociotechnical systems perspective (Mumford, 2006; Trist and Bamforth, 1951), which emphasizes the coevolution of technology and human systems. In last-mile delivery, AI functions simultaneously as a technical optimizer and a managerial mediator, restructuring workflows while reshaping employee perceptions, organizational culture, and labor relations. Complementary insights come from algorithmic management theory (Duggan et al., 2020; Kellogg et al., 2020; Veen et al., 2020), which highlights the sub-

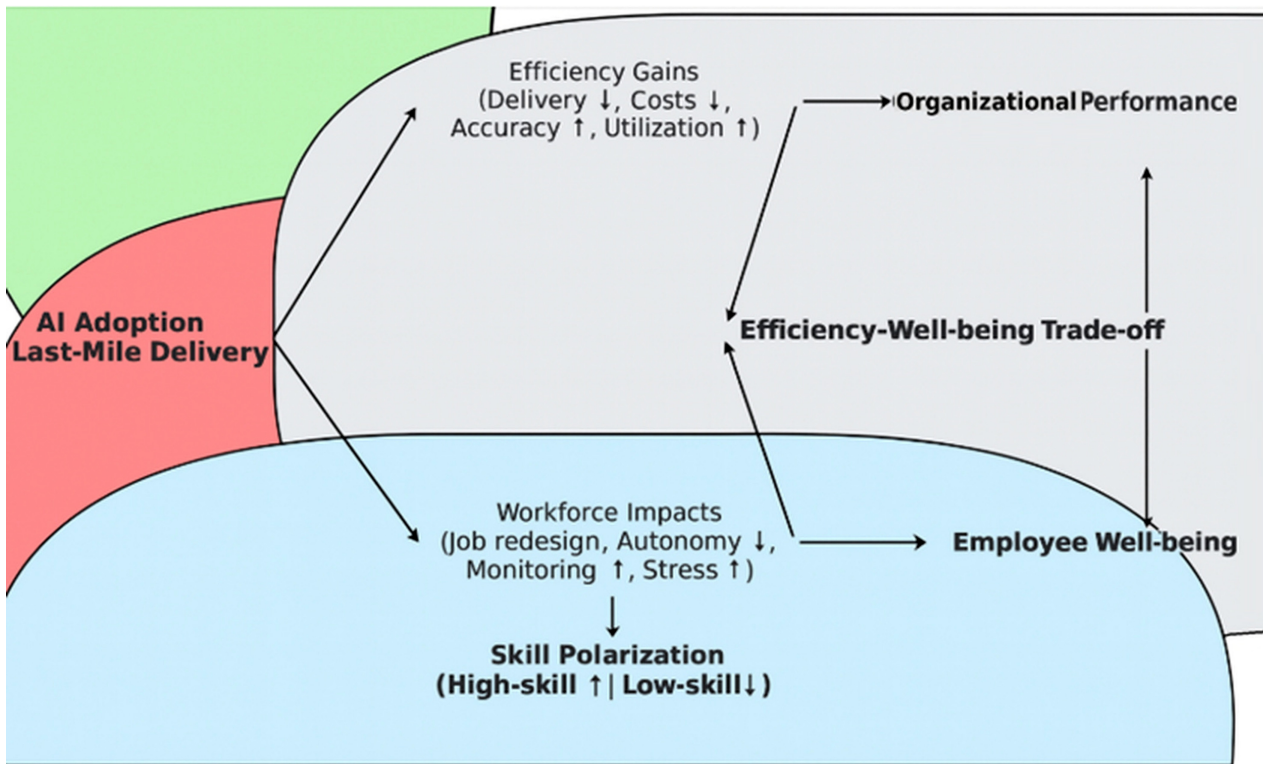


Fig. 4. Conceptual framework – efficiency–well-being trade-off & skill polarization. Note: The arrows indicate the direction of influence between AI adoption, operational efficiency, workforce well-being, and skill polarization. They show how AI-driven technological changes may simultaneously generate performance gains and workforce-related challenges.

stitution of managerial functions by algorithms, and from the technostress literature (Tarafdar et al., 2019), which explains how employees experience strain under conditions of constant monitoring and data-driven evaluation. Taken together, these perspectives highlight the efficiency–well-being trade-offs and the tendency toward skill polarization that emerge consistently in our corpus. This dynamic is summarized conceptually in Fig. 4, which frames AI adoption in last-mile delivery as a dual process of performance enhancement and workforce transformation.

Unlike earlier socio-technical frameworks, which primarily examined the general interaction between technology and the workforce, the framework proposed here explicitly combines logistics and HRM perspectives under the lens of AI integration. This interdisciplinary articulation not only highlights operational gains but also captures how these are connected to processes of autonomy, motivation, and skill transformation. In this sense, its main contribution lies in overcoming the fragmentation of the literature and advancing an integrated model that simultaneously reflects performance and human sustainability.

The implications extend across both logistics and HRM scholarship. For logistics researchers, AI adoption transcends technical optimization, reconfiguring allocation, scheduling, and routing in ways that directly impact human labor. For HRM scholars, algorithmic management is not solely a matter of employee autonomy but also shapes op-

erational structures, customer service reliability, and organizational resilience. This underscores the need for truly interdisciplinary approaches.

International comparisons further illuminate these dynamics. In China, AI has been used extensively for large-scale demand forecasting and fleet optimization (Yuan et al., 2023), driven by platforms such as JD.com and Alibaba’s Cainiao. However, this efficiency is shadowed by labor exploitation concerns on gig platforms (Huang, 2023). In the United States, research on Amazon Flex and United Parcel Service (UPS) has shown how algorithmic scheduling and data-driven evaluation yield operational precision but simultaneously heighten worker stress and reduce job satisfaction (Jarrahi et al., 2021; Mulugeta, 2022). The European Union presents a contrasting trajectory, emphasizing governance, labor rights, and ethical AI adoption, with GDPR introducing strong constraints on intrusive monitoring (Abraha, 2023; Adams-Prassl et al., 2023). In India, hybrid delivery models combining formal courier networks with gig platforms reveal both the efficiency potential of AI and its limits under infrastructural constraints and labor informality (Abraha, 2022). These cross-regional comparisons, visualized in Fig. 5, confirm that regulatory frameworks, labor markets, and infrastructural maturity are decisive in shaping how efficiency and workforce well-being are balanced.

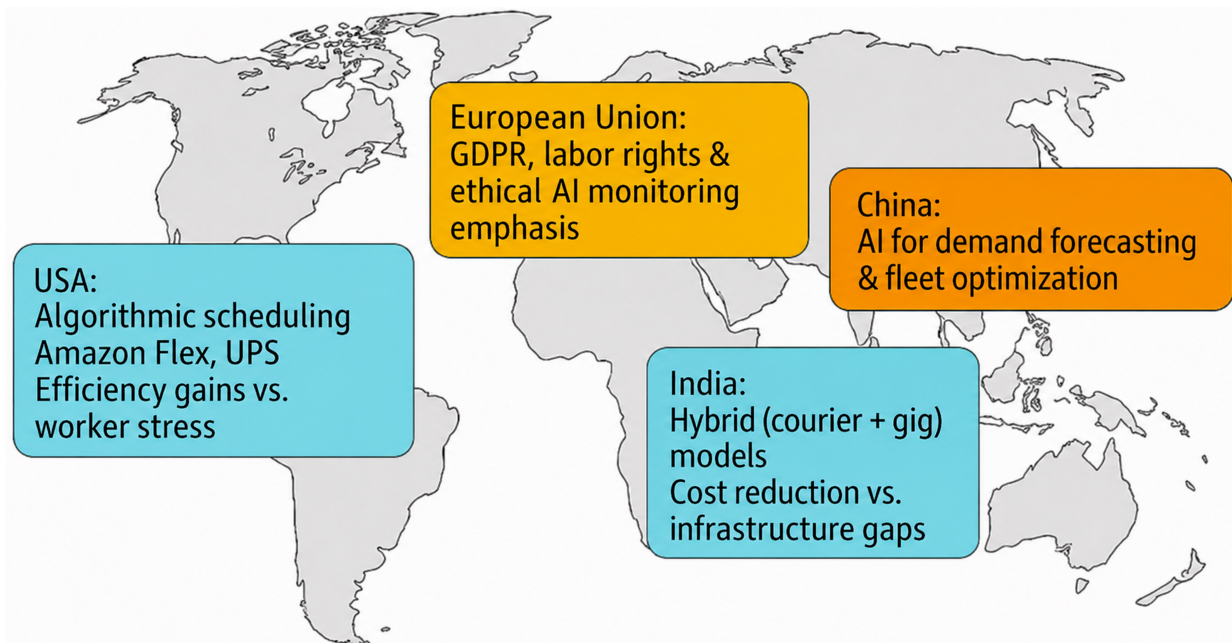


Fig. 5. Comparative international insights on AI in last-mile HRM. UPS, United Parcel Service; GDPR, General Data Protection Regulation.

From the perspective of Eastern Europe, including Romania, AI adoption in last-mile delivery is still emergent, often constrained by infrastructural fragmentation and regulatory inertia.

4.1 AI Adoption in Last-Mile Delivery: Managerial Realities in Central and Eastern Europe

It is important to clarify that, given the limited empirical coverage of Central and Eastern Europe in the reviewed literature, the following discussion does not claim to synthesize region-specific evidence, but rather offers a context-sensitive interpretation of global findings through the institutional, managerial, and labor-market characteristics of CEE economies.

In CEE economies, the adoption of AI in last-mile delivery unfolds within a distinctive managerial environment shaped by transition legacies, institutional volatility, and uneven digital readiness. Unlike highly centralized platform ecosystems in China or large-scale corporate logistics networks in the United States, AI implementation in CEE contexts is often incremental, resource-constrained, and embedded in hybrid organizational forms combining traditional employment with platform-mediated labor. Managers in this region face specific constraints related to infrastructural fragmentation, particularly in secondary cities and rural areas, where AI-driven routing systems must compensate for inconsistent transport quality and limited real-time data availability. Simultaneously, regulatory inertia and ambiguity—especially in the interpretation and enforcement of EU-level digital labor regulations—create uncertainty regarding acceptable levels of algorithmic monitoring and performance evaluation.

These conditions amplify the importance of managerial discretion and human judgment in mediating AI-driven decisions. From an HRM perspective, the post-socialist legacy of hierarchical control and limited participatory management can exacerbate employee resistance to algorithmic management, reinforcing perceptions of surveillance rather than support. Consequently, successful AI adoption in CEE last-mile delivery firms depends less on technological sophistication alone and more on the development of trust-based HRM practices, transparent communication, and gradual capability-building aligned with local institutional realities.

Unlike China or the United States, where large-scale corporate platforms spearhead innovation, progress in this region tends to be incremental and closely tied to European Union policy frameworks. This divergence highlights the need for more regionally sensitive studies that capture both the opportunities and vulnerabilities of transition economies.

Yet, a clear knowledge gap persists. Contributions from Latin America and Africa are minimal, despite the rapid expansion of platform-mediated e-commerce in these regions. It remains unclear whether AI adoption here reproduces the efficiency–well-being trade-offs observed in more developed economies or whether distinct institutional settings alter the trajectory. Likewise, sectoral asymmetries exist: courier and parcel logistics dominate scholarly attention, while grocery delivery, microhub logistics, and gig-based crowdshipping remain underexplored, even though they present unique HRM challenges.

4.2 Managerial Mediation and ESG Implications in AI-Enabled Last-Mile Delivery

For managers, the evidence suggests that AI implementation must be approached as both a technological and a human resource intervention. Predictive analytics improve workforce planning and reduce overtime, but they must be coupled with flexibility to maintain morale. Job redesign demands continuous upskilling in digital literacy, human–AI interaction, and customer service. AI-driven performance evaluation can enhance transparency but risks depersonalization if deployed without managerial discretion.

Most importantly, organizational culture and change management play a decisive role. Where managers frame AI as a collaborative tool rather than a surveillance instrument, employees are more likely to perceive technological change positively (Alabdali et al., 2024; Hamilton and Sodeman, 2020; Upadhyay et al., 2021). For managers operating in CEE last-mile delivery firms, AI implementation requires context-sensitive strategies that account for infrastructural, regulatory, and workforce-specific constraints. In environments characterized by fragmented transport infrastructure, AI routing systems should be deployed with built-in flexibility, allowing human dispatchers to override algorithmic recommendations when local knowledge proves critical. From an HRM standpoint, gradual implementation combined with targeted upskilling initiatives can mitigate resistance and reduce perceptions of technological imposition. Moreover, in settings marked by regulatory ambiguity, managers should proactively align AI-enabled HRM practices with EU governance principles, not merely for compliance but to build employee trust and organizational legitimacy. These dimensions are captured in Fig. 6, which illustrates the four managerial domains—workforce planning, skill development, performance evaluation, and change management—that mediate AI adoption outcomes in last-mile organizations.

The environmental, social, and governance (ESG) dimensions of AI adoption further complicate the picture. Beyond structural ethical concerns, AI adoption also generates a form of “ethical anxiety” among both employees and managers, reflecting uncertainty about fairness, accountability, and the human consequences of algorithmic decision-making. This psychological dimension can significantly moderate the relationship between AI adoption and organizational outcomes, potentially undermining innovation and sustainability efforts. In last-mile delivery contexts, anxieties related to algorithmic surveillance, opaque performance metrics, and automated disciplinary mechanisms are particularly salient. HRM plays a critical role in mitigating ethical anxiety through transparent communication, participatory system design, and clearly articulated safeguards that reaffirm human oversight and moral responsibility within AI-enabled workplaces. Algorithmic bias in recruitment and evaluation perpetuates inequities, while GPS tracking and performance dashboards challenge

norms of privacy and dignity (Adams-Prassl et al., 2023; Hmoud and Laszlo, 2019; Köchling and Wehner, 2020; Madanchian et al., 2023; Zhang et al., 2021). AI intensifies labor polarization, disproportionately benefiting digitally skilled workers while marginalizing those in low-skill roles unless inclusive reskilling policies are enacted. Policymakers in the EU, United States, and China are beginning to recognize these risks, as evidenced by the EU AI Act, the proposed EU Directive on Platform Work, and ongoing debates in the U.S. Department of Labor regarding algorithmic management standards. China has also moved toward more explicit governance, issuing regulations that compel platform companies to disclose algorithmic management practices to regulators and workers. These developments reflect the growing realization that AI governance in labor contexts must balance innovation with labor rights and social sustainability. The interplay of these environmental, social, and governance challenges is synthesized in Fig. 7.

The broader ESG agenda also intersects with AI-driven logistics. Achieving the environmental and social benefits associated with AI-driven last-mile optimization increasingly depends on inter-organizational cooperation across digital supply chains. Recent research highlights collaboration as a critical enabler of eco-innovation, particularly in fragmented logistics ecosystems where no single firm controls end-to-end delivery processes. In this context, HRM practices play a pivotal coordinating role: incentive systems aligned with shared sustainability goals, joint training programs focused on AI-enabled operations, and cross-organizational knowledge-sharing mechanisms can foster cooperation among delivery firms, technology providers, and platform operators. Such collaborative HRM arrangements are especially relevant in Central and Eastern Europe, where smaller logistics firms often rely on network-based coordination to compensate for limited internal resources and infrastructural constraints.

On the environmental side, AI contributes positively by reducing emissions through optimized routing and energy-efficient fleet management. Yet, on the social side, it produces “hidden costs” in the form of technostress, job insecurity, and alienation. These social externalities must be factored into any assessment of sustainable digital transformation, ensuring that operational decarbonization does not come at the price of workforce degradation.

Taken together, these findings position AI adoption in last-mile delivery as a multidimensional transformation—technological, organizational, and societal. It functions as both an enabler of operational excellence and a catalyst of workforce disruption. Understanding this duality requires theoretical integration across sociotechnical, algorithmic management, and technostress frameworks; contextual sensitivity to geography and sector; and managerial strategies that align efficiency with human sustainability. It also demands policy interventions that embed worker rights, fair-

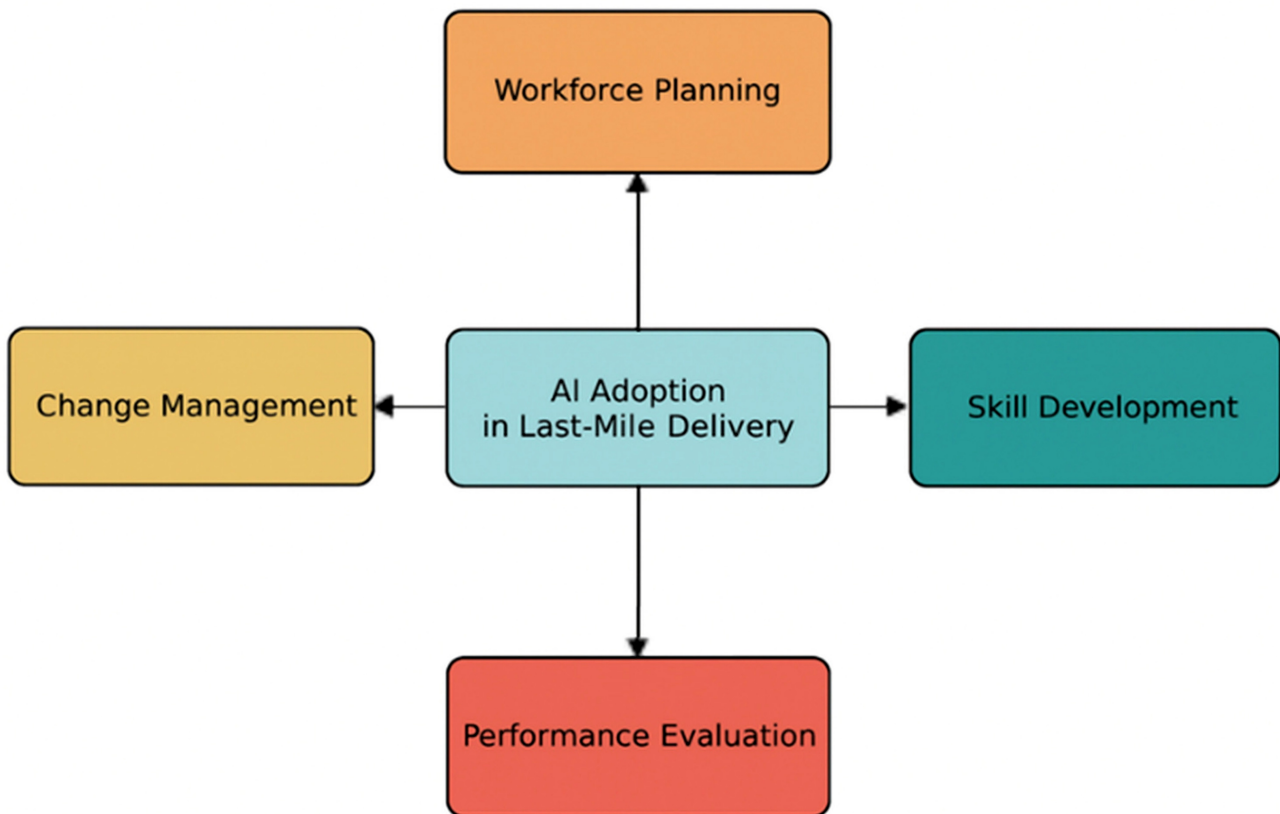


Fig. 6. Managerial implications of AI in last-mile delivery.

ness, and inclusion within AI governance structures. Only by integrating these dimensions can last-mile e-commerce delivery evolve toward a model that is technologically advanced, economically efficient, ethically responsible, and socially sustainable.

Finally, we consider it appropriate to acknowledge a specific limitation relevant to the context of this study, namely the use of AI tools in the process of research synthesis. While AI-based applications are increasingly employed in systematic reviews for tasks such as automated text mining or reference screening, in this study all inclusion and exclusion decisions, as well as the interpretative coding, were carried out manually by the authors to ensure the methodological rigor required in such circumstances. Nevertheless, future reviews may benefit from exploring hybrid approaches that combine algorithmic support with human judgment, while remaining attentive to the risks associated with automation bias.

5. Conclusions

Our systematic review has carried out a relatively comprehensive evaluation of the quantitative and qualitative implications of adopting AI in HRM within the last-mile delivery sector of e-commerce, synthesizing evidence from a considerable number of scientific articles (WoS-indexed journals) published between 2013 and 2025. By

integrating perspectives from logistics, operations, organizational behavior, and HRM research, the study provides an extensive synthesis of how AI technologies are reshaping both organizational efficiency and workforce dynamics.

We emphasize that, from a quantitative standpoint, the results confirm that AI adoption consistently generates measurable operational gains. Improvements in delivery times, cost efficiency, fleet utilization, and labor allocation strengthen the economic case for AI-based logistics, especially against the backdrop of global e-commerce expansion and increasing customer expectations for speed and reliability. Such findings confirm the idea that AI is no longer a supplementary tool but a central pillar of last-mile competitiveness. However, the analysis equally demonstrates that these efficiency gains cannot be separated from their human consequences. From a qualitative perspective, the picture is more complex, revealing intensified worker surveillance, loss of autonomy, and new risks of workforce fragmentation. Accordingly, we found that algorithmic scheduling and data-driven performance evaluation, while powerful in resource optimization, tend to undermine employee motivation and amplify perceptions of stress and depersonalization. Conversely, job redesign, skill transformation, and inclusion challenges highlight the fact that the human costs of AI adoption can counterbalance or even erode the value of operational optimization. Thus, these perspectives bring to light a persistent tension: AI enhances logistics per-

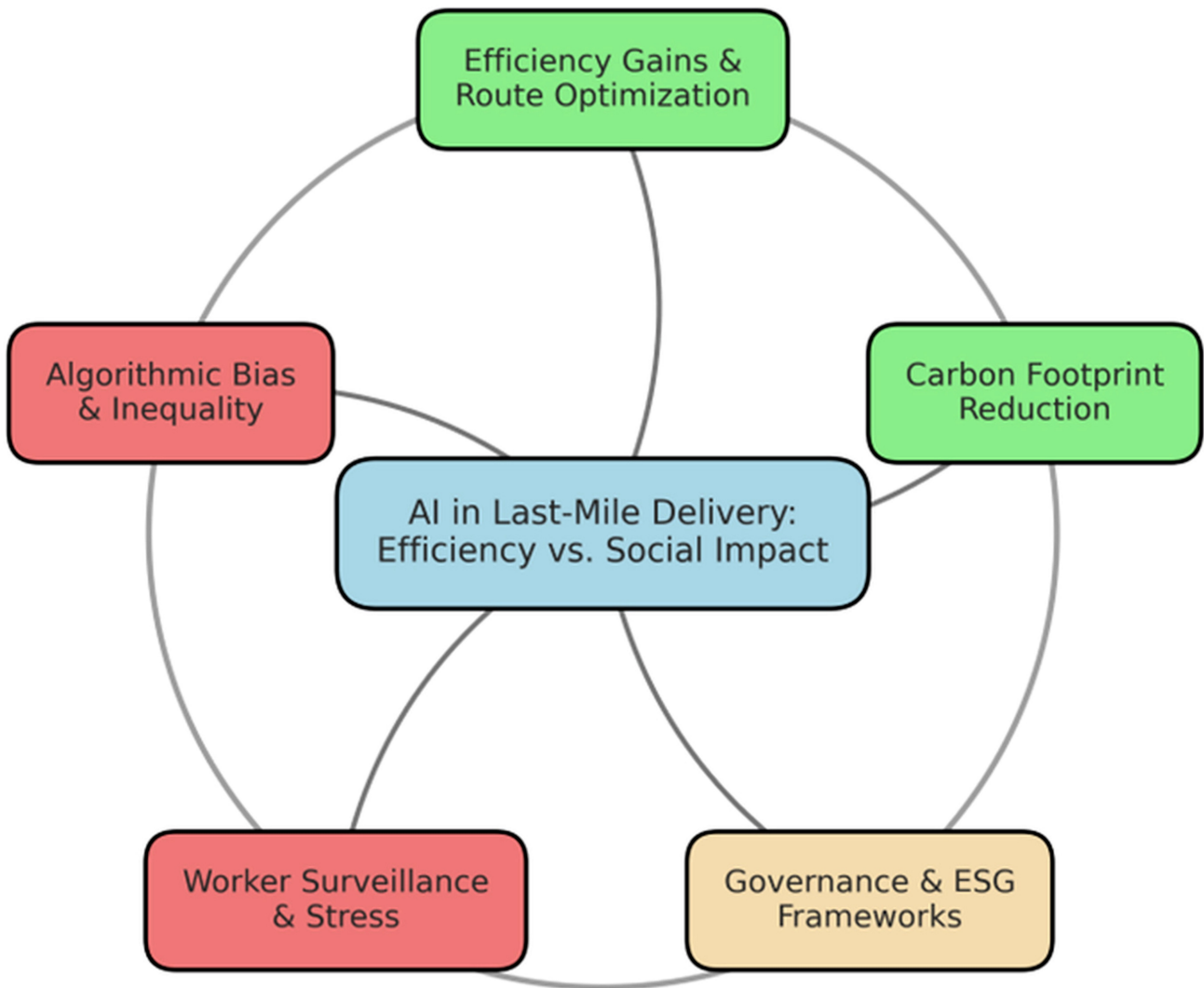


Fig. 7. Environmental, social, and governance implications of AI in last-mile delivery. ESG, environmental, social, and governance.

formance but simultaneously introduces risks of workforce alienation, polarization, and ethical controversy.

The central contribution of this study lies in demonstrating the inseparability of technical efficiency and human outcomes in AI-driven last-mile delivery. We considered that efficiency gains and employee well-being are not parallel but interdependent dimensions that must be managed together. Indeed, the proposed conceptual framework (Fig. 4) captures this duality, underlining that managerial mediation and ethical governance determine whether AI is integrated as a support mechanism or deployed as a control instrument. In this regard, our analysis advances theory by positioning AI adoption as both a sociotechnical and socio-organizational transformation, connecting fields that have traditionally examined efficiency and human impacts in isolation.

On a practical level, the evidence used highlights the necessity for managers to adopt human-centered approaches, with AI implementation being embedded in

broader strategies of participatory change management, transparent communication, and continuous upskilling. Organizations that frame AI as a collaborative partner rather than a surveillance tool are more likely to preserve employee trust and sustain long-term performance. On the policy level, the results underscore the urgency of regulatory frameworks that move beyond data protection and algorithmic transparency to explicitly address labor rights and workforce inclusion in AI-mediated workplaces. We wish to underline that the European Union’s initiatives in AI governance and platform work regulation provide important models, though global harmonization remains a critical challenge.

Evidently, the merit of this analysis lies in consolidating existing knowledge, but at the same time, we also chart some new directions for research and practice. Future research should move beyond general assertions of underrepresentation and explicitly interrogate how AI adoption unfolds within CEE institutional contexts. Promising av-

enues include examining the extent to which EU-level regulations such as GDPR and the proposed AI Act constrain or enable algorithmic HRM practices in last-mile delivery firms in new member states. Additional research questions include how post-socialist cultural legacies shape employee trust in AI-driven monitoring systems, and whether ethical anxiety moderates acceptance of algorithmic management differently in transition economies compared to Western contexts. Addressing these questions would significantly advance context-aware management theory and practice. Thus, it should be noted that by integrating quantitative and qualitative evidence, the study provides an analytical foundation for a balanced evaluation of AI adoption in last-mile delivery. Importantly, this review offers logistics scholars a deeper understanding of human factors, HRM scholars a stronger grasp of operational dynamics, and practitioners and policymakers actionable ideas for developing strategies aimed at achieving sustainable digital transformation.

As a final reflection, in our view, the trajectory of last-mile delivery is inseparable from AI, which will remain a cornerstone of logistics innovation in the coming decade. However, we must stress to the reader that the long-term success of AI does not depend solely on technical sophistication; it equally rests on embedding human considerations into technological adoption, ensuring that gains in efficiency are not achieved at the expense of workforce dignity, inclusion, and well-being. Therefore, we are convinced that organizations and societies that succeed in striking this balance will not only enhance their competitive advantage but also fulfill their broader social responsibilities, aligning innovation with sustainability and equity. At the same time, it is important to acknowledge regional specificities that condition how these dynamics unfold.

Availability of Data and Materials

The datasets used and analyzed during the current study are available from the corresponding author on reasonable request.

Author Contributions

IB and AM conceived the research study. IB and AM conducted the research. CML provided assistance and advice on the validation of the review procedure, the interpretation of the findings and the critical revision of the manuscript. IB, AM and CML analysed and interpreted the material included in the review. IB, AM and CML contributed to the editorial revisions of the manuscript. All authors read and approved the final manuscript. All authors have participated sufficiently in the work and agreed to be accountable for all aspects of the work.

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Conflicts of Interest

The authors declare no conflicts of interest.

Declaration of AI and AI-Assisted Technologies in the Writing Process

During the preparation of this manuscript, the authors used ChatGPT-5 to check spelling and grammar and, to a lesser extent, to assist in synthesizing certain portions of text. Following the use of this tool, the authors thoroughly reviewed and edited the content as necessary and assume full responsibility for the final publication.

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