Digital Workforce Augmentation for Intelligent Supply Chain and Logistics Operations in Saudi Arabia under Vision 2030

Abstract

Saudi Arabia's ambition to become a globally connected logistics centre creates an important question about digital transformation: which technologies genuinely extend the capabilities of supply chain workers, rather than merely accelerating transactions? This integrative review examines digital workforce augmentation across forecasting, procurement, warehousing, freight coordination and disruption management. Drawing on thirty peerreviewed contributions published between 2020 and 2025, it synthesises evidence concerning humanalgorithm decisionmaking, intelligent assistants, workflow automation, connected data and organisational capability. The analysis distinguishes information access, cognitive support and coordinated action, arguing that their value depends on task characteristics, information quality and accountable human intervention. Four tensions emerge: visibility versus surveillance, automation versus discretion, decision speed versus explainability, and efficiency versus resilience. A workforcecentred framework links digital infrastructure to augmentation mechanisms, job redesign and measurable operational outcomes. For Saudi Arabia, implementation should prioritise interoperable logistics information,occupationspecificdigital competence,bilingual interfaces, auditable recommendations and staged evaluation. The review contributes an explicit distinction between replacing work and improving professional judgement, and develops a research agenda centred on field evidence, inclusive skills development and crossorganisational governance.

Keywords

digital workforce augmentation; intelligent logistics; humanAI collaboration; supply chain analytics; Saudi Arabia; Vision 2030; digital capabilities

UNDER PEER REVIEW IN IJAP

1. Introduction

The contemporary logistics workplace is simultaneously more connected and more demanding. Warehouse operators increasingly encounter scanners, allocation algorithms and exception queues; freight coordinators reconcile carrier information with changing border requirements;

and planners must interpret predictions formed from incomplete transaction histories. Digitalisation can make these tasks faster, but faster information movement is not equivalent to better decisions. Organisational value depends on whether people can interpret technological outputs, challenge weak recommendations and coordinate decisions across institutional boundaries. Evidence on demand planning demonstrates that human judgement can improve forecasts when its contribution is incorporated systematically rather than appended as an unexamined adjustment [1]. Research on digitally enabled retail supply chains similarly shows that managerial judgement remains important even where analytical capability is extensive [2].

Saudi Arabia provides a consequential setting for studying these relationships. Vision 2030 seeks to diversify economic activity, deepen regional and international connectivity and develop human capital alongside transport infrastructure. The National Transport and Logistics Strategy places integrated modes, logistics facilities and institutional performance within this development agenda. These priorities imply growing dependence on people capable of supervising interconnected digital processes, rather than an exclusive requirement for more machines. Yet much supply chain research emphasises technological adoption or firm performance without specifying how frontline and professional work changes. Human factors research cautions that technology suitability depends upon employee acceptance, task fit and training investment [3].

The central argument of this review is that workforce augmentation should be understood as a designed relationship among a worker, a task, an information environment and an accountable decision. It is not synonymous with labour substitution. A forecasting system augments a planner when it communicates uncertainty and accommodates justified intervention. A transport dashboard augments a coordinator when it makes an actionable exception visible without overwhelming attention. By contrast, a poorly integrated application may shift work into duplicate entry, create excessive alerts or narrow professional discretion. The paper therefore asks how organisations can evaluate digital tools on the quality of human contribution as well as conventional productivity measures.

The review develops this argument through a transparent, bounded synthesis of recent literature. It first defines augmentation and establishes its theoretical basis; next it examines four operational domains and the limits of available evidence. It then proposes a conceptual architecture, identifies Saudispecific implementation conditions and sets out propositions suitable for empirical testing. This narrower focus on the mechanisms linking technology, work and performance is intended to complement, rather than repeat, broader discussions of digital supply chain transformation.

2. Aim, objectives and research questions

The study aims to explain how digital technologies can enhance the judgement, coordination and adaptability of personnel engaged in Saudi supply chain and logistics operations while

UNDER PEER REVIEW IN IJAB

preserving operational accountability. Its objectives are to classify the tasks most amenable to augmentation; compare the evidential strength of humanalgorithm collaboration and automated execution; identify organisational and ethical conditions affecting adoption; construct an evaluable framework connecting workforce capability with logistics outcomes; and formulate research priorities relevant to Vision 2030. These objectives differ from a conventional inventory of technologies because they concern the transformation of work, not simply the presence of software.

Three research questions guide the synthesis. RQ1 asks which augmentation mechanisms improve the performance of distinct logistics occupations and under what task conditions. RQ2 asks how information quality, training, trust and decision rights shape those mechanisms. RQ3 asks which implementation and measurement arrangements would allow Saudi organisations to test workplace benefits without confusing technological deployment with organisational improvement. These questions permit evidence to be compared across sectors while retaining the distinctive requirements of freight movements, warehouses and procurement processes.

3. Conceptual foundations

Augmentation describes a change in the joint capabilities of human and digital actors. Its informational form improves access to accurate, timely and contextualised facts. Its cognitive form helps people recognise patterns, forecast outcomes or compare alternatives. Its coordinative form converts those insights into synchronised action across functions and organisations. The distinctions matter because the same technology may strengthen one form while weakening another. A dashboard might improve visibility but increase the cognitive burden of interpreting conflicting alerts; automated routing might accelerate planning but conceal assumptions about driver availability or delivery restrictions.

Humancentred studies of logistics technology emphasise that worker characteristics must enter adoption decisions before systems are installed [3]. Reviews of digital assistants similarly distinguish information retrieval, collaborative operations and knowledge transfer, while warning that shortterm demonstrations cannot establish durable improvements in working conditions [4]. Research on digital competence across transport and related sectors shows that new systems can increase administrative demand and workplace traceability even as they expand informational capacity [5]. The resulting evaluation problem is therefore sociotechnical: the unit of analysis should be the human–system task, not the software product in isolation.

A second foundation is bounded judgement. Workers possess local information that modelling datasets cannot always capture, but local expertise can also introduce inconsistency. A field experiment in warehouse packing illustrates a constructive alternative: models can learn from the circumstances in which employees override prescriptions, improving the fit between recommendations and actual operations [6]. This supports an adaptive division of labour in which routine classification is computational, contextual interpretation remains human, and

UNDER PEER REVIEW IN IJAR

recurring interventions become structured learning signals. For Saudi logistics, such a design could be relevant to shipment exceptions, delivery access restrictions and project cargo documentation, subject to careful validation.

The final foundation is capability development. A workforce cannot benefit from increasingly sophisticated data products without the ability to interrogate their meaning, assess reliability and communicate decisions. Recent Saudi evidence on futureoriented competencies highlights digital literacy, critical thinking, adaptability and collaboration as interdependent dimensions of labourmarket readiness [7]. These capabilities are not an afterthought to system procurement: they are part of the operating conditions under which augmentation can exist. The proposed theoretical position consequently combines task fit, information processing and capability renewal, treating measured work outcomes as the ultimate test of a deployment.

4. Review methodology

4.1 Review design and boundaries

This paper employs a structured integrative review with critical thematic synthesis. The approach is appropriate because relevant evidence spans operations management, information systems, human factors and transport studies, and because the immediate objective is to explain mechanisms rather than estimate a pooled intervention effect. The review uses a deliberately bounded set of thirty peerreviewed journal articles with identifiable digital object identifiers and publication dates from 2020 to 2025. The cited studies form a purposive analytical corpus, not a statistically representative sample of everything published in the period. No comprehensive database export, pooled effect estimate or numerical screening flow is claimed.

4.2 Search logic and eligibility

Search concepts were assembled into three domains: workforce terms, including human judgement, digital competence, logistics employees, decision support and intelligent assistants; technology terms, including artificial intelligence, predictive analytics, robotic process automation, digital supply chain and integration; and operational terms, including warehousing, freight, transport, procurement, resilience and forecasting. A reproducible search expression can combine synonyms within each domain using OR and connect domains using AND. Equivalent title, abstract and keyword searches are suitable for Scopus and Web of Science, while reference tracing identifies influential studies whose titles use different terminology. Studies were retained where they examined a relevant work activity, a technological mechanism or a measurable organisational condition. Purely technical optimisation without an interpretable human or organisational implication was given lower priority.

UNDER PEER REVIEW IN IJAR

4.3 Extraction and critical synthesis

Each source was examined for setting, research design, occupational or managerial task, technology, proposed mechanism, outcomes, boundary conditions and limitations. Findings were compared through a questionled matrix rather than counted as interchangeable endorsements of digitalisation. Empirical field evidence received stronger interpretive weight when it described a decision process or observable outcome; conceptual papers informed theoretical mechanisms but were not treated as empirical proof. Differences between warehouse experiments, crosssectional surveys and broad reviews were retained explicitly. A deductive framework based on information, cognition and coordination was refined by inductive attention to worker discretion, visibility, skills, trust and governance.

4.4 Trustworthiness and scope restrictions

DOI metadata and article details were checked against publisher records or DOIbearing references; citation dates were kept within the stipulated interval. The review distinguishes findings reported by cited authors from applications proposed specifically for Saudi Arabia. It excludes quantitative claims about national productivity gains where comparable field evidence is unavailable. Selection remains subject to Englishlanguage bias, publication visibility and the limits of a purposively assembled corpus. Consequently, the synthesis supports conceptual propositions and implementation guidance, not causal claims that a particular intervention will succeed across all Saudi logistics organisations.

5. Thematic evidence synthesis

5.1 Forecasting and exceptionsensitive decisions

Predictive systems can estimate demand, inventory requirements and delivery risks at a scale unattainable through manual analysis. Their weakness lies in events that are absent from historical data or poorly represented by model features. Experimental and field research on humanguided forecasting shows that professional input contributes most when analysts identify exceptional conditions and the model learns how much weight to assign to those signals [1]. Interviews with supply chain executives reinforce the need to distinguish decisions supported by stable data from decisions requiring contextual negotiation and interpretation [2]. The practical lesson is not to preserve every manual adjustment, but to classify interventions, document their justification and evaluate subsequent forecast errors.

Generative systems add a conversational interface to predictive and analytical models, potentially allowing employees to request scenario summaries or interrogate planning assumptions. A capabilitybased study of generative artificial intelligence in operations suggests opportunities for knowledge access and interactive assistance, while also identifying substantial reliability and implementation constraints [8]. These tools should therefore explain a calculation or retrieve a verified source rather than invent a logistics decision. Organisations need clear

UNDER PEER REVIEW IN IJAR

boundaries between summarisation, recommendation and execution. A human signoff becomes especially important where decisions affect contractual obligations, safety, regulated cargo or trade compliance.

5.2 Documentintensive and repetitive workflows

Order status checks, invoice reconciliation, shipment record updates and repetitive correspondence consume substantial administrative effort. Evidence from logistics process automation indicates that software robots can reduce repetitive orderhandling work when input structures and exception rules are sufficiently stable [9]. However, automating a flawed process can accelerate errors and move responsibility into obscure integration failures. The distinction between augmentation and substitution is apparent: employees should be released from routine copying to investigate mismatches, manage customers and resolve policysensitive exceptions. Such reallocation requires occupational redesign; it does not follow automatically from deploying a bot.

Research on smart supply chain management connects digital technologies with improved process coordination, but it also points to the organisational management needed to realise performance [10]. Studies of supply chain digitalisation further indicate that intangible information flows and collaboration practices matter alongside physical movement [11]. Consequently, an effective procurement or freight automation programme should begin with process mapping, ownership of master data, documented exception pathways and a record of which decisions remain with authorised personnel.

5.3 Visibility, coordination and resilience

Freight operations generate signals from carriers, ports, warehouse systems, customs platforms and customers, but these signals are rarely consistent in granularity or timing. Research on supply chain digitalisation and resilience finds that connected information can strengthen response, although the relationship depends on operational arrangements rather than connectivity alone [12]. Saudifocused evidence likewise associates smart supply chain capabilities with firm performance, while leaving room for sectoral and organisational differences [13]. A genuinely augmented coordination role requires a shared operational picture that identifies actionable deviations, their probable consequences and a person empowered to respond.

Evidence on regional supply networks highlights the importance of local relationships, institutional context and the interpretive knowledge embedded in interorganisational coordination [14]. During major disruptions, studies of manufacturing and service supply chains demonstrate that resilience combines information, flexibility and relationship management [15]. Visibility is therefore necessary but insufficient: a delayed shipment alert has little value if staff cannot secure an alternative route, revise a production schedule or communicate with a customer. The relevant outcome is the time and quality of coordinated recovery, not the number of dashboard events displayed.

UNDER PEER REVIEW IN IJAP

Research on endtoend visibility during pandemic disruption argues for digital models that allow organisations to anticipate and monitor supply chain risks [16]. Related evidence finds that integration and visibility can mediate the performance benefits of advanced production technologies [17]. These findings justify building interoperable event definitions across procurement, warehouse and freight systems. They do not justify granting an opaque algorithm full control over emergency decisions. Escalation authority and reliable human communication remain decisive where observations are incomplete or consequences are irreversible.

5.4 Adaptation and organisational learning

Technological value changes as supply networks become more volatile. Empirical work on Industry 4.0 associates digital capabilities with supply chain resilience and performance [18], but responsiveness also depends on whether personnel recognise when operating assumptions no longer hold. Delphibased research on postdisruption industrial systems emphasises capability renewal rather than technology acquisition as a complete response to uncertainty [19]. Big data analytics research similarly describes resilience as dependent on organisational abilities to turn information into timely action [20]. Collectively, these contributions suggest that augmentation is a recurrent learning process: personnel interpret exceptions; organisations review interventions; and systems are updated in light of observed failure modes.

The evidence has an important asymmetry. Technologyperformance associations are common, whereas rigorous longitudinal accounts of individual skill development, judgement quality and employee wellbeing remain less frequent. Evidence on resilience measurement warns against treating one indicator as a comprehensive operational outcome [21]. The review therefore rejects any universal ranking of digital tools. Selection should depend on the specificity of a task, availability of trustworthy data, consequences of error, workforce preparedness and the organisation's capacity to act upon recommendations.

Table 1. Tasklevel augmentation mechanisms and evaluable outcomes

Work domain	Human–system arrangement	Proposed evaluation evidence
Demand planning	Model estimates; planner identifies context and validates exceptions	Forecast error, reasoncoded overrides, decision latency
Order documentation	Software prepares standard records; staff investigate mismatches	Error rate, rework minutes, unresolved exceptions
Freight coordination	Live events flag feasible alternatives; coordinator	Response time, ontime completion, partner

UNDER PEER REVIEW IN IJAR

	confirms changes	confirmations
Warehouse work	Decision support sequences work; supervisor checks safety and resources	Task accuracy, load, escalation quality, worker feedback

6. A workforcecentred augmentation framework

The proposed framework connects five layers: operational data, intelligent interpretation, human decision rights, coordinated execution and learning feedback. Data quality is the entry condition, because erroneous inventory records or inconsistent shipment identifiers can produce confident but unusable recommendations. The interpretation layer should express estimated effects and uncertainty in formats appropriate to each occupation. For planners, that might involve forecast distributions and exception causes; for freight coordinators, route feasibility, customs status and timesensitive alternatives; for warehouse teams, prioritised work instructions and safety constraints.

The decision layer assigns authority explicitly. Lowconsequence, reversible tasks can be automated within approved rules, while material financial, legal or safety effects require review and accountable approval. Workers need to see why a recommendation was made and how to challenge it. A review of technologies in operations and supply chains identifies the relationship between innovation, sustainability and supply chain design as a matter of complementary organisational choices [22]. Work on advanced manufacturing capabilities also suggests that digital maturity must translate into specific operational routines before it supports sustained performance [23]. Accordingly, the framework evaluates job redesign and operational governance as mediators, not peripheral contextual variables.

The execution layer concerns collaboration across organisational boundaries. Sensors, platforms and mobile interfaces may transmit signals continuously, yet a human coordinator must still align incentives and communicate commitments. Studies of connected retail supply chains demonstrate that network integration requires practical reconciliation of information exchanged across activities [24]. Research on dynamic capabilities suggests that technological investments yield greater value where organisations can reconfigure processes and relationships as conditions evolve [25]. An augmentation initiative should therefore specify not only system access, but also who can authorise exceptions, notify partners and close a case.

Finally, feedback must measure the performance of the combined humantechnology system. Relevant metrics include forecast bias after justified adjustment, exception resolution time, avoidable duplicate work, ontime completion, record accuracy, escalation quality, perceived cognitive load and employee learning. Digital supply chain sustainability research warns that efficiency gains should be considered alongside environmental and wider organisational effects

UNDER PEER REVIEW IN IJAR

[26]. Figure 1 summarises the mechanism, and Table 1 identifies corresponding tasklevel measures. These are proposed indicators, not reported estimates of Saudi sector performance.

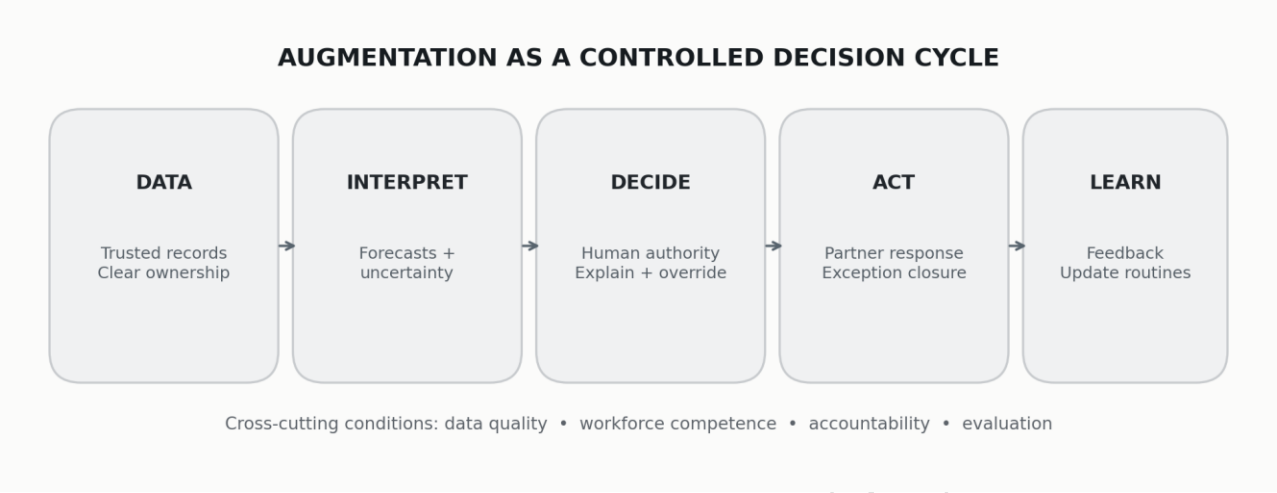


Figure 1. Proposed workforcecentred augmentation architecture (original conceptual illustration).

7. Saudi Arabian implementation conditions

Saudi Arabia's transport and logistics development program creates opportunities to apply this framework across ports, distribution facilities, industrial zones and multimodal freight corridors. The national strategic orientation is towards stronger connectivity, economic diversification and human capital. However, neither physical infrastructure expansion nor software procurement guarantees a digitally capable workforce. A regional review of supply chain management illustrates why institutional arrangements and partner relationships should inform technology transfer [14]. The proposed Saudi application therefore begins with work activities that involve repeated information reconciliation, high exception frequency or significant coordination delays.

A phased approach would first identify the occupational decisions with measurable service consequences. Second, employers would inventory available data, distinguish authoritative records from unofficial spreadsheets and define shared identifiers. Third, they would test narrow workflows, such as automated shipmentstatus compilation paired with humanled exception resolution. Fourth, they would evaluate reliability, workload and workforce development before extending a system across departments or partners. Research involving thirdparty logistics providers demonstrates that legacy integration, organisational readiness and workforce practice complicate digital transformation [27]. These constraints are particularly relevant when firms differ in size, technical resources and subcontracting arrangements.

Capability building should be occupational, not limited to generic software familiarisation. Freight coordinators need data interpretation, documentation checks, stakeholder communication

UNDER PEER REVIEW

and escalation judgement. Procurement analysts require supplier data literacy, anomaly detection and an understanding of contractual implications. Warehouse supervisors need the ability to validate automated task assignments against operational safety and realtime resource availability. Evidence on future Saudi workforce skills supports programmes that combine digital literacy with critical thinking and adaptability [7]. Technical training should be reinforced through supervised practice, realistic exception simulations and feedback on how an employee used information to reach a decision.

Governance cannot be delegated to technology providers. Datasharing agreements, access controls, audit trails, retention decisions and accountability for erroneous recommendations should be established at the point of deployment. Digital competence research highlights the risk that operational monitoring can become excessive worker surveillance [5]. Organisations should therefore separate safety and service oversight from intrusive individual tracking, involve employees in interface testing and provide accessible mechanisms for contesting recommendations. The goal is not maximal data collection but defensible decisions, reliable coordination and higherquality work.

Table 2. Proposed staged assessment for Saudi logistics applications

Stage	Management test	Go / revise criterion
Define	Task owner, baseline, error consequences and intervention rights	Decision map and measurable baseline agreed
Prepare	Data completeness, compatibility and staff competence	Authoritative sources and training demonstrated
Pilot	Compare operational results and employee experience	No critical safety or compliance degradation
Scale	Partner integration, audit logs and ongoing review	Benefits sustained across normal and peak demand

8. Discussion: tensions, contingencies and contributions

The synthesis exposes four persistent tensions. First, operational visibility can improve reaction time while multiplying notifications and employee monitoring. The design response is to privilege prioritised, explainable exceptions over indiscriminate event volume. Second, automation can release staff from repetitive administration but also erode expertise if personnel no longer understand the decisions they supervise. Periodic manual validation, simulation and explicit decision rights are therefore compatible with efficient automation. Third, rapid

UNDER PEER REVIEW IN IJAR

algorithmic recommendation can conflict with legitimate uncertainty. Decision quality improves when models communicate limitations and request human input in poorly observed situations. Fourth, local optimisation may undermine network resilience if partners adopt incompatible data definitions or incentives.

Existing evidence supports these tensions without making them universal laws. Studies of organisational resilience repeatedly distinguish technical tools from adaptive capabilities [18,20]. Research on crisis responses finds that external alliances and digital transformation jointly influence firms' ability to develop dynamic supply chain capabilities [28]. This is relevant to Saudi Arabia because a successful national logistics system requires coordinated action across firms, regulators and modes rather than isolated digital excellence. The literature therefore suggests that workforce augmentation should be assessed both within organisations and at handover points between them.

The review contributes three propositions. Proposition 1: taskspecific augmentation will improve operational decisions when workers receive actionable information, understand uncertainty and retain proportionate authority. Proposition 2: the effect of intelligent systems on resilience will be mediated by digital competence, data quality and crossfunctional escalation capability. Proposition 3: implementation will yield more durable outcomes when evaluation jointly measures service performance, employee experience and organisational learning, rather than software usage alone. These statements are conceptual deductions from the analysed evidence; they require empirical testing and should not be represented as established causal findings.

These contributions also clarify why workforce development is an economic issue rather than merely an organisational training expense. In digital logistics, professional knowledge allows imperfect information to become coordinated, trustworthy action. Research on supply chain transformation after the pandemic stresses the need to interpret performance through disruption preparedness and changed operating conditions [29]. Investments in workforce capability are consequently investments in the practical reliability of logistics networks, especially when unexpected events invalidate normal planning rules.

UNDER PEER REVIEW IN IJAR

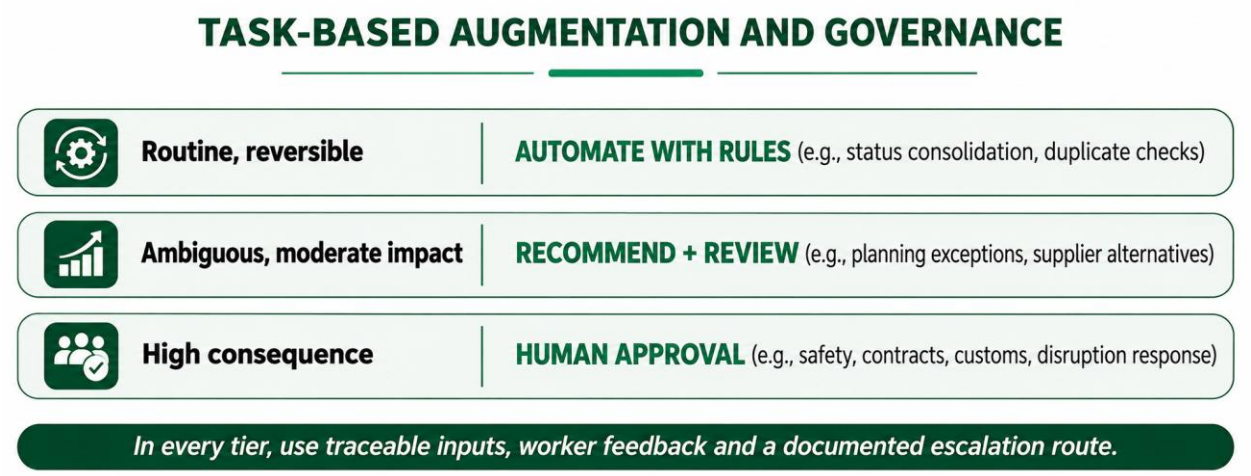


Figure 2. Decisionrights matrix for progressively consequential tasks (original conceptual illustration).

9. Research gaps and future agenda

The immediate research gap concerns causal evidence at the level of individual logistics tasks. Many existing studies examine firmwide digital maturity or broad performance perceptions, making it difficult to isolate whether improved service stems from better algorithms, changed responsibilities or concurrent investment. Future Saudi studies should compare similar teams before and after a bounded intervention, document baseline data quality and measure both the frequency and quality of human overrides. Where feasible, staggered implementation across comparable sites would strengthen causal interpretation without interfering with essential freight operations.

A second gap concerns occupational differences. Forecast planners, customs specialists, procurement coordinators and warehouse supervisors encounter different forms of uncertainty, and a single adoption model is unlikely to explain them equally well. Research should examine decision criticality, workload, language accessibility, prior digital experience and the consequences of false alerts. Third, crossorganisational investigations should test whether shared identifiers and escalation arrangements outperform additional analytics when coordination is the dominant bottleneck. Fourth, longitudinal research is required to identify whether assistance strengthens independent judgement or produces gradual dependence on tools.

A final gap is the design of balanced evaluation. Studies should pair operational outcomes, such as error rates and recovery times, with workerlevel measures of comprehension, cognitive load, trust calibration, participation and perceived fairness. The longterm benefits of workforce training also require careful assessment, since technical access cannot demonstrate durable professional competence [30]. Research programmes aligned with Vision 2030 would be

UNDER PEER REVIEW

particularly useful if they reported implementation failures as well as successes, enabling firms of different sizes to make evidencebased decisions.

The evaluation protocol should also record unexpected secondary work. For example, a warehouse assistant may reduce search time while increasing clarification calls; an automated freight update may lower typing effort while generating avoidable reconciliation. These displacement effects can reverse a superficially positive business case. Researchers should therefore log task transitions, the distribution of decision authority and the proportion of exceptions that remain unresolved after automation. Performance comparisons should use common exposure periods and report denominator definitions, especially where shipment volumes or product complexity change. Worker interviews can explain why a measured effect occurred, but should not substitute for operational records. A welldesigned study would protect employee confidentiality, predefine escalation thresholds and distinguish normal learning curves from persistent defects. This approach permits organisations to evaluate whether a digital tool expands professional capability or simply redistributes hidden effort across the supply chain. Such trials should distinguish process compliance from actual decision quality. Teams should report missing data rather than impute precision without justification. This distinction matters when seasonal peaks alter staffing and service expectations. Evaluation reports should identify which occupations benefited and which experienced additional workload. Crosssite comparisons should disclose differences in system integration and staff experience. These safeguards support reproducibility, fair interpretation and responsible scaling. Crossfunctional feedback helps identify recurring interface failures and unsupported assumptions. Such comparisons remain provisional.

10. Practical and policy implications

Managers should begin with a decision inventory rather than a technology catalogue. Each candidate task needs an accountable owner, a documented failure mode, trusted data sources and a measurable reason for improvement. Procurement arrangements should require interoperable interfaces, explainable recommendations, auditability and procedures for human override. Worker representatives and operational supervisors should participate in acceptance testing so that the user interface reflects real constraints. The training programme should teach employees how to recognise incorrect outputs and when to escalate, not simply how to operate the application.

Policymakers and sector bodies can support the exchange of common logistics data definitions, workforce competency standards and anonymised evaluation methods. Training partnerships between employers and educational institutions should include realistic scenarios involving shipment exceptions, inventory discrepancies and timecritical freight coordination. The public interest lies in promoting reliable, inclusive capability across the logistics ecosystem, not privileging adoption figures as proof of impact. International research indicates that operational

UNDER PEER REVIEW IN IJAR

recovery depends on adaptable routines, transparent information and collaboration [15,28]. Saudi implementation should be evaluated against these capabilities and against local occupational requirements.

11. Limitations

This review relies on a purposive corpus of thirty DOIbearing articles rather than a comprehensive database census. Publication concentration, uneven access to full research data and Englishlanguage selection may limit the representation of smaller logistics firms and frontline occupational experience. Much of the empirical evidence originates outside Saudi Arabia; national applications are consequently reasoned implications rather than observed outcomes. The conceptual framework has not been fieldtested, and the suggested indicators require operational definition before comparative use. These limits also define a feasible next step: prospectively registered, taskspecific evaluations with transparent outcome definitions and employee participation.

12. Conclusion

Digital transformation becomes workforce augmentation only when technology increases employees' capacity to interpret uncertainty, coordinate responses and make accountable decisions. The reviewed literature offers credible mechanisms across predictive forecasting, intelligent assistance, process automation and endtoend visibility, but also reveals unresolved risks of excessive monitoring, hidden model error and weakened professional judgement. For Saudi Arabia, the strategic opportunity is to connect investments in logistics infrastructure with deliberate job redesign, trustworthy data exchange and occupationspecific learning. The proposed framework positions human decision rights and measurable learning feedback between digital systems and operational performance. Future research should test these relationships in real freight, procurement and warehousing settings, establishing when assistance improves service, resilience and the quality of work simultaneously.

UNDER PEER REVIEW IN IJAR

References

1. Brau, R. I., Aloysius, J., & Siemsen, E. (2023). Demand planning for the digital supply chain: How to integrate human judgment and predictive analytics. Journal of Operations Management, 69(6), 965–982. https://doi.org/10.1002/joom.1257
2. Brau, R. I., Sanders, N. R., Aloysius, J., & Williams, D. (2024). Utilizing people, analytics, and AI for decision making in the digitalized retail supply chain. Journal of Business Logistics, 45(1), e12355. https://doi.org/10.1111/jbl.12355
3. Lagorio, A., Cimini, C., Piffari, C., Galimberti, M., Pirola, F., & Pinto, R. (2024). Operationalisation and validation of a human factorsbased decision support framework for technology adoption in the logistics sector. International Journal of Logistics Research and Applications, 27(11), 2238–2260. https://doi.org/10.1080/13675567.2023.2235298
4. Zheng, T., Grosse, E. H., Morana, S., & Glock, C. H. (2024). A review of digital assistants in production and logistics: Applications, benefits, and challenges. International Journal of Production Research, 62(21), 8022–8048. https://doi.org/10.1080/00207543.2024.2330631
5. Ramstedt Stadin, M., Asplund, S., Nyman, T., Svartengren, M., & Hellman, T. (2024). Digital competence is a must: Manager and safety representative perspectives on evolving job skills and balancing digital work environments in transportation, logistics, and home care. Computers in Human Behavior Reports, 16, 100486. https://doi.org/10.1016/j.chbr.2024.100486
6. Sun, J., Zhang, D. J., Hu, H., & Van Mieghem, J. A. (2022). Predicting human discretion to adjust algorithmic prescription: A largescale field experiment in warehouse operations. Management Science, 68(2), 846–865. https://doi.org/10.1287/mnsc.2021.3990
7. Alrashedi, A. K. (2025). Future workforce skills for Saudi Arabia: A PLSSEM analysis of Vision 2030 readiness. Journal of Information Science, online first. https://doi.org/10.1177/02666669251357311
8. Jackson, I., Ivanov, D., Dolgui, A., & Namdar, J. (2024). Generative artificial intelligence in supply chain and operations management: A capabilitybased framework for analysis and implementation. International Journal of Production Research, 62(17), 6120–6145. https://doi.org/10.1080/00207543.2024.2309309
9. Lam, H. Y., Tang, V., & Wong, L. (2024). Raising logistics performance to new levels through digital transformation. International Journal of Engineering Business Management, 16. https://doi.org/10.1177/18479790241231730
10. Nasiri, M., Ukko, J., Saunila, M., & Rantala, T. (2020). Managing the digital supply chain: The role of smart technologies. Technovation, 96–97, 102121. https://doi.org/10.1016/j.technovation.2020.102121
11. Perano, M., Cammarano, A., Varriale, V., Del Regno, C., Michelino, F., & Caputo, M. (2023). Embracing supply chain digitalization and unphysicalization to enhance supply chain performance: A conceptual framework. International Journal of Physical Distribution & Logistics Management, 53, 628–659. https://doi.org/10.1108/IJPDLM0620220201

UNDER PEER REVIEW IN IJAP

12. Zouari, D., Ruel, S., & Viale, L. (2021). Does digitalising the supply chain contribute to its resilience? International Journal of Physical Distribution & Logistics Management, 51, 149–180. https://doi.org/10.1108/IJPDLM0120200038
13. AlMulhim, A. F. (2021). Smart supply chain and firm performance: The role of digital technologies. Business Process Management Journal, 27, 1353–1372. https://doi.org/10.1108/BPMJ1220200573
14. Durugbo, C. M., Amoudi, O., AlBalushi, Z., & Anouze, A. L. (2021). Wisdom from Arabian networks: A review and theory of regional supply chain management. Production Planning & Control, 32, 1265–1281. https://doi.org/10.1080/09537287.2020.1796144
15. Belhadi, A., Kamble, S., Jabbour, C. J. C., Gunasekaran, A., Ndubisi, N. O., & Venkatesh, M. (2021). Manufacturing and service supply chain resilience to the COVID19 outbreak: Lessons learned from the automobile and airline industries. Technological Forecasting and Social Change, 163, 120447. https://doi.org/10.1016/j.techfore.2020.120447
16. Ivanov, D. (2024). Digital supply chain management and technology to enhance resilience by building and using endtoend visibility during the COVID19 pandemic. IEEE Transactions on Engineering Management, 71, 10485–10495. https://doi.org/10.1109/TEM.2021.3095193
17. Reaidy, P., Alaeddini, M., Gunasekaran, A., Lavastre, O., & Shahzad, M. (2024). Unveiling the impact of Industry 4.0 on supply chain performance: The mediating role of integration and visibility. Production Planning & Control, advance online publication. https://doi.org/10.1080/09537287.2024.2440454
18. Qader, G., Junaid, M., Abbas, Q., & Mubarik, M. S. (2022). Industry 4.0 enables supply chain resilience and supply chain performance. Technological Forecasting and Social Change, 185, 122026. https://doi.org/10.1016/j.techfore.2022.122026
19. Spieske, A., Gebhardt, M., Kopyto, M., Birkel, H., & Hartmann, E. (2023). The future of Industry 4.0 and supply chain resilience after the COVID19 pandemic: Empirical evidence from a Delphi study. Computers & Industrial Engineering, 181, 109344. https://doi.org/10.1016/j.cie.2023.109344
20. Bahrami, M., & Shokouhyar, S. (2022). The role of big data analytics capabilities in bolstering supply chain resilience and firm performance: A dynamic capability view. Information Technology & People, 35, 1621–1651. https://doi.org/10.1108/ITP0120210048
21. Han, Y., Chong, W. K., & Li, D. (2020). A systematic literature review of the capabilities and performance metrics of supply chain resilience. International Journalof Production Research, 58, 4541–4566. https://doi.org/10.1080/00207543.2020.1785034
22. Liu, Y., Zhu, Q., & Seuring, S. (2020). New technologies in operations and supply chains: Implications for sustainability. International Journal of Production Economics, 229, 107889. https://doi.org/10.1016/j.ijpe.2020.107889
23. Bag, S., Gupta, S., & Kumar, S. (2021). Industry 4.0 adoption and 10R advance manufacturing capabilities for sustainable development. International Journal of Production Economics, 231, 107844. https://doi.org/10.1016/j.ijpe.2020.107844

UNDER PEER REVIEW IJAR

24. De Vass, T., Shee, H., & Miah, S. J. (2021). IoT in supply chain management: A narrative on retail sector sustainability. International Journal of Logistics Research and Applications, 24, 605–624. https://doi.org/10.1080/13675567.2020.1787970
25. Eslami, M. H., Jafari, H., Achtenhagen, L., Carlbäck, J., & Wong, A. (2024). Financial performance and supply chain dynamic capabilities: The moderating role of Industry 4.0 technologies. International Journal of Production Research, 62, 8092–8109. https://doi.org/10.1080/00207543.2021.1966850
26. Sharma, M., Kumar, A., Luthra, S., Joshi, S., & Upadhyay, A. (2022). The impact of environmental dynamism on lowcarbon practices and digital supply chain networks to enhance sustainable performance: An empirical analysis. Business Strategy and the Environment, 31, 1776–1788. https://doi.org/10.1002/bse.2983
27. Mvubu, M., & Naude, M. J. (2024). Digital transformation at thirdparty logistics providers: Challenges and best practices. Journal of Transport and Supply Chain Management, 18, a1023. https://doi.org/10.4102/jtscm.v18i0.1023
28. Dubey, R., Bryde, D. J., Blome, C., Dwivedi, Y. K., Childe, S. J., & Foropon, C. (2024). Alliances and digital transformation are crucial for benefiting from dynamic supply chain capabilities during times of crisis: A multimethod study. International Journal of Production Economics, 269, 109166. https://doi.org/10.1016/j.ijpe.2024.109166
29. Sarkis, J. (2020). Supply chain sustainability: Learning from the COVID19 pandemic. International Journal of Operations & Production Management, 41, 63–73. https://doi.org/10.1108/IJOPM0820200568
30. Foroughi, A. (2020). Supply chain workforce training: Addressing the digital skills gap. Higher Education, Skills and WorkBased Learning, 11, 683–696. https://doi.org/10.1108/HESWBL0720200159

UNDER PEER REVIEW IN IJAR