INTERNATIONAL JOURNAL OF eBUSINESS AND eGOVERNMENT STUDIES
Vol: 17 **No:** 1 **Year:** 2025 **ISSN:** 2146-0744 (Online) (**pp.**209-232) **Doi:** 10.34109/ijebeg.2025170110
Received: 05.12.2024 | **Accepted:** 27.02.2025 | **Published Online:** 30.03.2025

-RESEARCH ARTICLE-

AN EMPIRICAL INVESTIGATION OF WAREHOUSE LABOUR COST OPTIMIZATION IN CROSS-BORDER E-COMMERCE FULFILMENT USING THE SCOR FRAMEWORK

Yingjie Fu*

Budapest University of Economics and Business, Budapest, Hungary,1149
ORCID: https://orcid.org/0009-0004-2832-1014
Email: fu.yingjie.51@unibge.hu

Dr. Habil. Kozma Tímea

Budapest University of Economics and Business, Budapest, Hungary. 1149
ORCID: https://orcid.org/0000-0002-6164-8922
Email: kozma.timea@uni-bge.hu

—Abstract—

This research examines the composition of labour costs and the efficiency of operations within the outbound warehouse function of cross-border e-commerce supply chains. By applying the Supply Chain Operations Reference (SCOR) model, the study assesses labour strategies across the Source and Deliver dimensions, emphasising factors such as processing capacity, labour intensity, and the cost per unit order. Using empirical evidence from Chinese e-commerce exporters, the analysis highlights significant performance disparities between in-house and outsourced fulfilment models. Based on these results, a SCOR-oriented maturity framework is proposed to provide a structured approach for evaluating and improving warehouse labour performance in diverse operational environments.

Keywords: Cross-Border E-Commerce, Warehouse Labour, SCOR Model, Supply Chain Optimization, Fulfilment Cost, Outsourcing

Citation (APA): Fu, Y., Tímea, H. K. (2025). An Empirical Investigation of Warehouse Labour Cost Optimization in Cross-Border E-Commerce Fulfilment using the SCOR Framework. *International Journal of eBusiness and eGovernment Studies, 17*(1), 209-232. doi:10.34109/ijebeg.2025170110

Vol: 17 **No:** 1 **Year:** 2025 **ISSN:** 2146-0744 (Online) (**pp.** 209-232) **Doi:** 10.34109/ijebeg.2025170110

INTRODUCTION

The swift growth of cross-border e-commerce has significantly transformed global supply chains, creating fresh opportunities for international trade while also heightening operational complexity (Du, 2025). Overseas fulfilment centres have become essential infrastructure, enabling firms to reduce delivery times, enhance customer satisfaction, and improve responsiveness to market dynamics. Nonetheless, managing overseas warehouses presents distinctive challenges compared with domestic logistics, such as unpredictable demand patterns, fragmented order profiles, and diverse labour systems across different jurisdictions. Within warehouse operations, labour cost remains one of the most critical and unstable components, exerting a direct influence on both fulfilment efficiency and long-term financial viability (Vallas et al., 2022).

The labour-intensive character of cross-border e-commerce fulfilment, which includes inbound receiving, quality checks, picking, packing, and handling returns, amplifies the dependence of warehouse operations on workforce deployment and productivity. Empirical studies reveal that fluctuations in demand and seasonal surges frequently cause either underutilisation of labour capacity or heavy reliance on overtime and temporary staffing, which in turn generate cost inefficiencies and reduce service standards (Barnes & Ali, 2022; Warren & Gibson, 2023). Consequently, restructuring labour arrangements has become an urgent managerial concern, particularly for Chinese e-commerce exporters expanding into Central and Eastern Europe. From a conceptual standpoint, the SCOR model provides a unified framework for assessing and improving supply chain performance across six core processes: Plan, Source, Make, Deliver, Return, and Enable (Nguyen, 2024). While the SCOR model has been extensively applied in manufacturing and logistics, its utilisation in analysing warehouse labour optimisation within cross-border e-commerce remains underdeveloped. Most existing studies have concentrated on transportation costs, inventory efficiency, and automation adoption (Nurlan, 2025), with comparatively limited attention to labour cost strategies within the SCOR structure. Furthermore, prior work has often neglected the governance issues linked to outsourcing arrangements, service-level agreements, and performance monitoring in overseas warehouses, despite their central role in labour-intensive fulfilment operations (Schaupp, 2021).

E-commerce in the world has been experiencing a rapid transformation with the cross-border transactions playing a greater role in global commerce and economic growth. This growth has increased the complexity of operations in warehouse and fulfilment activities, especially in new markets where the management of labour costs has not been integrated well in the standardised performance frameworks of the supply chain. The

Vol: 17 **No:** 1 **Year:** 2025 **ISSN:** 2146-0744 (Online) (**pp.** 209-232) **Doi:** 10.34109/ijebeg.2025170110

cost of labour is 60-65% of total warehousing costs in e-commerce business, which means that optimizing the cost of labour is a crucial but under-researched aspect of supply chain competitive advantage (Wang & Liu, 2025). Although the automation of warehouses and digitalisation has been scientifically proven, empirical findings that can correlate labour productivity indicators with established supply chain performance measurement models, namely, the SCOR model, are scattered and confined to the developed-economy enivronment. The recent literature on warehouse management has been excessively focused on technological solutions, with the automation technologies having reached 20-30% improvement in productivity and cost reduction (Khare & Chansoriya, 2023).

On the other hand, recent studies also point out that the cost optimization of labour in warehouses is still mostly an ad hoc effort that does not connect with an integrated supply chain management solution. The time-driven activity-based costing study by Rodríguez-Garcia et al. (2023) that determined picking costs in warehouse fulfillment strategies were the most labour-intensive activity, nearly twice the scale of other e-fulfillment activities, but did not connect them to other supply chain performance measures. This fragmentation continues regardless of the fact that the SCOR version 13.0 provides more performance measuring features (Özkanlısoy, & Bulutlar, 2023) that are aimed at measuring cost, reliability, responsiveness, agility, and asset management aspects across the supply chain processes.

The e-commerce fulfilment of cross-border business entails unique labour management issues that have not been encountered in local transactions. Semi-controlled models of fulfillment that will be adopted in the year 2024-2025 will mandate the sellers to coordinate labour and inventory control in multiple geographies with different regulatory environments, wage systems and skill base profiles (Oteri et al., 2023). Emerging markets- especially in Southeast Asia, India and Latin America- are confronted with even greater challenges of infrastructure limitations with a growing wage pressure and increasing customer delivery expectation. Recent sources exploring the topic of emerging-economy logistics (Yáñez-Hernández, 2025) record that the agroindustrial and medium-sized companies in the resource-constrained settings do not feature a formalised labour performance measurement system and rely on empirically-driven as opposed to analytically-grounded management practices.

Already, artificial intelligence and machine learning have made major progress in the field of the supply chain business, where they have faced supply chain operations, making them 15 percent more efficient and improving the accuracy of predicting orders and fulfillment to 95 percent (Özkanlısoy, & Bulutlar, 2023). Nevertheless, labour

Vol: 17 **No:** 1 **Year:** 2025 **ISSN:** 2146-0744 (Online) (**pp.** 209-232) **Doi:** 10.34109/ijebeg.2025170110

workforce management, i.e., worker scheduling optimization, cross-training performance, and variable demand labour utilization, is under a methodological development in supply chain performance frameworks. Most recent optimization studies on the scheduling of workers at logistics are based on the genetic algorithms and simulated annealing (Ali et al., 2025), but they do not relate to the SCOR-based performance measurement systems, which means that the managerial applicability and strategic integration are limited.

SCOR model has proved to be effective in enhancing the performance of any supply chain in any industry and geography. A case study that applied SCOR version 12.0 to an agroindustrial company located in Mexico found operational bottlenecks in the supplier, provisioning, warehouse and customer processes with a benefit-cost ratio of 1.26 (Yáñez-Hernández, 2025). The five processes of the model plan, source, make, deliver, return, and five performance attributes reliability, responsiveness, agility, cost and asset management give uniform language in processes optimization. However, peer-reviewed literature on systematic implementation of SCOR to the analysis of labour costs in cross-border fulfilment is yet to be found. The studies that have tried to quantify supply chain performance in terms of SCOR (Özkanlısoy, & Bulutlar, 2023) handle high basis operational measures without breaking down labour cost drivers or operationalizing labour productivity indicators based on SCOR performance attributes.

This study aims to bridge these gaps by undertaking an empirical analysis of warehouse labour cost optimisation in cross-border e-commerce fulfilment, applying the SCOR model as the analytical framework. Using case evidence from Chinese e-commerce firms operating warehouses in Poland, the research (1) identifies major cost determinants of warehouse labour, (2) systematically associates them with SCOR process categories, and (3) assesses the performance outcomes of shifting from hourly-based contracts to piece-rate outsourcing models. Through combining empirical evidence with the SCOR framework, the study makes two main contributions. First, it extends the relevance of the SCOR model to labour-intensive fulfilment contexts, broadening its theoretical application beyond manufacturing. Second, it delivers practical insights for managers facing the simultaneous demands of reducing costs while sustaining service quality in cross-border e-commerce logistics.

LITERATURE REVIEW

Trends and Current Status of Cross-Border E-Commerce Supply Chains

In the past decade, China's cross-border e-commerce industry has undergone accelerated growth, shifting away from its early emphasis on exports toward a more

integrated model that positions overseas warehouses at the centre of logistics and supply chain services (F, 2022). Driven by globalisation and initiatives such as the Belt and Road, these supply chains have become increasingly intricate, with enterprises adopting digitalisation and advanced decision-support systems to strengthen supply chain management (Lei, 2021). Within Central and Eastern Europe, and particularly in Poland, Chinese e-commerce firms have established overseas warehouses as a means of shortening delivery times, reducing logistics expenditure, and improving customer service quality (Dörflinger et al., 2021; Ren et al., 2024).

Scholarly work consistently stresses that the growth of platform-driven e-commerce has reconfigured traditional supply chain practices. Through digital interfaces, algorithmic regulation, and data-oriented coordination, platforms have enhanced visibility and responsiveness across supply chains (Delfanti, 2021; Warren & Gibson, 2023). At the same time, research points out that these developments, although efficiency enhancing, introduce new governance concerns. In particular, when operating across diverse institutional and cultural settings, platform firms encounter enduring obstacles in relation to labour management, legal adherence, and organisational integration (Barnes & Ali, 2022). From a regional perspective, studies show that Chinese cross-border e-commerce operators in Poland and comparable markets face recurring constraints, including limited automation in warehouses, weak precision in inventory control, and delays in meeting local demand (Ren et al., 2024). Such shortcomings reduce competitiveness relative to domestic firms and act as barriers to achieving wider market penetration and large-scale expansion (Lei, 2021; Warren & Gibson, 2023).

In addition, there are also some modern studies who have explored the trends and modern status in the cross-border E-commerce supply chain management practices. For example, Chen et al. (2022) have claimed that the current body of literature is mainly focusing on the factors influencing the domain of cross-border e-commerce, where there is no focus on the systematic macro overview of such development in the domain of E-commerce. For this purpose, the authors have conducted a systematic bibliographic analysis while covering over 198 references during the period of 2016-2021. The findings reveal the fragmented nature of cross-border e-commerce research, while identifying key trends, gaps, and future research directions. Another study as conducted by Wang et al. (2020) have considered the cross-border e-commerce firms as the key role players of supply chain integrators. The authors have focuses on four Chinese e-commerce firms with the main focus on information, logistics, and finance flows as the three supply chain resources. The study mainly highlights the importance of managing

Vol: 17 **No:** 1 **Year:** 2025 **ISSN:** 2146-0744 (Online) (**pp.** 209-232) **Doi:** 10.34109/ijebeg.2025170110

these resources to foster strong relationships, which is essential for gaining a competitive edge in the market. Zhou and Liu (2022) claimed that the cross-border e-commerce industry can get some rapid development based on the logistic channels improvements and advanced information technology. For this reason, the role of Blockchain technology is quite evident and considering the same issue, the authors have conducted a data-driven bibliography analysis for the period of 2013-2021. The study mainly considers the nexus between cross-border e-commerce supply chain and blockchain.

Overseas Warehouse Process Management: Current Status and Optimization Progress

Effective management of warehouse processes is a fundamental element of cross-border e-commerce supply chains, as it directly shapes order responsiveness, delivery reliability, and overall service quality (Schaupp, 2021; Vallas et al., 2022). In recent years, a substantial body of research has concentrated on advancing warehouse logistics, with optimisation efforts primarily targeting automation technologies, improved picking strategies, and enhanced inventory control systems. For instance, the deployment of intelligent picking robots and automated sorting solutions has considerably raised efficiency levels, though their adoption remains uneven across markets due to high implementation costs and difficulties in local adaptation (Barnes & Ali, 2022; Delfanti, 2021). Vassiliadis et al. (2001) focus on the modelling of the data Wherehouse. The provided paper has presented a metamodel for the data warehouse operational processes. The given model focuses on the complex activities and their interrelationships, along with connections to data sources and execution details. Moreover, this metamodel has integrated with existing architecture and quality models, forming a comprehensive framework for managing data warehouses (Maté & Trujillo, 2012). However, it is important to note that the framework challenges the idea that data warehouses are merely collections of materialized views. The metamodel was implemented using the Telos language along with the concept-based metadata repository system, respectively. Kłodawski et al. (2017) have provided the debate about the issues related to the designing and organization of the logistic process in the domain of Wherehouse and related facilities. Moreover, the authors claim that there are several different ways through which the Wherehouse process can be implemented. However, there are several associated factors having their role towards such implementation.

Despite these technological advancements, labour-intensive functions continue to dominate overseas warehouse operations. Warren and Gibson (2023) noted that while

the standardisation of skill sets and work roles contributes to operational consistency, the imposition of continuous monitoring and performance assessments intensifies pressure on employees, particularly temporary staff who experience frequent turnover. Similarly, Schaupp (2021) contended that the use of algorithmic scheduling and human–machine collaboration can enhance efficiency, yet these approaches face critical obstacles, including the lack of transparency in algorithmic decision-making and employee reluctance to embrace automation. Further investigations highlight that the complexity of overseas warehouse operations compounds managerial challenges, especially in achieving accurate inventory control and process optimisation (Ren et al., 2024; Schor et al., 2024). In practical terms, the predominance of small-batch, multi-variety, and high-frequency orders represents one of the most persistent difficulties in managing cross-border warehouse processes (Vallas et al., 2022).

Berezina (2016) focus on the inventory management along with the Wherehouse management process. It is believed that due to higher level of the competition in the marketplace, the company's operations are significantly connected with the stock control. Moreover, the inventory management process has been defined by the factors like efficiency and effectiveness. The author provides some of the valuable recommendation regarding the inventory and Wherehouse management practices.

Application and Limitations of the SCOR Model in Cross-Border E-Commerce Warehousing

The SCOR model has been extensively applied within manufacturing and logistics sectors and, more recently, has gained traction in cross-border e-commerce supply chain management as a means of standardising processes and optimising performance. (Wei, 2024). It provides firms with a structured methodology to improve supply chain efficiency across multiple operational dimensions. Despite its proven effectiveness, the application of SCOR in cross-border e-commerce presents distinctive challenges. The fragmented, small-batch, and high-frequency ordering patterns characteristic of this sector differ substantially from the batch-based logic of traditional manufacturing, raising concerns about the framework's adaptability (Nguyen, 2024). In addition, most applications overlook critical factors such as the dynamic interplay between processes, the coordination of labour with workflows, and the real-time synchronisation of inventory and order fulfilment, which are vital in cross-border warehouse operations (Schor et al., 2024; Vallas et al., 2022). Nevertheless, scholars recognise the strengths of SCOR in performance assessment, particularly regarding metrics such as response speed, order accuracy, and customer satisfaction (Barnes & Ali, 2022). However, current studies remain largely confined to indicator mapping and outcome

Vol: 17 No: 1 Year: 2025 ISSN: 2146-0744 (Online) (pp. 209-232) Doi: 10.34109/ijebeg.2025170110

measurement, with limited attention given to the development of systematic frameworks or empirical analyses that embed SCOR into actual operational settings (Delfanti, 2021; Schaupp, 2021).

Research Gaps and Future Directions

In summary, although previous studies on cross-border e-commerce supply chains, warehouse process management, and the SCOR model have provided valuable contributions, several important research gaps persist.

a) There is a lack of comprehensive inquiry into how automation can be effectively combined with localisation strategies in overseas warehouse operations, particularly in relation to institutional and market differences across countries.
b) Human resource management in warehouse settings remains underexplored, with limited attention to the role of temporary workers, the protection of employee rights, and the implications of algorithm-driven labour management systems.
c) The adaptability of SCOR to cross-border e-commerce characterised by small-batch, high-frequency orders has not been adequately examined, especially in terms of indicator design, framework development, and empirical testing.

Accordingly, future investigations should prioritise:

a) Developing collaborative optimisation strategies for warehouse process reengineering and labour management using the SCOR model;
b) Designing integrated approaches that align digital and algorithmic management systems with SCOR;
c) Exploring differentiated pathways for warehouse automation and localised supply chain coordination across varying national and regional contexts.

Advancing scholarship in these areas would enhance the understanding of the complexities that define cross-border e-commerce supply chains while equipping firms with practical strategies to optimise operations and strengthen long-term competitiveness.

METHODOLOGY

Research Design and Context

This research employs an embedded case study design, concentrating on a Chinese

Vol: 17 **No:** 1 **Year:** 2025 **ISSN:** 2146-0744 (Online) (**pp.** 209-232) **Doi:** 10.34109/ijebeg.2025170110

cross-border e-commerce firm managing an overseas warehouse in Poland. The investigation systematically explores the company's transition in labour models, its related managerial practices, and approaches to process optimisation. The central aim is to evaluate how the SCOR framework can be utilised to standardise labour processes and align them with performance objectives in overseas warehouses, thereby addressing both cost-efficiency and compliance with local regulations. In light of the research gaps identified in the literature—particularly the absence of studies on the integration of SCOR-based warehouse process reengineering with labour management strategies—this study places emphasis on the evolution of labour structures and their interconnection with order fulfilment workflows. Specific attention is devoted to three areas: (1) the standardised definition of process nodes, (2) the measurable breakdown of operational activities, and (3) the design of dual accountability mechanisms that directly link performance indicators with managerial responsibility.

Data Sources and Research Pathway

Data were obtained from three principal sources:

Labour Market Survey: Field investigations were carried out in three major Polish cities (Warsaw, Łódź, and Wrocław), collecting information from labour service platforms on agency fee structures, job classifications, and standard employment contract templates.

Policy and Regulatory Review: Relevant labour regulations, temporary employment provisions, and tax compliance documents introduced in Poland and the European Union since 2020 were compiled and verified through official sources, including KRS and GOV.pl.

Operational Data and Semi-Structured Interviews: Archival warehouse management records (such as process flowcharts, SOPs, and job descriptions) together with performance data (including attendance logs and order fulfilment records) were compared across pre- and post-transformation periods. Additionally, three rounds of semi-structured interviews were undertaken with both managerial staff and frontline workers to ensure triangulation of the findings.

Transformation of Labour Models: From Hourly Pay to Piece-Rate Outsourcing

At the initial stage of operations, the Polish overseas warehouse largely depended on an hourly-paid workforce, which provided flexibility and straightforward settlement but

Vol: 17 No: 1 Year: 2025 ISSN: 2146-0744 (Online) (pp. 209-232) Doi: 10.34109/ijebeg.2025170110

also exposed three key shortcomings:

High Labour Costs: Demand fluctuations caused underutilisation of workers and the accumulation of idle wage expenses.

High Managerial Burden: Significant time and resources were consumed by attendance monitoring, shift coordination, and managing absenteeism.

Weak Incentive Structures: Employees demonstrated a "time-oriented" approach, which led to inconsistent responsiveness and variable processing efficiency.

To overcome these constraints, and following a comprehensive evaluation of legal compliance and managerial practicability, the enterprise shifted in late 2024 to a piece-rate outsourcing system. Under this model, core warehouse activities (inbound receiving, quality inspection, packing, and outbound handling) were standardised and delegated to third-party service providers, compensated on a per-unit basis.

The transformation yielded notable outcomes:

a) Average operating costs declined by 44 per cent, while responsiveness during peak demand periods improved.
b) Task boundaries were clarified, supporting more precise workflow optimisation and clearer role delineation.
c) Incentive structures became more transparent, enhancing worker motivation and contributing to more stable productivity levels.

However, the new arrangement also generated additional challenges:

a) Service provider management became more complex, requiring the introduction of SLA-based performance contracts and quality monitoring systems.
b) A stronger reliance on SOPs and process documentation emerged, since task specifications and workflows needed to be rigorously codified.
c) Enhanced monitoring measures were required, including random inspections, on-site evaluations, and closed-loop data feedback mechanisms.
d) These shifts collectively established both the practical impetus and the organisational framework for adopting the SCOR model.

SCOR Mapping and Integration: Aligning Process, Performance, and Management

To enhance the coordination between labour allocation, process quality, and service

Vol: 17 **No:** 1 **Year:** 2025 **ISSN:** 2146-0744 (Online) (**pp.** 209-232) **Doi:** 10.34109/ijebeg.2025170110

delivery within the returns-processing warehouse, this study employs the SCOR model as its analytical framework. The SCOR methodology offers a standardised approach for decomposing operational processes, tracking performance indicators, and defining enabling capabilities. Table 1 covers the outlook for the SCOR mapping of the return's inspection process.

Table 1: SCOR Mapping of the Returns Inspection Process

SCOR Module	Mapped Process & Operational Node	Practical Implementation	Corresponding KPIs	Managerial Focus
Plan	Workload and Labour Scheduling Model; Returns Volume Forecasting	Two-Week Returns Forecasting Linked to Shift Planning and Working Hours	Average Returns Processed per Worker; Labour Response Cycle	Avoid Overstaffing/Understaffing; Reduce Response Delays
Source	Coordination with Current Service Providers; Admission Rules for New Providers	Outsourced Labour Allocation based on Required Headcount and Skill Levels	Supplier Response Lead Time; Compliance Coverage Rate	Establish Rapid Coordination Mechanisms; Maintain Compliance Documentation
Make	Task Division and Job Standards	Standardization of Inspection Tasks Via SOPs to Minimize Subjectivity	Inspection Pass Rate; Processing Time per Unit	Continuous Training; SOP Supervision; Detailed Traceability Records
Deliver	Packing and Outbound Preparation	Qualified Items Processed and Transferred to Resale System	Outbound Accuracy Rate; Daily Throughput	Verification and Approval Mechanisms; Standardized Handover Procedures
Return	Re-Inspection and Exception Handling	Secondary Inspection Mechanism to Reduce False Positives/Negatives	Rework Rate; Inspection Error Rate	Data-Driven Feedback Loop to Minimize Judgment Variability
Enable	Training Programs, Inspection Capability Assessment, and Sampling System	Monthly Training Plans with Integrated Feedback Loops	Training Coverage Rate; Sampling Consistency Rate	Dual-Track Mechanism of Training and Supervision; Iterative Feedback for Continuous Improvement

This renders it particularly effective in contexts where labour demand fluctuates according to return volumes, while maintaining stringent quality requirements in inspection procedures. In operational practice, the Polish warehouse is mainly responsible for handling return inspections, where daily labour demand is highly responsive to shifts in return volumes. Given that tasks necessitate human judgement and supplementary verification, strict adherence to processes and consistent worker training are of critical importance. For this reason, the actual workflow—Inbound → Scanning → Inspection → Packing → Outbound Preparation → Secondary Random Inspection—was systematically integrated into the SCOR framework to facilitate

Vol: 17 **No:** 1 **Year:** 2025 **ISSN:** 2146-0744 (Online) (**pp.** 209-232) **Doi:** 10.34109/ijebeg.2025170110

structured performance monitoring and managerial oversight.

The primary focus is on labour scheduling driven by demand forecasting. A seven-day moving average of return volumes was applied to project staffing needs for each task, while a seasonal contingency pool was established to prevent backlog during peak return periods.

Permanent employees were integrated with outsourced labour resources, with differentiated skill requirements defined for scanning, inspection, and packing functions. Service providers were obliged to submit worker rosters and training certifications on a regular basis to guarantee skill alignment and compliance with regulatory standards. Manual inspection, which had previously relied heavily on individual worker experience, was standardised into a structured five-step procedure: scanning confirmation, visual inspection, data verification, functional testing, and repackaging. This restructuring ensured the development of processes that were both trainable and measurable.

A secondary inspection system was introduced in which 8–10 items were randomly re-examined for every 100 approved products. Any inconsistencies triggered full reinspection and retraining of the original inspector, with penalties imposed on service providers. This mechanism significantly enhanced inspection accuracy and reduced both customer complaints and subsequent returns. This layer established systemic support capabilities under the principle of "training–documentation–feedback." All workers were required to pass SOP-based operational assessments before assignment. Sampling performance was directly linked to training results, forming a closed-loop cycle of problem identification, process revision, and retraining.

Empirical Results

This section outlines the principal empirical findings derived from the transformation of labour models within the returns inspection warehouse of a Chinese cross-border e-commerce enterprise based in Poland. The analysis emphasises the shifts observed in labour cost management, efficiency of process execution, and mechanisms for maintaining service quality. The results are validated through triangulation of diverse data sources, including labour market surveys, regulatory reviews, operational records, and semi-structured interviews.

Labour Market Survey in Poland (2024)

A comparative investigation was undertaken in three principal Polish cities—Warsaw,

Vol: 17 **No:** 1 **Year:** 2025 **ISSN:** 2146-0744 (Online) (**pp.** 209-232) **Doi:** 10.34109/ijebeg.2025170110

Łódź, and Wrocław—to examine the structure of labour supply within the warehousing sector (Table 2) which shows that estimated share of hourly workers are 65%-75%, 70%-80% and 60%-70% respectively.

Table 2: Labour Market Characteristics in Poland (2024)

City	Main Labour Sources	Estimated Share of Hourly Workers	Average Annual Wage (PLN)	Estimated Hourly Wage (€)	Common Job Types
Warsaw	Ukraine, Belarus, Moldova	65–75%	≈ 69,000 PLN/Year	≈ 33 PLN/h ≈ €7.3	Loading, Quality Inspection, Sorting
Łódź	Ukraine, Georgia	70–80%	Similar Level	≈ €7.3	Packing, Scanning, Warehouse labour
Wrocław	Ukraine, Asia (Nepal, Bangladesh)	60–70%	Slightly Lower than Poznań	≈ €6.8–7.0	Packing, Inspection, Sorting

Source: The salary estimates are drawn from ERI SalaryExpert data (33 PLN/h ≈ €7.3). The share of hourly workers is derived from labour platform estimates and further validated against employment practices in Chinese firms to ensure representativeness.

Contract Types and Comparative Advantages

The Polish labour market offers three principal contractual arrangements, each characterised by specific attributes and carrying different implications for cross-border e-commerce enterprises as shown in (Table 3) where Employment Contract, Mandate Contract and Contract for Specific Work has been differentiated according to their features and worker rights.

Table 3: Contract Types and Advantages for Chinese E-Commerce Enterprises

Contract Type	Application Scenario	Features and Worker Rights	Potential Advantages
Employment Contract	Long-Term, Formal Positions (e.g., Full-Time QC)	Full Social Security, Paid Leave, Stable Working Hours, Dismissal Protection	Stable Workforce, Reduced Turnover, Compliance with Labour Law
Mandate Contract	Temporary, Flexible Hourly or Piece-Rate Jobs	Partial Social Security, Minimum Hourly Rate, Flexible Termination	Cost Control, Rapid Response to Peak Demand
Contract for Specific Work	One-Off Tasks (e.g., re-Inspection, Quality Audits)	Typically, No Social Contributions; Accountability Based on Output	Clear Pricing, Convenient Management, Suitable for Short-Term Tasks

Source: Collected by the author.

Structured Interview Insights

Semi-structured interviews were carried out with managerial staff, frontline inspectors, and team supervisors as shown in (Table 4).

Vol: 17 **No:** 1 **Year:** 2025 **ISSN:** 2146-0744 (Online) (**pp.** 209-232) **Doi:** 10.34109/ijebeg.2025170110

Table 4: Interview Themes and Representative Insights

Group	Theme	Sample Size	Key Terms	Representative Quote
Management	Post-Transition Complexity	3	"Clearer Processes," "More Frequent Training," "Stricter Evaluation"	"Previously, supervision relied on oversight; now it relies on forms and scores."
Frontline Staff	Changes in Work Intensity	20	"Piece-Rate Driven," "Bonuses," "Faster Pace"	"The pace is tougher, but bonuses motivate us, and overtime is no longer a concern."
Team Leaders	Service Provider Performance	5	"KPI Scoring," "Accountability," "Handover Records"	"We review quality in every weekly meeting—non-compliance results in penalties."

Source: Collected by the author.

Integrated Evaluation and SCOR Alignment

The empirical findings yield several managerial implications:

Balancing Cost and Efficiency: Non-formal contractual arrangements, such as mandate contracts or contracts for specific tasks, are well suited for managing fluctuations in return volumes, as they help to avoid the accumulation of social security expenses linked to standard employment contracts. Approximately 70 per cent of inspectors and team leaders are non-local workers, predominantly from Ukraine and the Philippines, who prefer flexible contractual arrangements that are not restricted by overtime provisions. For positions involving core quality assurance responsibilities and shift supervision, however, formal employment contracts are advisable in order to secure workforce stability and facilitate the transfer of skills.

Compliance and Risk Management: Adopting a hybrid portfolio of contracts enables firms to achieve an effective balance between regulatory compliance and operational flexibility. Employment contracts contribute to legal conformity and labour force stability, whereas mandate and task-specific contracts support adaptability and cost reduction.

SCOR Model Integration: Within the Source component, contract types can be strategically adjusted in response to return volume forecasts. In the Plan component, contract structures serve as critical inputs to labour budgeting models, thereby enhancing the predictability of workforce expenditure.

Changes in Labour Cost and Utilization

Financial data from the warehouse demonstrated substantial efficiency improvements following the transition in labour models.

Vol: 17 **No:** 1 **Year:** 2025 **ISSN:** 2146-0744 (Online) (**pp.** 209-232) **Doi:** 10.34109/ijebeg.2025170110

Pre-Transition (Hourly System): Under the pre-transition hourly-based system, the average processing efficiency was 17 pieces per hour, while monthly unit labour costs varied between €4.93 in 2023 and €5.94 in 2024 per worker hour.

The comparative analysis of total warehouse output and actual hourly efficiency under Different Models have been well covered in Figure 1, whereas Figure 2 reflects the comparative trends between theoretical and actual warehouse efficiency.

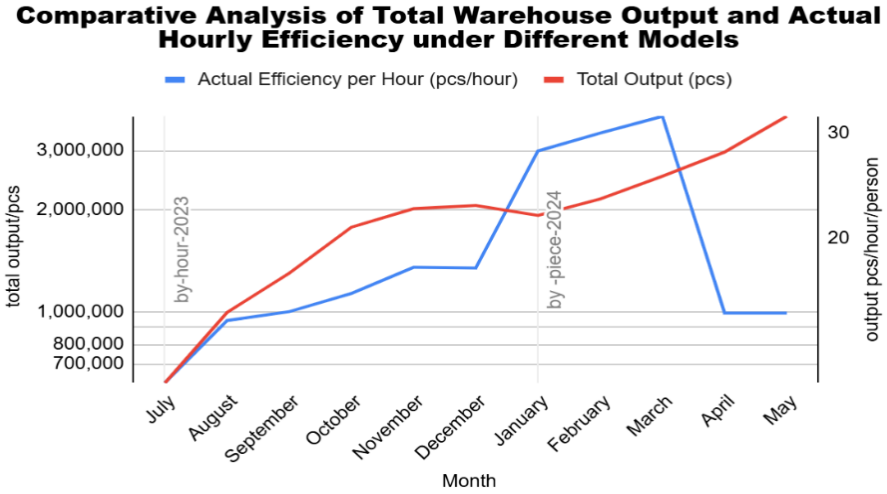

Figure 1: Comparative Analysis of Total Warehouse Output and Actual Hourly Efficiency under Different Models

Source: Collected by the author.

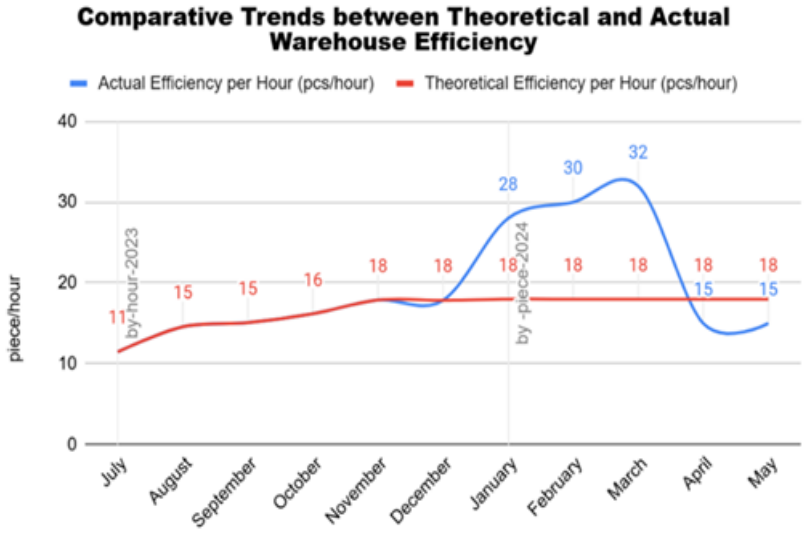

Figure 2: Comparative Trends between Theoretical and Actual Warehouse Efficiency

Source: Collected by the author.

Vol: 17 **No:** 1 **Year:** 2025 **ISSN:** 2146-0744 (Online) (**pp.** 209-232) **Doi:** 10.34109/ijebeg.2025170110

Table 5 covers the minimum monthly wages along with the minimum hourly rate during 2023 and 2024.

Post-Transition (Piece-Rate System): Efficiency rose to 32 pieces per hour, with per-order costs standardised at €0.18, reflecting a 44.6 per cent decrease in unit labour costs compared with the hourly-based system (approximately €0.325 per order).

Table 5: Minimum Wages in Poland (2023–2024)

Year	Minimum Monthly Wage (€)	Minimum Hourly Rate (€)
2023	755	4.93
2024	908.5	5.94

Source: Collected by the author.

The variation of cost per piece under different models is presented using Figure 3 below.

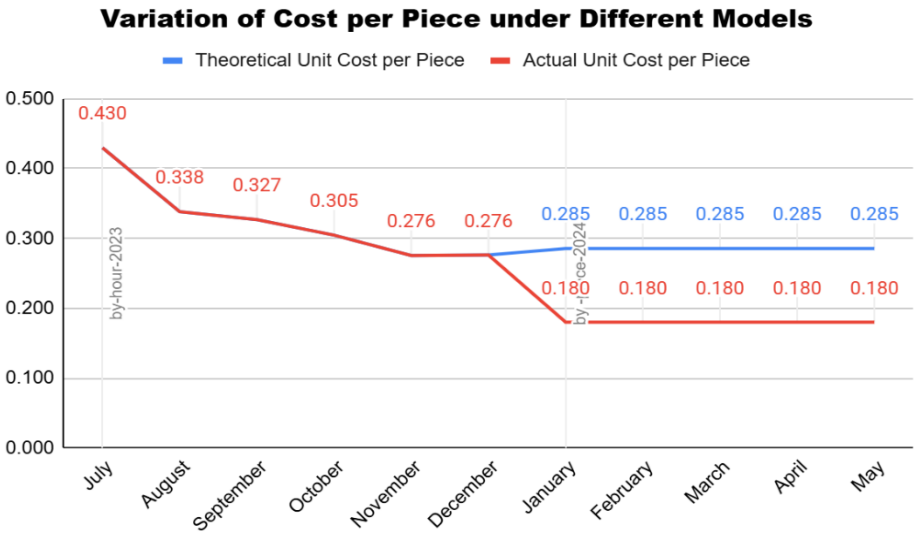

Figure 3: Variation of Cost per Piece under Different Models
Source: Collected by the author.

Improvements in Service Performance and Operational Stability

Figure 4 covers the quality inspection performance and working hours per unit time after model change. The piece-rate outsourcing model produced notable enhancements in service quality. Average order processing time, measured from picking to shipping, declined from 5.23 seconds to 3.15 seconds. Inspection efficiency also improved, with

Vol: 17 **No:** 1 **Year:** 2025 **ISSN:** 2146-0744 (Online) (**pp.** 209-232) **Doi:** 10.34109/ijebeg.2025170110

defect detection rates rising from 1.76 per cent to 8.25 per cent, demonstrating a more rigorous quality control process. This transition enabled the warehouse to sustain high standards of inspection performance despite the continued growth in order volumes.

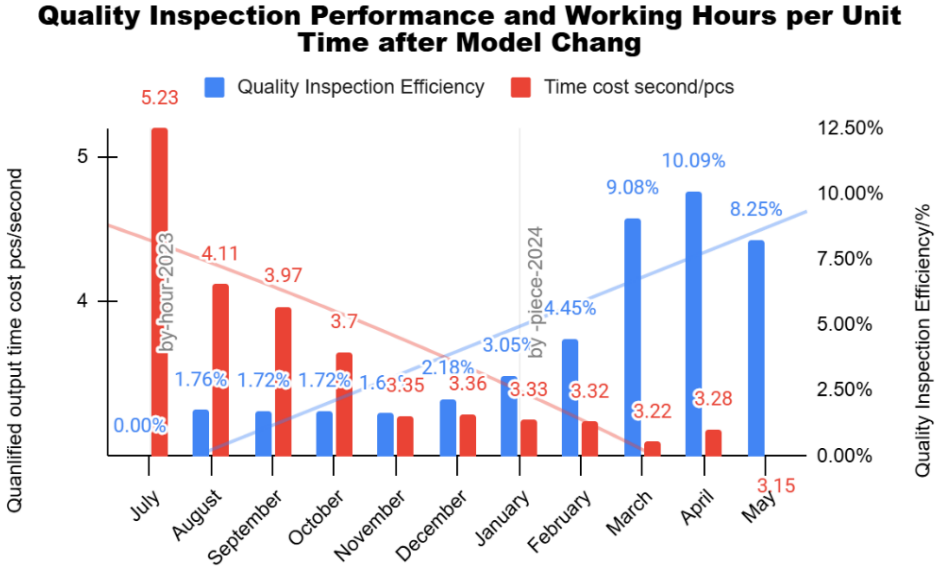

Figure 4: Quality Inspection Performance and Working Hours per Unit Time after Model Change

Source: Collected by the author.

Increased Governance Complexity

While efficiency improved, managerial oversight requirements intensified:

The frequency of SOP revisions increased from quarterly to once every 1.5 months to accommodate task modifications. Additional quality assurance measures were implemented, including random inspections (five per 100 orders) and SLA-based performance scoring. The average response time to operational anomalies declined from 23 minutes to 15 minutes, attributable to clearer accountability mechanisms. Managerial investment expanded, requiring monthly bilateral meetings between HR, operations, and procurement teams and service provider supervisors to enforce systems of penalties and rewards.

The empirical findings confirm two central observations: Piece-rate outsourcing substantially improved labour productivity and cost structures, particularly in the context of fluctuating order volumes and seasonal demand peaks. SCOR-based process reconfiguration strengthened operational execution and service loop efficiency, although it simultaneously heightened dependence on SOPs and supplier monitoring

Vol: 17 **No:** 1 **Year:** 2025 **ISSN:** 2146-0744 (Online) (**pp.** 209-232) **Doi:** 10.34109/ijebeg.2025170110

mechanisms. These results not only establish the empirical foundation for the subsequent theoretical discussion but also provide practical insights for Chinese cross-border e-commerce enterprises considering comparable workforce transitions in Central and Eastern Europe.

DISCUSSION AND THEORETICAL INTEGRATION

Empirical Findings in Relation to the Literature

This study employs the labour model transformation in a Polish overseas warehouse as an empirical lens to analyse the shift from hourly-based employment to piece-rate outsourcing. The findings contribute empirical evidence to current debates surrounding the localisation of cross-border e-commerce warehousing, the institutionalisation of outsourcing, and the optimisation of service-oriented processes. First, the results align with the arguments of Warren and Gibson (2023) regarding the rise of "platform-driven flexible labour regimes" in logistics. The evidence indicates that piece-rate outsourcing substantially improved labour productivity and operational stability, yet it also heightened reliance on standardised procedures and intensified monitoring requirements. This outcome supports Schaupp (2021) assertion that "the more finely structured a process, the greater the control pressure." Second, the findings resonate with Karabegović et al., (2025), who highlighted the limited penetration of automation and the continued predominance of labour in Eastern European warehouses. Although automation remains restricted, this study extends prior research by demonstrating that human resources themselves can be institutionalised and systematised through process reengineering and performance-based contracting. In this respect, labour becomes subject to modelling and standardisation, thereby mitigating the absolute dependence on automation.

Reflections on SCOR Model Adaptability and Extensions

Through structural mapping, this study demonstrates the integration of "outsourced labour systems combined with process reengineering" into the Deliver, Make, and Enable modules of the SCOR model, thereby offering fresh evidence of the framework's adaptability within cross-border e-commerce contexts. More specifically, the SCOR model's focus on process standardisation and quantitative performance metrics corresponds closely with outsourcing practices that are governed by SOPs and KPIs. The Plan and Source modules provide structural guidance for labour cost estimation and supplier coordination, which Make and Deliver modules facilitate task decomposition and establish accountability for performance in warehouse operations.

Vol: 17 No: 1 Year: 2025 ISSN: 2146-0744 (Online) (pp. 209-232) Doi: 10.34109/ijebeg.2025170110

The Enable module supports system-level functions such as training initiatives, feedback mechanisms, and monitoring procedures.

Despite these contributions, several limitations were observed during implementation: Absence of endogenous modelling for labour-oriented service processes. The SCOR framework is primarily oriented towards material production and delivery, offering limited analytical depth for labour-intensive service chains. The model presumes linear chains of accountability, which do not adequately reflect the collaborative and contractual dynamics of platform-based outsourcing, where SLA arrangements and service rating mechanisms are critical. The influence of performance metrics on worker motivation and compliance is not explicitly accounted for, highlighting the need for supplementation with human factors engineering and labour governance theories.

Constructing a Platform-Based Logic of Labour Governance

Building on both the empirical findings and the SCOR-based analysis, this study argues that labour governance in overseas warehouses within cross-border e-commerce is shifting away from the conventional "employment plus dispatch" approach towards a platform-oriented governance model. This transformation is characterised by three key transitions: (a) From employment-based arrangements to service-oriented contractual relationships. (b) From manual task allocation to enforcement through contracts and SOP-regulated processes (c) From remuneration determined by time to performance-linked incentives reinforced by quality feedback mechanisms.

This evolving platform-driven logic is consistent with the empirical evidence and aligns with Faraoun, (2024) theoretical reflections on the restructuring of labour within platform systems. It also serves as an industry-specific adaptation of the SCOR framework, extending its applicability to labour-intensive processes in the cross-border e-commerce domain.

CONCLUSION AND RECOMMENDATIONS

This study explored the challenges encountered by Chinese cross-border e-commerce enterprises in adapting labour management practices for overseas warehouses in Eastern Europe, with Poland selected as the primary case. Employing the SCOR supply chain framework, the research conducted a structured examination of the transition from hourly-wage employment models to piece-rate outsourcing systems. Drawing on comprehensive labour market surveys, regulatory reviews, and case-specific empirical

Vol: 17 **No:** 1 **Year:** 2025 **ISSN:** 2146-0744 (Online) (**pp.** 209-232) **Doi:** 10.34109/ijebeg.2025170110

evidence, the study developed a tri-dimensional framework encompassing process, performance, and institutional dimensions, and systematically mapped warehouse operational stages onto modular SCOR components, each linked to relevant performance indicators. The empirical results indicate that the piece-rate outsourcing model, while maintaining compliance, significantly lowered labour costs and improved order-processing efficiency. Nonetheless, the transition also intensified reliance on standard operating procedures and strengthened monitoring demands. Collectively, the findings affirm the effectiveness of the SCOR framework in process standardisation and performance governance within cross-border e-commerce operations, while also highlighting its adaptability in aligning human capital, task configuration, and operational flows. At the same time, the study emphasises the necessity of extending SCOR to integrate service-oriented labour structures and platform-based governance mechanisms.

Drawing on the findings, three practical recommendations are advanced for Chinese e-commerce enterprises expanding overseas warehouse operations: Firms should reconceptualise warehouse functions as modular, task-oriented units and adopt piece-rate contractual arrangements supported by service-level agreements (SLAs). This shift requires the systematic application of SOPs and KPI-based evaluation mechanisms to achieve process standardisation, transparent accountability, and measurable outcomes. Embedding warehouse operations within SCOR or APICS frameworks enhances operational replicability, auditability, and cost visibility. Such integration also strengthens knowledge transfer across international teams and ensures consistent alignment of performance indicators across multiple geographical contexts. Outsourcing labour does not diminish the necessity of oversight. Enterprises should designate clear process ownership, establish supervisory and coordination structures, and deploy dual mechanisms for quality assurance and performance monitoring. These measures enable the creation of a closed-loop system that safeguards both operational reliability and service delivery standards.

CONTRIBUTIONS AND DIRECTIONS FOR FUTURE RESEARCH

This study makes contributions on three levels: first is to embed labour model transformation into SCOR process chains, demonstrating the feasibility of modularising, quantifying, and institutionalising labour management. It extends SCOR by adapting its Deliver and Enable modules to incorporate labour control loops, thereby enhancing the framework's applicability to service-oriented contexts. It offers a replicable model of labour transformation and performance governance for Chinese

cross-border e-commerce enterprises operating in regulatory complex markets such as Eastern Europe and Central Asia. Future research could extend these insights in several directions: Development of a tri-dimensional SCOR sub-model integrating processes, labour, and data for service-oriented operations, examination of how firms can balance control and flexibility in outsourced labour governance and design of global KPI systems for labour modules, applicable across multi-warehouse and multi-country e-commerce networks.

REFERENCES

Ali, A., Khattak, S. N., Rabbani, A. A., Hussian, M., & Mateen, A. (2025). Logistics Entrepreneurship in the Digital Era: Opportunities, Challenges, and Growth Models in Smart Warehousing and Last-Mile Delivery. *Inverge Journal of Social Sciences*, *4*(4), 98-111. https://doi.org/10.63544/ijss.v4i4.183

Barnes, T., & Ali, J. (2022). Articulations of workplace precarity: challenging the politics of segmentation in warehouse logistics. *The Sociological Review*, *70*(6), 1163-1180. https://doi.org/10.1177/00380261211059918

Berezina, E. (2016). Inventory Process Management & Optimization in Small Businesses: Based on Warehouse Management Systems & Inventory Management Approaches. https://api.semanticscholar.org/CorpusID:54804826

Chen, Y., Li, M., Song, J., Ma, X., Jiang, Y., Wu, S., & Chen, G. L. (2022). A study of cross-border E-commerce research trends: Based on knowledge mapping and literature analysis. *Frontiers in Psychology*, *13*, 1009216. https://doi.org/10.3389/fpsyg.2022.1009216

Delfanti, A. (2021). Machinic dispossession and augmented despotism: Digital work in an Amazon warehouse. *New media & society*, *23*(1), 39-55. https://doi.org/10.1177/1461444819891613

Dörflinger, N., Pulignano, V., & Vallas, S. P. (2021). Production regimes and class compromise among European warehouse workers. *Work and Occupations*, *48*(2), 111-145. https://doi.org/10.1177/0730888420941556

Du, J. (2025). Innovation of cross border e-commerce supply chain management mechanism under digital background. *International Journal of Networking and Virtual Organisations*, *32*(1-4), 291-312. https://doi.org/10.1504/IJNVO.2025.145394

Faraoun, A. (2024). Theorizing labor in the platform economy: Labor restructuring in historical perspective. *Sociology Compass*, *18*(11), e70018. https://doi.org/10.1111/soc4.70018

F, R. S. (2022). El (emergente) papel del diálogo social en la gobernanza de la dimensión laboral de la digitalización. *Cuadernos de Relaciones Laborales*, *40*(2), 367-385. https://doi.org/10.5209/crla.77774

Karabegović, I., Mahmić, M., Karabegović, E., & Husak, E. (2025). Optimization and Increase of Production Efficiency by Using Service Robots for Maintenance, Inspection and Logistics. In *International Conference "New Technologies, Development and Applications"* (pp. 3-18). Springer, Cham. https://doi.org/10.1007/978-3-031-95194-7_1

Kłodawski, M., Jacyna, M., Lewczuk, K., & Wasiak, M. (2017). The Issues of Selection Warehouse Process Strategies. *Procedia Engineering*, *187*, 451-457. https://doi.org/https://doi.org/10.1016/j.proeng.2017.04.399

Khare, P., & Chansoriya, M. (2023). Impact of Technology on Warehouse Management: A Mixed-Methods Research Approach. *IUP Journal of Supply Chain Management*, *20*(4). https://papers.ssrn.com/sol3/Delivery.cfm?abstractid=4920144

Lei, Y.-W. (2021). Delivering solidarity: Platform architecture and collective contention in China's platform economy. *American Sociological Review*, *86*(2), 279-309. https://doi.org/10.1177/0003122420979980

Maté, A., & Trujillo, J. (2012). A trace metamodel proposal based on the model driven architecture framework for the traceability of user requirements in data warehouses. Information Systems, 37(8), 753-766. https://doi.org/10.1016/j.is.2012.05.003

Nguyen, T. T. H. (2024, April). Measuring supply chain performance using the SCOR model. In *Operations Research Forum* (Vol. 5, No. 2, p. 37). Cham: Springer International Publishing. https://doi.org/10.1007/s43069-024-00314-y

Nurlan, A. (2025). The influence of automation of logistics processes on the economic efficiency of small and medium enterprises. *Холодная наука*(16), 13-25.

Oteri, O. J., Onukwulu, E. C., Igwe, A. N., Ewim, C. P. M., Ibeh, A. I., & Sobowale, A. (2023). Cost optimization in logistics product management: strategies for operational efficiency and profitability. *International Journal of Business and Management. Forthcoming*. https://www.allmultidisciplinaryjournal.com/uploads/archives/20250215171124_MGE-2025-1-361.1.pdf

Özkanlısoy, Ö., & Bulutlar, F. (2023). Measuring supply chain performance as SCOR v13. 0-based in disruptive technology era: scale development and validation. *Logistics*, *7*(3), 65. https://doi.org/10.3390/logistics7030065

Ren, S., Islam, M. T., & Chadee, D. (2024). Careers in disarray? COVID-19 and self-perceived employability. *Journal of Career Assessment*, *32*(2), 207-225. https://doi.org/10.1177/10690727231187096

Rodríguez-Garcia, M., Ortiz Bas, A., Prado-Prado, J. C., & Lyons, A. (2023). Fulfillment costs in online grocery retailing: comparing retail store and warehouse strategies. https://riunet.upv.es/server/api/core/bitstreams/973b321d-8a9a-4b71-af26-f7bc33ced98c/content

Schaupp, S. (2021). Technopolitics from below: a framework for the analysis of digital politics of production. *NanoEthics*, *15*(1), 71-86. https://doi.org/10.1007/s11569-021-00386-8

Schor, J. B., Tirrell, C., & Vallas, S. P. (2024). Consent and contestation: How platform workers reckon with the risks of gig labor. *Work, employment and society*, *38*(5), 1423-1444. https://doi.org/10.1177/09500170231199404

Vallas, S. P., Johnston, H., & Mommadova, Y. (2022). Prime suspect: mechanisms of labor control at Amazon's warehouses. *Work and Occupations*, *49*(4), 421-456. https://doi.org/10.1177/07308884221106922

Vassiliadis, P., Quix, C., Vassiliou, Y., & Jarke, M. (2001). Data warehouse process management. *Information Systems*, *26*(3), 205-236. https://doi.org/https://doi.org/10.1016/S0306-4379(01)00018-7

Wang, Y., Jia, F., Schoenherr, T., Gong, Y., & Chen, L. (2020). Cross-border e-commerce firms as supply chain integrators: The management of three flows. *Industrial Marketing Management*, *89*, 72-88. https://doi.org/https://doi.org/10.1016/j.indmarman.2019.09.004

Wang, K., & Liu, Z. (2025). Logistics Cost Management and Control of E-Commerce Enterprise Under the Background of IoT. *Journal of Applied Mathematics*, *2025*(1), 7683850. https://doi.org/10.1155/jama/7683850

Warren, A., & Gibson, C. (2023). Struggles over skills: lived experiences of evolving technologies and gendered hierarchies at work. *Annals of the American Association of Geographers*, *113*(5), 1071-1091. https://doi.org/10.1080/24694452.2022.2157790

Wei, Y. (2024). Optimization Analysis of Supply Chain of Cross-Border E-commerce Enterprises Based on SCOR Model. In *International Conference on Frontier Computing* (pp. 264-273). Singapore: Springer Nature Singapore. https://doi.org/10.1007/978-981-96-2798-1_29

Yáñez-Hernández, O. I. (2025). Improving supply chain performance through the

SCOR model: A case study in the agroindustrial sector. *IngenIería InvestIgacIón y tecnología*, *26*(4), 1-14. https://www.revistaingenieria.unam.mx/numeros/2025/v26n4-07.pdf

Zhou, F., & Liu, Y. (2022). Blockchain-Enabled Cross-Border E-Commerce Supply Chain Management: A Bibliometric Systematic Review. *Sustainability*, *14*(23). https://doi.org/10.3390/su142315918