INNOVATIONAS AND SOLUTIONS IN BUSINESS LOGISTICS

Syamily THANNIMOOTTIL SABU, Vytautas Magnus University Agriculture Academy, Faculty of Bioeconomy Development, email: syamily.thannimoottil.sabu@vdu.lt

Abstract

This paper explores how innovation affects business logistics performance by conceptualizing and empirically supporting a comprehensive model of technological, operational, organizational, and sustainable logistics innovations. The research design adopted was a quantitative research design with a structured survey conducted on logistics professionals and supply chain practitioners. Partial Least Squares Structural Equation Modeling (PLS-SEM) was used to analyze the data collected to determine the relationships between the proposed constructs. The findings reveal that all innovation dimensions significantly influence logistics innovation, with technological innovation ($\beta = 0.41$, $p < 0.001$) exerting the strongest effect, followed by operational innovation ($\beta = 0.36$, $p < 0.001$), sustainable logistics ($\beta = 0.33$, $p < 0.001$), and organizational innovation ($\beta = 0.29$, $p = 0.002$). Furthermore, logistics innovation significantly enhances business logistics performance ($\beta = 0.58$, $p < 0.001$). The model explains 64% of the variance in logistics innovation and 34% in business logistics performance, indicating substantial explanatory power. Overall, the findings support the significance of an integrated innovation approach to enhance the efficiency, reliability, and sustainability of logistics, and provide both theoretical and practical aspects of attaining competitive advantage.

Keywords: business logistics; supply chain innovation; artificial intelligence (ai); internet of things (iot); smart warehousing; sustainable logistics; last-mile delivery.

Introduction

Business logistics has stood out as an important part of contemporary supply chain management with organizations struggling to provide products effectively and in line with the growing expectations of customers. In the modern globalized economy, logistics work does not confine to the conventional operations like transportation, warehousing and inventory management. They now have integrated systems that mobilize the flow of goods, storage and distribution of goods in complex supply networks. The rapid adoption of technologies, the development of e-commerce, and the need to provide quicker deliveries have greatly changed the logistics processes and prompted organizations to explore new methods of operations. Artificial Intelligence (AI), Internet of Things (IoT), blockchain, and big data analytics are technological innovations that have been important in enhancing efficiency in logistics and decision-making. These technologies facilitate real time tracking, automated procedures, demand predictions, and increased transparency in the supply chains. Moreover, robotics and automated storage-based smart warehousing systems have enhanced accuracy of inventory, operational efficiency, as well as the speed of order processing. Green transportation, electric cars, environmentally friendly packaging, and eco-friendly route optimization systems have also become the key issue of sustainability in logistics in order to minimize the environmental footprint. Moreover, drones and micro-fulfilment canters are innovations which deal with the problem of congestion and the delay of delivery in the city. In general, technology, operational, and sustainability innovation is necessary to create effective, strong, and competitive logistics systems in the contemporary business environment.

Research Aim. The main aim of this research is to investigate the impact of technological, operational, organizational, and sustainable innovations on logistics innovation and business logistics performance.

Research objectives:

- To define and conceptualize some of the important aspects associated with logistics innovation that include technological, operational, organizational, and sustainable perspectives.
- To evaluate the influence of the identified innovation aspects on logistics innovation.
- To assess the influence of logistics innovation on the performance of business logistics.
- To build and validate a structural model on the identified innovation and logistics performance using PLS-SEM methodology.

Research Object and Methods

The concept of logistics and supply chain management innovation has been gaining more and more importance over the past years because of the rapid advancement of digital technologies, globalization, and the growing expectations of customers. Researchers have emphasized that innovations of logistics services play a major role in enhancing operations efficiency, service quality and competitiveness in supply chains. Innovation is very crucial in enhancing efficiency in the logistics and supply chain. Wasielewska-Marszałkowska (2026) believes that the adoption of the new technologies, better processes, and new service models to improve the efficiency and coordination of logistics in supply

chains by the logistics service providers (LSPs), especially 3PL and 4PL firms, has become more common. Such innovations like containerization have dramatically increased efficiency in transportation and minimized the international trade costs; such technologies like cross-docking, EDI, or RFID have made inventory management and responsiveness in the operations more efficient (Grawe, 2009; Wasielewska-Marszaalkowska, 2026). Innovation of logistics has been termed as the introduction of new logistics processes, systems as well as management practices that enhance the performance of logistics and generate economic value (Van Klink & Visser, 2004; Wagner & Busse, 2008). Innovation is also facilitated by teamwork between the logistics professionals and supply chain partners as they can share knowledge and co-create logistics solutions enhancing service efficiency and competitive advantage (Grawe et al., 2015; Fugate et al., 2010). The uptake of logistics innovation is enhanced through systematic approaches and stakeholder collaboration within supply chain networks (Baalsrud Hauge et al., 2014). Logistics innovation is influenced by multiple factors, including organizational capabilities, technological adoption, and external environmental conditions (Lianguang et al., 2010). Logistics performance can be effectively evaluated through an integrated framework combining efficiency and effectiveness dimensions (Mentzer & Konrad, 1991).The current literature emphasizes how Industry 4.0 technologies, including artificial intelligence, blockchain, big data, and IoT, can revolutionize the conventional logistics and make smart, data-driven systems more transparent, efficient, and sustainable (Moyano-Londono et al., 2025). Furthermore, new technology in last-mile delivery is crucial because of the growing demand in e-commerce and urban logistics challenges because last-mile logistics represent a substantial amount of logistics expenses and environmental effects (Ranieri et al., 2018). PLS-SEM techniques are widely applied for analyzing complex relationships and moderating effects in supply chain and logistics research (Kock, 2014). Innovation in third-party logistics firms is shaped by strategic practices and organizational processes that enhance service capabilities and competitive advantage (Lianguang et al., 2010).

Research gap

Even though some research has been conducted on the subject of logistics innovation and supply chain efficiency, the majority of research is confined to only one aspect of logistics service providers, individual technology or the last-mile delivery system. The results of numerous studies, such as Wasielewska-Marszawkowska (2026) and Grawe et al. (2015), focus primarily on the effect of innovation on the performance of logistics services, whereas research on Industry 4.0 technologies is more focused on the digital transformation of supply chains (Moyano-Londono et al., 2025). Nevertheless, the current literature does not provide the overall view where the technological innovation, sustainable logistics practices, and operational strategies in the business logistics are integrated. Thus, it is necessary to conduct research that offers a unified perspective on innovations and viable solutions that can result in improvement of efficiency, sustainability, and resilience of modern business logistics systems.

Methodology

The present study is a quantitative research study aimed at exploring innovations and solutions to the business logistics issue with the help of a systematic literature review and empirical study. First, the systematic literature review was organized to find the key dimensions of logistics innovation and to learn about the latest situation in the field of knowledge about technological, organizational, and sustainable logistics solutions. A survey-based research design was adopted as an empirical test to the proposed relationships. The logistics companies, supply chain managers and the logistics service providers engaged in transport, warehousing and distribution services can be used to gather data. To identify the perceptions about logistics innovation and operational efficiency, the questions will be asked in a Likert scale that will be deprived of 1 (strongly disagree) and 5 (strongly agree). The questionnaire tool consists of several areas, such as the organizational data, implementation of logistics innovations, technological adoption in logistics activities, sustainable logistics practices, and business logistics performance measures. Measurement items were created on the basis of existing literature which is associated with the topics of logistics innovation and supply chain performance. To conduct the data analysis, Partial Least Squares Structural Equation Modeling (PLS-SEM) was applied to investigate the connections between constructs and test the research hypotheses. PLS-SEM is famous as a recognized tool of research in logistics and supply chain since it is possible to examine the intricate connection between multiple latent variables, and valid outcomes are attainable with comparatively small samples.This will be done in two phases of analysis. The measurement model will be tested in the first stage to determine the reliability and validity of the constructs with the help of such indicators as Cronbach alpha, composite reliability, and average variance extracted (AVE). The second stage will involve the evaluation of the structural model, which will be used to evaluate the relationship among the dimensions of logistics innovation and business logistics performance.

Conceptual Research Model

The conceptual map, provided in fig 1 displays the sequential nature of the relationship between various kinds of innovations in the sphere of logistics and their impact on the overall business logistics performance. According to the model, technological, operational, organizational and sustainability-based innovations are all relevant to the logistics innovation, which eventually enhances the performance of business logistics systems. The model identifies that technological innovations, operational innovations, organizational innovations and sustainable innovations all combine in the development of the logistics innovations which eventually lead to the improvement of the business logistics performance. Companies with a combined approach to innovation could build more effective, reliable, and more resilient logistic systems.

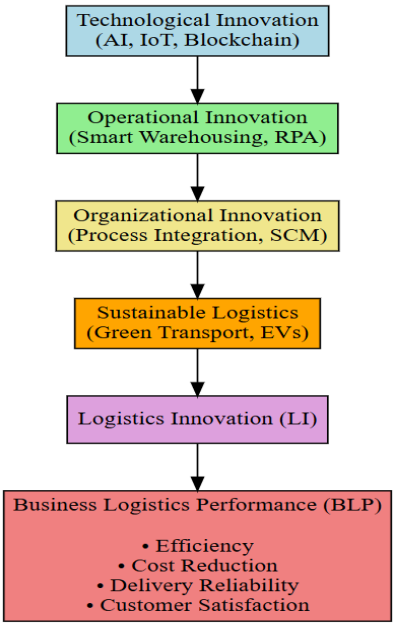

Fig 1. Conceptual model of innovations in business logistics and their impact on business logistics performance

Research Hypotheses

Based on the literature review and conceptual framework, the following hypotheses are proposed:

H1: Technological innovation in logistics has a positive impact on business logistics efficiency.
H2: Operational innovation in logistics positively influences supply chain performance.
H3: Organizational innovation in logistics service providers positively affects logistics operational effectiveness.
H4: Sustainable logistics practices positively influence overall business logistics performance.
H5: Logistics innovation collectively has a significant positive impact on business logistics performance.

Explanation of Variables

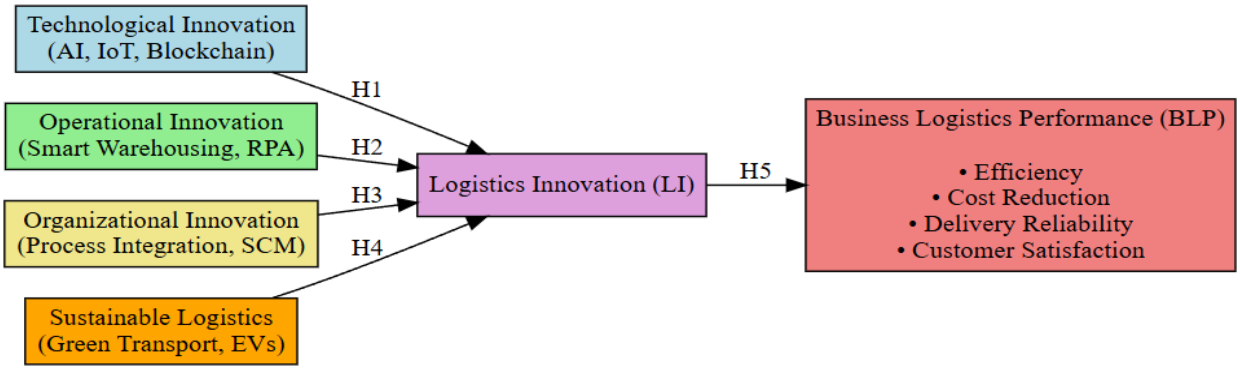

Fig 2. Structural model showing the influence of logistics innovation factors on business logistics performance.

Data Collection

In this study, data were gathered through a structured questionnaire which was focused on logistics professionals, supply chain managers, and logistics service providers in the transportation, warehousing and distribution activities. A survey-based approach was to be employed in order to extract the perceptions of the respondents of the logistics innovation and the performance of the business logistics. The questionnaire was developed based on the constructed constructs extracted out of existing body of knowledge on logistics innovation and supply chain performance. All the measurement items were rated on a five-point Likert scale (1 strong disagree, 5 strong agree). The survey was administered via [online modes method], and the surveys were responded to in a given time. The valid responses were 236 and this was analysed. To ensure quality of data, incomplete and inconsistent responses were weeded out prior to analysis. The final data was found to be suitable in PLS-SEM analysis.

Data Analysis Technique

Partial Least Squares Structural Equation Modeling (PLS-SEM) with the assistance of SmartPLS (version 4.0) was used to analyze the data. PLS-SEM was chosen because it is appropriate with complex models that include multiple latent constructs and can be used with a relatively small to medium size sample. The two-phase analysis was done,

measurement model and structural model. The measurement model was tested in the first stage to determine reliability and validity. Cronbachs alpha and composite reliability (CR) were checked to determine internal consistency reliability with a threshold value of 0.70 as acceptable. The Average Variance Extracted (AVE) was used to determine convergent validity, where the value should be above 0.50 to ensure that indicators converge well. The second stage was the evaluation of the structural model in which the hypothesized constructs relationships were tested. The PLS algorithm estimated path coefficients (β) and the statistical significance of the coefficients was determined via a bootstrapping test with 5,000 resamples. The output of bootstrapping gave t-values and p-values to test the hypothesis. There was also the coefficient of determination (R^2) which was employed in determining the explanatory power of the model which shows the percentage of the variance explained in the endogenous constructs by the independent variables.

Research Results and Discussion

This part shows the findings of the empirical research performed with the help of Partial Least Squares Structural Equation Modeling (PLS-SEM). The two steps to be taken were the analysis of the measurement model (to determine the reliability and validity of the constructs) and the structural model (to test the hypotheses proposed).

Measurement Model Assessment

The reliability and convergent validity of the constructs were assessed using Cronbach's alpha (α), Composite Reliability (CR), and Average Variance Extracted (AVE). As shown in Table 1, all constructs exceeded the recommended thresholds ($\alpha \geq 0.70$, $CR \geq 0.70$, $AVE \geq 0.50$), indicating satisfactory internal consistency and convergent validity.

Table 1. Reliability and Convergent Validity of Constructs

Construct	Cronbach's Alpha (α)	Composite Reliability (CR)	AVE
Technological Innovation (TI)	0.84	0.89	0.67
Operational Innovation (OI)	0.81	0.87	0.64
Organizational Innovation (OR)	0.79	0.86	0.62
Sustainable Logistics (SL)	0.83	0.88	0.66
Logistics Innovation (LI)	0.86	0.91	0.72
Business Logistics Performance (BLP)	0.88	0.92	0.74

These results confirm that the measurement items adequately capture the underlying constructs and are suitable for further structural model analysis.

Structural Model Assessment

The structural model was evaluated using path coefficients (β), t-statistics, and p-values to test the proposed hypotheses. The results presented in Table 2 indicate that all hypothesized relationships are positive and statistically significant.

Table 2. Hypothesis Testing Results

Hypothesis	Relationship	Path Coefficient (β)	t-value	p-value	Result
H1	Technological Innovation → Logistics Innovation	0.41	4.32	<0.001	Supported
H2	Operational Innovation → Logistics Innovation	0.36	3.87	<0.001	Supported
H3	Organizational Innovation → Logistics Innovation	0.29	3.21	0.002	Supported
H4	Sustainable Logistics → Logistics Innovation	0.33	3.76	<0.001	Supported
H5	LogisticsInnovation→Business Logistics Performance	0.58	5.12	<0.001	Supported

The model explains a substantial proportion of variance in logistics innovation and business logistics performance. The coefficient of determination (R^2) for Logistics Innovation is **0.64**, indicating that the four innovation dimensions explain 64% of its variance. Similarly, the R^2 value for Business Logistics Performance is **0.34**, suggesting that logistics innovation significantly contributes to improving logistics performance.

Conclusions

The current study empirically investigated the importance of innovation in improving business logistics performance by a multidimensional model that includes technological, operational, organizational and sustainable logistics innovations. The results give good statistical evidence to the proposed model. These findings suggest that the four dimensions of innovation are all important predictors of logistics innovation, with technological innovation ($\beta = 0.41$, $p < 0.001$) having the most significant impact, then operational ($\beta = 0.36$), sustainable ($\beta = 0.33$), and organizational innovation ($\beta = 0.29$). Moreover, the logistics innovation is shown to have the significant positive impact on the business logistics performance ($\beta = 0.58$, $p < 0.001$), which proves its pivotal position as the mediating construct. The model accounts 64% of the variation in logistics innovation and 34% of business logistics performance, which implies moderate and strong explanatory power. These results indicate that the implementation of integrated innovation approaches by organizations would be more likely to lead to the improvement of the aggregate logistics performance, especially

operational efficiency, system reliability, and effectiveness of coordination. Yet, although an enhanced logistics performance can indirectly influence the results of such aspects like cost efficiency and customer satisfaction, they were not directly measured in the given study. Hence, these implications must be seen with a grain of salt. Further investigation can elaborate this research by adding more performance measures such as cost reduction, service quality and customer satisfaction to present a more extensive analysis of the results of logistics innovation. Additionally, longitudinal research and industry-specific research might be used to further increase the generalizability of the results. Findings of the study empirically prove the existence of a strong relationship between innovation and improvements in business logistics. The main research objectives have been successfully met with the help of statistically supported empirical findings derived from PLS-SEM method.Firstly, this research confirmed that innovation has a multi-dimensional character, and technology innovation, operations innovation, organization innovation, and sustainable innovation are all significant predictors of logistics innovation. From all four variables, technological innovation was proved to be the most significant one ($\beta = 0.41$, $p < 0.001$).Secondly, it has been found that all types of innovation have a positive impact on innovation in logistics, which means that the first four hypotheses are supported.Thirdly, it is empirically proven that logistics innovations have a substantial influence on logistics performance ($\beta = 0.58$, $p < 0.001$). Thus, it is possible to conclude that hypothesis five has been confirmed. Innovation proves to be an important factor contributing to the effectiveness, reliability, and competitive advantage of logistics activities. Fourthly, the value of coefficients of determination (0.64 for logistics innovation and 0.34 for logistics performance) demonstrates the validity and practical applicability of the theoretical framework. Summing up the obtained results, one may say that the hypotheses have been proved empirically, meaning that the application of integrated innovations leads to improved logistics performance outcomes

References

1. Baalsrud Hauge, J., Müller, R., Aifadopoulou, G., Forcolin, M., Roso, V., Tsoukos, G., & Westerheim, H. (2014). Accelerating the innovation uptake in logistics. In T. Blecker, W. Kersten, & C. M. Ringle (Eds.), *Innovative Methods in Logistics and Supply Chain Management: Current Issues and Emerging Practices* (pp. 3–24). Berlin: epubli GmbH.
2. Fugate, B. S., Mentzer, J. T., & Stank, T. P. (2010). Logistics performance: Efficiency, effectiveness, and differentiation. *Journal of Business Logistics, 31*(1), 43–62. https://doi.org/10.1002/j.2158-1592.2010.tb00127.x
3. Grawe, S. J. (2009). Logistics innovation: A literature-based conceptual framework. *The International Journal of Logistics Management, 20*(3), 360–377. https://doi.org/10.1108/09574090911002823
4. Grawe, S. J., Daugherty, P. J., & Roath, A. S. (2015). Knowledge synthesis and innovative logistics processes: Enhancing operational flexibility and performance. *Journal of Business Logistics, 36*(1), 69–80.
5. Kock, N. (2014). Using data labels to discover moderating effects in PLS-based structural equation modeling. International Journal of e-Collaboration, 10(4), 1-16. https://doi.org/10.4018/ijec.2014100101
6. Lianguang, C., Hertz, S., & Su Shong-Iee, I. (2010). Innovation in an international third party logistics firm: A strategy-as-practice perspective. Journal of Transport and Supply Chain Management, 4(1), 69-88. https://doi.org/10.4102/jtscm.v4i1.12
7. Lianguang, C., Zhaofang, M., & Xun, X. (2010). Research on logistics innovation and its influencing factors. *International Journal of Logistics Systems and Management, 6*(1), 69–88.
8. Mentzer, J. T., & Konrad, B. P. (1991). An efficiency/effectiveness approach to logistics performance analysis. *Journal of Business Logistics, 12*(1), 33–62.
9. Moyano-Londono, G. A., Cardona-Granada, V., & Alzate, P. (2025). Logistics 4.0 and emerging technologies: A scientometric perspective on innovation in supply chains. *Journal of Digital Economy, 4*, 108–122. https://doi.org/10.1016/j.jdec.2025.08.002
10. Ranieri, L., Digiesi, S., Silvestri, B., & Roccotelli, M. (2018). A review of last mile logistics innovations in an externalities cost reduction vision. *Sustainability, 10*(3), 782. https://doi.org/10.3390/su10030782
11. Van Klink, H. A., & Visser, E. J. (2004). Innovation in logistics services and the new business model: A conceptual framework. *Transport Reviews, 24*(3), 335–350.
12. Wagner, S. M., & Busse, C. (2008). Managing innovation: The new competitive edge for logistics service providers. *Bern: Haupt Verlag*.
13. Wasielewska-Marszałkowska, I. (2026). Innovation of logistics service providers and its impact on logistics service efficiency of supply chains. *Argumenta Oeconomica, 56*(1), 57–68. https://doi.org/10.15611/aoe.2026.1.04