

ORIGINAL RESEARCH ARTICLE

The impact of training and traceability on operational performance in Hong Kong Air Cargo Terminals Limited: The mediating role of agility

Peiyun Yu^{1,2*} , Chunhui Li¹, and Junping Huang³¹School of Management, Guangzhou College of Commerce, Guangzhou, Guangdong, China²Faculty of Economics and Management, National University of Malaysia, Bangi, Selangor, Malaysia³Hong Kong Air Cargo Terminals Limited, Island District, Hong Kong SAR, China

Abstract

Hong Kong Air Cargo Terminals Limited (Hactl) handles over 40% of cargo at Hong Kong International Airport. However, its fixed infrastructure leaves little room for physical expansion. Better operational performance (OP) should come from how the terminal deploys its existing resources. Grounded in the dynamic capability theory (DCT) and the resource-based view (RBV), this study examines the roles of training, traceability, and OP, as well as the mediating role of organizational agility in these relationships. This study used partial least squares structural equation modeling on survey data gathered from 70 Hactl professionals. The findings reveal that training improves OP both directly and indirectly through agility, whereas traceability affects OP only via agility. These findings contribute to the RBV and DCT literature by showing that technological resources require full mediation through dynamic capabilities to translate into OP. In practice, managers should treat traceability not as a standalone performance driver but as an input to agility. Meanwhile, training programs should sustain both routine efficiency and adaptive capacity.

Keywords: Air-cargo logistics platforms; Operational performance; Traceability; Agility; Dynamic capability theory; Resource-based view; Partial least squares structural equation modeling

***Corresponding author:**Peiyun Yu
(yupeiyun@gcc.edu.cn)

Citation: Yu P, Li C, Huang J. The impact of training and traceability on operational performance in Hong Kong Air Cargo Terminals Limited: The mediating role of agility. *Supply Chain Manag Res.* 2026;1(2):026050003.
doi: 10.36922/SCMR026050003

Received: January 26, 2026**Revised:** May 11, 2026**Accepted:** May 12, 2026**Published online:** May 26, 2026

Copyright: © 2026 Author(s). This is an Open-Access article distributed under the terms of the Creative Commons Attribution License, permitting distribution, and reproduction in any medium, provided the original work is properly cited.

Publisher's Note: AccScience Publishing remains neutral with regard to jurisdictional claims in published maps and institutional affiliations.

1. Introduction

Hong Kong Air Cargo Terminals Limited (Hactl) handles over 40% of cargo at Hong Kong International Airport, approximately 4.9 million tonnes in 2024.¹ Despite this scale, the terminal faces mounting operational pressures. Its infrastructure, such as runways, warehouses, trucks, and handling equipment, is fixed, but the demands of regulatory cargo delivery shift constantly. This means better operational performance (OP) rarely comes from adding more equipment. Rather, its origins lie in how well the terminal deploys its existing organizational resources to adapt in real time.²

In the air cargo logistics sector, operations represent the terminal's physical handling activities, such as loading, unloading, storage, customs clearance, and transfer, while logistics encompass the broader coordination of information and material flows across

the multiple players.³ In this context, OP represents the logistics performance of the cargo terminal specifically.

The resources that drive this performance fall into two broad categories. In terms of human resource management, training prepares staff to interpret system data and execute decisions under time pressure.^{4,5} When a last-minute booking arrives, or a United States (US)-bound shipment triggers the Air Cargo Advance Screening (ACAS) pre-filing requirement, trained staff can resolve these exceptions without delays. On the technology side, traceability provides accurate, real-time visibility across cargo flows and handling processes.⁶ Both are embedded within the same air cargo logistics information systems.^{7,8} However, previous studies have tended to examine them in isolation, treating each as a direct driver of OP.^{9,10}

Combining organizational and digital information capital could help Hactl improve its OP, while training and traceability have been examined separately in general logistics and manufacturing contexts.^{11,12} Empirical evidence comparing their complementary yet distinct roles in air cargo terminal operations remains scarce.¹³ These characteristics make the resource, capability, and performance linkage particularly complex. Specifically, it is unclear whether training and traceability follow similar or differentiated pathways in shaping OP through dynamic capabilities. The resource-based view (RBV) suggests that training and traceability are valuable and heterogeneous resources. Only limited evidence demonstrates their direct impact on performance.¹⁴ What matters is whether the firm can leverage them to sense environmental shifts, seize opportunities, and reconfigure operational processes.¹⁵

In addition, the dynamic capability theory (DCT) stresses that the competitive advantage of the company is hidden within the distinctive process.¹⁶ Agility here captures this conversion mechanism. Although organizational agility has been widely recognized as a critical factor in dynamic environments¹⁷, it is frequently conceptualized as an outcome variable rather than as a mediating mechanism that translates resources into performance.^{2,4} Existing studies provide limited insight into how agility functions as a dynamic capability that enables firms to reconfigure operational processes and embrace uncertainty.^{18,19} These gaps lead to three questions: Research question (RQ)1: Do training and traceability affect OP? RQ2: Do training and traceability contribute to agility? RQ3: Does agility mediate their respective relationships with OP?

This study collects survey data from 70 professionals at Hactl and examines how training and traceability affect OP through agility. It makes three key contributions. Firstly, it shows human and technological resources. Training

and traceability influence OP through different pathways. Training enhances OP directly and through agility, while traceability only works when agility serves as a mediator. Secondly, it extends the RBV and DCT frameworks to explain the situation at Hactl. Lastly, for terminal operators, implementing better tracking systems will not help if they merely capture data. Digital investments should be coordinated with agility to enable companies to reconfigure.

This paper is organized as follows. Section 2 reviews the relevant literature and develops hypotheses. Section 3 describes the research methodology. Section 4 presents empirical results. Section 5 discusses the findings and outlines theoretical and managerial implications. Section 6 concludes the study and highlights limitations and directions for future research.

2. Literature review and hypotheses development

2.1. Training

Training refers to the extent to which an organization provides its employees with opportunities to develop and upgrade work-related skills through regular training programs.⁵ It reflects management's commitment to continuous skill enhancement as a means of strengthening workforce flexibility, operational efficiency, and organizational adaptability. Training programs cultivate versatile, adaptable, and well-connected employees, who are vital for achieving logistics agility and sustaining a competitive position.^{4,20} In the logistics industry, continuous investment in training helps logistics firms boost operational efficiency, reduce operational errors, and foster innovation.²¹

Training equips employees to identify and overcome system interface constraints and data flow bottlenecks. By strengthening cross-system information coordination capabilities, employees can ensure data consistency, integrity, and timeliness across heterogeneous platforms while adapting to the transition from traditional paper-based operations to cloud-enabled, collaborative, real-time, and modifiable digital workflows.²² In doing so, training helps alleviate shortages of specialized skills and pressure on human resource allocation, and it helps build a logistics workforce characterized by operational efficiency, system adaptability, and the capability to manage multi-customer compliance requirements.^{21,22}

2.2. Traceability

Traceability offers data to enable comparison between the actual condition and the expected goals.²³ Most empirical

work on traceability has focused on the manufacturing industry and the pharmaceutical supply chain, where the primary concerns are batch recalls and temperature control.^{24,25} Air cargo terminals present a different problem. Here, traceability is not just about tracing a defect back to its source, but more about knowing where a shipment is right now. Specifically, whether it has cleared customs, been loaded, or missed its connection. Ground handlers, therefore, can reallocate labor and equipment before a delay.²⁶ This capability enables rapid source identification and timely corrective actions, including recalls in the event of quality or safety incidents.^{27,28} More importantly, traceability is widely recognized as a critical operational capability in complex and time-sensitive air cargo logistics environments.

Platform-based traceability integrates data from airlines, freight forwarders, and customs systems into a single system. Previous studies have shown that traceability increases supply chain resilience and improves performance in the era of Industry 4.0.²³ Khan *et al.*²⁸ found that supply chain traceability depends on transparency. However, they rarely tested whether traceability translates into agility or further affects OP. Air-cargo operations are characterized by high cargo value, strict time constraints, multi-actor coordination, and frequent cross-border handovers. In this context, traceability enhances real-time visibility, reduces operational uncertainty, improves exception handling, and supports more efficient coordination among airlines, ground handlers, freight forwarders, and regulatory authorities.²⁹ This gap is obvious in air cargo research, where high cargo value and tight schedules make speed as important as the accuracy of data.

2.3. Agility

Agility varies greatly across industries. In the primary sector, a high level of agility is greatly valuable, but it is insufficient to maintain high performance in the coffee supply chain.³⁰ Even in the coffee industry, which requires agility, being agile alone is not sufficient. In the secondary industry, evidence suggests that adopting agility can help manufacturing firms improve their response capacity and reduce instability.¹⁷ In tertiary industries, logistics agility indicates an organization's ability to respond to supply chain disruptions, with information sharing and collaborative forecasting as antecedents.⁴ Air cargo terminals face a sharper issue. The aim of logistics agility is to reconfigure strategies for variable aircraft schedules or complex customs clearances.

Empirical studies of agility in the air cargo sector remain scarce. Most existing studies treat agility as an outcome of artificial intelligence and human resource management,

both of which help firms become more agile.^{2,4} Whether agility transforms prior resources into OP is unclear. Teece³¹ underlined that sensing, seizing, and reconfiguring are keys to companies' success regarding technological change and uncertain environments. Nevertheless, few studies in air cargo logistics have tested agility as a mediator and have barely compared human and technological resources.^{17,18}

2.4. Operational performance

Generally, OP is described as the outcome that converts input into output through daily operational activities. Pattanaik and Pattanaik³ defined it as companies that actively reduce costs, improve quality, and enhance delivery in the green supply chain. Furthermore, in the manufacturing industry, Hautala-Kankaanpää³² divided OP into delivery performance, cost performance, and quality performance, and linked them to production flexibility. However, in the air cargo sector, OP should include cargo handling time accuracy, operational process control, turnover flexibility during peak times, and unit capacity.³³ More specifically, OP in Hactl's cargo terminal can be measured through five dimensions: cost, timeliness, quality, customer value-added, and waste reduction.³⁴

2.5. Theoretical paradigm

Through the lens of RBV, a firm's training and traceability are treated as valuable assets that are difficult for its competitors to imitate.¹⁵ However, RBV remains silent on how these assets generate returns in a rapidly changing environment and translate into faster turnaround times and lower handling errors. The DCT addresses this gap by introducing dynamic capabilities as the mediator that converts resources into performance. Teece's³¹ framework distinguishes sensing, seizing, and reconfiguring capabilities to help firms adapt to environmental shifts. The air cargo logistics company requires quick responses, and agility captures this adaptive capacity.¹⁸

Critically, the DCT suggests that different resources may rely on dynamic capabilities to some degree. Human capital, such as training, can produce immediate performance gains through direct skill training. Employees who understand customs regulations or operate the system smoothly can handle cargo faster and make fewer errors.¹⁰ Technological capability includes traceability that detects the cargo location, status, and the subsequent flow direction.²³ Their value depends entirely on whether the organization can rapidly translate that information into operational activities. This indicates an asymmetric mediation pattern. Training may drive OP both directly and through agility, while traceability may influence OP only when agility mediates the relationship.

Empirical studies show evidence. If the resource is a common technology, competitors might easily mimic and adopt it.³² Reaidy *et al.*²⁹ found that Industry 4.0 technology does not have a significant direct effect on supply chain performance, but it does play a role through the mediating effects of supply chain integration and visibility. The empirical results of Hautala-Kankaanpää³² also showed that digital platforms may even have a negative impact on OP if they lack supply chain capabilities. These findings suggest that when exploring the impact of training and traceability on OP, we must focus on whether these factors achieve performance conversion through a specific operational capability, rather than assuming a simple linear relationship. Figure 1 presents the research model. Training and traceability serve as the resource base. Agility functions as a dynamic capability that mediates its influence on OP. It is expected that these mediated pathways will differ across the two resources, reflecting their distinct organizational roles.

2.6. Hypotheses development

Air cargo terminal operations depend heavily on employee proficiency and judgment under pressure.² Systematic training shortens cargo handling cycles, reduces breakage and error rates, and improves cost and quality performance.¹⁰ In changing logistics environments, effective training programs improve technical proficiency, decision-making speed, and adaptability to digital systems.^{5,33} Training directly strengthens the organization's capacity to execute tasks accurately and efficiently, thereby supporting higher levels of OP.^{10,22} At Hactl, where staff should navigate the Community Systems for Air Cargo Plus (COSAC-Plus) platform alongside various airline systems, structured training ensures that employees can interpret real-time data and manage exceptions. For example, when the staff has last-minute bookings or ACAS pre-filing requirements, they know how to maintain service reliability during disruptions. These improvements in the task directly strengthen OP.³² Thus, we proposed the following hypothesis (H):

(i) H1: Training has a positive effect on OP in Hactl.

The function of training is not just to execute tasks immediately. Training prepares staff to be familiar with advanced cargo management systems, such as COSAC-Plus. Furthermore, it helps employees cultivate communication and coordination skills to deal with specific cargo compliance issues.^{35,36} By enabling employees to understand and address airline and ACAS filings, training strengthens critical network relationships and facilitates the exchange of vital logistics information. A skilled workforce

can rapidly interpret knowledge, sense the situation, and make faster decisions to improve organizational agility.⁴ In Hactl, employees' training programs are indispensable for cultivating an adaptive operational team. This developed human capital enables the organization to sense changes, reconfigure processes, and execute responses effectively. Consequently, this finding led to H2.

(ii) H2: Training has a positive effect on agility in Hactl.

The existing literature is inconsistent regarding the direct relationship between traceability and OP. On the one hand, Khan *et al.*²⁸ hold that traceability can reduce information asymmetry and improve resource utilization, thereby enhancing supply chain performance. On the other hand, in the highly uncertain operational environment, with the coordinated organizational capacity, digital technology resources might cause negative effects or contribute nothing to the OP.³² At air cargo terminals, this debate comes to the fore. A traceability system such as COSAC-Plus provides real-time data throughout the flow of goods. However, these data are potential resources rather than actual performance. The main bottleneck in Hactl's operations is the increasing number of cargo and data conflicts. If the company cannot transform data into source reconfiguration within a few minutes or lacks dynamic capability, the traceability system will serve only as a recorder. It will be difficult to act on cost, delivery, and quality performance.²⁹ Therefore, even though traceability has a direct effect on OP in previous studies^{23,24}, its direct effects may be severely suppressed in the specific scenario of air cargo in high-speed and high-uncertainty situations.¹³ Based on the above discussion, we put forward H3.

(iii) H3: Traceability may positively affect OP in Hactl.

Traceability plays a crucial role in cultivating dynamic capability. According to DCT, traceability significantly enhances a firm's sensing capability, which is the first step in dynamic capability.³¹ At Hactl, COSAC-Plus, combined with Airwaybill Resource Scanning (AWRS) and the Logistics Control System (LCS) system, monitors detained goods and processing bottlenecks, and navigates location issues.¹¹ However, sensing is not equal to performance. Akhtar *et al.*¹⁹ found that real-time information can improve OP through organizational dynamics response capabilities. The situation endowed by traceability quickly captured threats and opportunities and flexibly reconfigured resources and processes through subsequent agility. Hong *et al.*² also confirmed that digital tracking and information sharing are important antecedents of hub agility. Therefore, the positive impact of traceability on operational agility is theoretically robust and contextual. Accordingly, H4 was proposed.

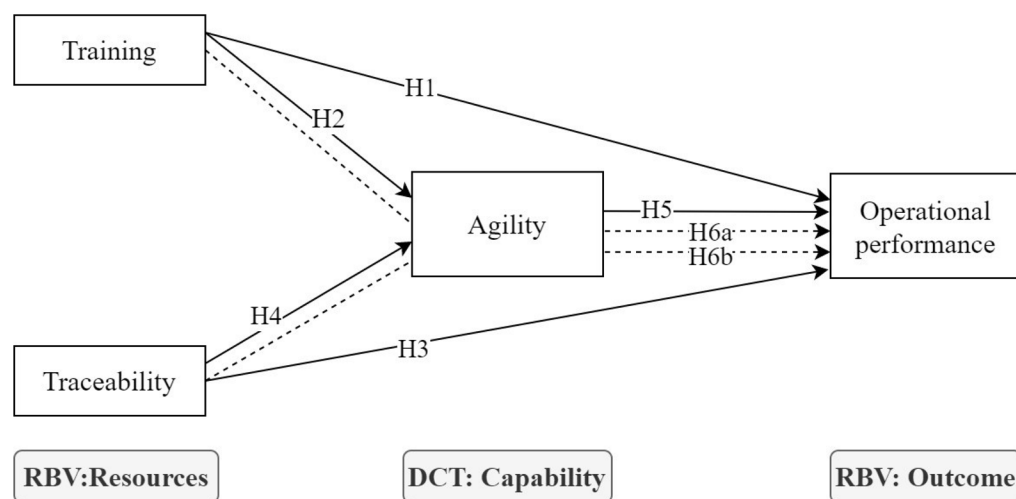


Figure 1. Research model
Abbreviations: DCT: Dynamic capability theory; RBV: Resource-based view.

(iv) H4: Traceability has a positive effect on the agility in Hactl.

As a high-level dynamic capability, the core function of agility is to transform organizational resources into operational outputs that adapt to changes in the environment.^{4,18} In the context of air cargo terminals, agility is the ability to quickly identify threats and opportunities, flexibly adjust operational plans, shorten decision-making cycles, and response quickly.² This capability is crucial for navigating the inherent uncertainties of air cargo, such as schedule changes, volume fluctuations, and regulatory mandate adjustments.

Through the lens of DCT, agility directly impacts OP through seizing and reconfiguring.³¹ Agile organizations are better positioned to align their operations with evolving customer and stakeholder demands, thereby strengthening competitiveness and overall supply chain performance.³⁶ In practice, agility is largely enabled by smooth and timely information flows that support rapid decision-making and coordinated action. When information is shared effectively across supply chain partners, organizations can shorten delivery lead times, improve order-processing efficiency, and reduce supply chain risks.³⁷ These capabilities are particularly important in air-cargo and airline-related operations, where tight schedules, high service expectations, and frequent disruptions require fast and flexible operational responses.

Prior studies have indicated that agility contributes to OP through improved cost efficiency and resource utility. Supply chains create value by enhancing logistics efficiency, which, in turn, improves profitability, sales performance, and satisfaction among customers and supply chain partners.³⁸ Similarly, Dubey *et al.*³⁹ argued

that agile supply chains, supported by information sharing, collaboration, and visibility, are better able to allocate and utilize resources efficiently, leverage assets effectively, and control operational costs. These improvements directly enhance OP by maintaining service reliability. Based on the above discussion, H5 was proposed.

(v) H5: Agility has a significant positive effect on OP.

Drawing on the integration logic of RBV and DCV, training and traceability are strategic resources, and their performance transformation in an uncertain environment relies on the activation of dynamic capabilities.⁴⁰ However, there is an asymmetry: these two types of resources depend on distinct dynamic capabilities.

For training, it can directly reduce human mistakes and shorten processing time by improving employees' operational skills.^{5,10} There is a direct effect between training and OP. At the same time, training enhances the organization's perception and reconstruction ability by cultivating employees' cross-system information operational skills and exception-handling abilities.⁴ Thus, it indirectly affects performance through agility.⁴¹ Therefore, agility works as a mediator between training and OP.

The essence of traceability is a set of recorded data and the tracking of orders, goods, and their location.²³ Although traceability provides rich, real-time data, these data cannot automatically translate into operational adjustments.^{28,42} Air cargo terminals are facing high pressure. In the context of an air cargo terminal, time pressure is extremely high, and coordination complexity is considerably high. If there is a lack of dynamic ability to quickly convert real-time tracking information into decision-making and execution, the traceability system may become an information island.¹¹

Therefore, the contribution of traceability to performance is more significantly dependent on the transmission of operational agility. Traceability provides the real-time data input required for perception, while agility completes the subsequent actions of capture and reconstruction, converting data into resource reallocation and process adjustment, ultimately improving OP.^{18,29} In other words, agility is a crucial bridge between traceability and OP.

In the context of Hactl, its air cargo information system integrates heterogeneous systems from multiple airlines and logistics partners, creating a shared foundation for coordination. Through agility, these human and technological resources are converted into faster responses to flight changes, improved coordination across cargo handling processes, and more efficient resource utilization, ultimately leading to enhanced OP. Agility is conceptualized as the mediator linking organizational resources to performance outcomes. Therefore, H6a and H6b were proposed:

- (vi) H6a: Agility positively mediates the relationship between training and OP in Hactl. H6b: Agility positively mediates the relationship between traceability and OP in Hactl.

3. Method

3.1. Data collection and sample

Before the survey data collection, this study conducted a pilot study. We collected 30 valid responses from firms at the Terminal Service Center (TSC) of Hactl. The document-processing unit serves as the core information department within the air-cargo process. It handles critical tasks, such as verifying waybills, pre-planning aircraft loading and unloading, coordinating with airline agents, and preparing customs documentation. TSC professionals were deeply involved at every step from data entry to the physical operations of both information exchange and operational decision-making.

Staff in this unit can comprehensively and accurately assess the actual levels of logistics-platform use, operational agility, and overall performance, providing feedback with high content validity and contextual representativeness. Based on the staff feedback, we refined some wording items to enhance clarity. Given that respondents in Hong Kong mainly read traditional Chinese and largely use English at work, the questionnaire was ultimately presented in a bilingual format (traditional Chinese and English) to reduce language burden and ensure high-quality data and validity.

Using purposive sampling, the questionnaires were sent to staff via Google Forms and Wenjuanxing. Purposive

sampling ensures that respondents possess direct, hands-on experience with Hactl's cargo information systems and operational decision-making. It is essential for accurately assessing training, traceability, agility, and OP. We received 70 questionnaires from respondents, covering approximately 87% of the targeted operational roles at Hactl. The response rate was adequate for this study, as it was well above the 20% minimum response rate recommended in the literature for supply chain research.⁴³ Because all questionnaires were sent via Google Forms and Wenjuanxing, there were no missing values. Despite the modest sample size, it met the minimum requirement for partial least squares structural equation modeling (PLS-SEM) analysis and represented key operational units within Hactl. Thus, all data were used in the data analysis.

In terms of gender, males accounted for 57.14% and females for 42.86%, indicating a relatively balanced gender distribution. The participants' ages were primarily between 20 and 40 years old, accounting for 74.29%, which is representative of the core workforce in enterprises. The data were collected from the Freightier front (34.29%), the Freightier back (38.57%), the Data Entry Clerk (14.29%), and the management (12.86%). The educational backgrounds of the respondents were distributed as follows: high school and below (31.43%), associate (28.57%), bachelor's (34.29%), and master's and above (5.71%). Besides, the working years of respondents were distributed as follows: 1 year and below (32.86%), 1 to 3 years (including 3 years) (32.86%), 3 to 5 years (including 5 years) (8.57%), 5 years and above (25.71%). Table 1 presents the descriptive statistics for the respondents.

3.2. Common method bias

This study employed SmartPLS 4 (PLS-SEM; SmartPLS GmbH, Germany). It was a quantitative study. Additionally, survey studies are prone to bias. Therefore, using Harman's single-factor test, the common method bias (CMB) and the model constructs were verified. Following the methods from Baah *et al.*¹⁸ and Reaidy *et al.*²⁹, this study assessed CMB using SPSS 27 (IBM, US). As explained by Podsakoff *et al.*⁴⁴, this test shows the observed variables in an exploratory factor analysis (EFA). A single factor should account for less than 50% of the cumulative variance. If a single factor accounts for 50% or more of the cumulative variance, then the CMB exists.⁴⁵ The EFA and principal component analysis indicated that the study was free of CMB, as the single factor explained 47.82% of the cumulative variance. Therefore, CMB was not of much concern in this study.

3.3. Research method

The study used PLS-SEM to analyze the data and test the

Table 1. Descriptive statistics ($N = 70$)

Variable	Items	Number of respondents	%
Gender	Male	40	57.14
	Female	30	42.86
Age	30 and under	31	44.29
	30 to 40 years old	22	31.43
	40 to 50 years old	11	15.71
	50 and above	6	8.57
Education	High school and below	22	31.43
	Associate	20	28.57
	Bachelor	24	34.29
	Master and above	4	5.71
Department	Freighter front	24	34.29
	Freighter back	27	38.57
	Data Entry Clerk	10	14.29
	Management	9	12.86
Working years	1 year and below	23	32.86
	1–3 years (including 3 years)	23	32.86
	3–5 years (including 5 years)	6	8.57
	5 years and above	18	25.71

hypotheses. According to Hair⁴⁶, PLS-SEM is suitable for explorative studies that identify the drivers of a construct. Fornell and Larcker⁴⁷ and Hair *et al.*⁴³ indicated that PLS-SEM is more appropriate for analyzing models in the early stages of theory development. In addition, PLS-SEM is useful for assessing reflective constructs and testing mediation. Considering that this paper examined both the direct effects of training and traceability and the mediating effect of agility through the lens of the RBV, it has little empirical evidence. PLS-SEM was deemed suitable for this study. The analysis of the data involved the evaluation of the measurement and structural models. The measurement model (including validity and reliability) was assessed using internal consistency reliability, convergent validity, and discriminant validity, while the structural model was assessed using coefficients of determination (R^2) and predictive relevance (Q^2) of the exogenous constructs on the endogenous constructs. We ran the PLS-SEM algorithm with 300 samples and 5,000 bootstrap samples. The blindfolding applied an omission distance of nine.⁴³

4. Results

The development of the questionnaires followed the guidelines stipulated by Podsakoff *et al.*⁴⁴ to minimize concerns. Specifically, the anonymous respondents completed the questionnaire, and then we obtained measures from diverse sources in Hactl.

4.1. Measurement model assessment

4.1.1. Reliability analysis

For the given theoretical model, the reliability of the measurement items was evaluated using Cronbach's alpha (CA), average variance extracted (AVE), and composite reliability (CR). The measurement model met the threshold of ≥ 0.7 , which is considered satisfactory.⁴³ The results are reported in Table 2. All the scales were measured with a 5-point Likert-type scale anchored with completely disagree (1) and completely agree (5), and were estimated through the respondent's perceptual evaluation. All these scales were considered as reflective constructs.

The factor loadings for the training sample ranged from 0.803 to 0.846, and the reliability (CA = 0.843; AVE = 0.679; CR = 0.894) was acceptable. The traceability scale (a 5-item scale) was adopted from a previous study by Ma *et al.*²⁴ All items loaded above the 0.7 level (0.772–0.840) and showed good reliability (CA = 0.863; AVE = 0.647; CR = 0.901). Agility (a 4-item scale) was measured on a scale adapted from that of Baah *et al.*¹⁸ (CA = 0.819; AVE = 0.649; CR = 0.881). OP (CA = 0.863; AVE = 0.710; CR = 0.907) was also measured.

The proposed theoretical model was examined for multicollinearity to assess whether predictor variables were strongly correlated. High multicollinearity may occur

when one predictor variable is highly correlated with or predicts another, potentially biasing the estimation results. Accordingly, multicollinearity was assessed using the variance inflation factor (VIF) values. The VIF values for most constructs fell within the acceptable threshold (<3.3). However, item OP4 exhibited a VIF of 4.618, exceeding the conservative threshold and suggesting multicollinearity. Therefore, OP4 was removed from the model to mitigate multicollinearity and improve the robustness of the analysis.

4.1.2. Discriminant validity

According to Fornell and Larcker⁴⁷, discriminant validity is used to assess the uniqueness of the latent variables and to ensure that each item loads onto its corresponding construct and that there is no overlap or repetition of the items. To assess this, the correlations among the constructs were examined (Table 3) and compared with the square roots of AVE values. If the square root of AVE values is greater than the diagonal elements, the constructs are distinct. Similarly, in the present study, the latent variables satisfied the criteria for discriminant validity.

To make it more reasonable, this study also used the heterotrait–monotrait (HTMT) ratio of correlations.⁴⁸ HTMT is widely used for testing discriminant validity. The HTMT ratios (0.664–0.824) of agility, OP, traceability, and training indicate that the model achieved discriminant validity (Table 4), as the values were <0.85 threshold suggested by Henseler *et al.*⁴⁸

4.2. Structural model assessment

In this section, the structural model was estimated to estimate path coefficients and test the proposed hypotheses among the constructs. The structural model (Figure 2) was evaluated to examine the explanatory and predictive power of the proposed relationships. In assessing the structural model, the coefficients of determination (R^2) and predictive accuracy (Q^2) were used to evaluate the model's predictive accuracy and relevance.

We assessed the explanatory power using the coefficient of determination (R^2). Following the work by Hair *et al.*⁴³, R^2 thresholds of 0.75, 0.50, and 0.25 can generally be interpreted as substantial, moderate, and weak explanatory power, respectively. The R^2 values for agility and OP were 0.474 and 0.579, respectively, both exceeding the threshold for weak explanatory power (0.25) and thus indicating moderate explanatory power (Table 5).

To assess the model's predictive relevance, we employed the blindfolding procedure to obtain Stone–Geisser's Q^2 values.^{49,50} As shown in Table 5, both Q^2 values were

significantly greater than zero (agility: $Q^2 = 0.289$; OP: $Q^2 = 0.384$). This confirms that the model was predictive of the endogenous constructs. Specifically, the higher Q^2 value for OP suggests that the model's predictors are particularly effective at forecasting this key outcome variable.

4.3. Hypothesis testing

The results of the direct effects are presented in Table 6 and Figure 2. The findings indicate that not all proposed direct paths were supported. Specifically, H1, H3, H4, and H5 were supported, while H2 was rejected due to the non-significant direct path from traceability to OP.

The analysis of indirect effects (mediation) revealed significant pathways. Both training and traceability exerted significant indirect effects on OP through the mediation of agility, supporting H6a and H6b. In addition, the bootstrapped confidence intervals (CIs) for both indirect effects did not include 0 (H6a: CI = [0.020, 0.264]; H6b: CI = [0.084, 0.377]), further confirming the robustness of the mediating role of agility (Table 7).

5. Discussion

5.1. The relationship between training, traceability, and operational performance

This study found that training has a positive effect on OP (H1 supported). The finding is consistent with the study by Jahangir *et al.*⁴, which surveyed human resources management practices in Chinese logistics companies. Training directly improves operational output by enhancing employees' ability to adopt technology and solve problems. In air cargo terminals, such as Hactl, air cargo operations are highly dependent on multiple systems. Employee training enables them to directly reduce error rates and shorten the cargo handling time, thereby translating human capital into cost and delivery performance.¹⁰

Noticeably, the direct effect of traceability on OP was not significant (H3: $\beta = 0.094$, $t = 0.850$, $p > 0.05$), which is contrary to the existing literature. Previous studies have shown that digital resources directly drive performance. In particular, Baah *et al.*¹⁸ pointed out that supply chain visibility has a direct effect on supply chain performance in the manufacturing industry. Also, Riaz *et al.*²³ confirmed that supply chain traceability affects OP through serial mediators. This means technical resources can directly contribute to efficiency improvement. In comparison, air cargo terminal operations are extremely time-constrained and operationally heterogeneous. COSAC-Plus processes nearly 1 million transactions per day and connects to the systems of more than 100 airlines. In this situation, cargo tracking and data recording only provide information to

Table 2. Measurement model assessment results

Items	Loadings	CA	AVE	CR	VIF
Training1: Our employees receive training to perform multiple tasks	0.803	0.843	0.679	0.894	2.017
Training2: Our plant employees receive training and development in workplace skills on a regular basis	0.831				2.180
Training3: Management at this plant believes that training and continual upgrading of employee skills are important	0.846				2.151
Training4: Our employees regularly receive training to improve their skills	0.816				2.016
TR1: Our cargo information system traceability facilitates the identification of cargo location information	0.772	0.863	0.647	0.901	2.075
TR2: Our cargo information system provides traceability for tracking the status of cargo shipments	0.740				1.585
TR3: Our cargo information system traceability facilitates tracking cargo from import to export	0.822				2.776
TR4: Our cargo information system facilitates tracking the source of cargo quality problems	0.818				1.965
TR5: Our cargo information system traceability facilitates the recall of cargo with safety concerns	0.840				1.752
AG1: Our firm quickly detects and adapts to changes, threats, and opportunities	0.740	0.819	0.649	0.881	1.415
AG2: Our firm frequently modifies tactics and operations when needed	0.822				1.866
AG3: Our firm can quickly make decisions	0.818				1.851
AG4: Our firm can implement decisions quickly in response to market changes	0.840				2.024
OP1: Our company significantly reduced overall operational costs	0.769				1.871
OP2: Our company significantly reduced lead times	0.891	0.863	0.710	0.907	2.636
OP3: Our company significantly improved product quality	0.813				1.954
OP4: Our company helped our customers develop better services	Removed				4.618
OP5: Our company significantly reduced waste within the service process	0.892				2.612

Abbreviations: AG: Agility; AVE: Average variance extracted; CA: Cronbach's alpha; CR: Composite reliability; OP: Operational performance; TR: Traceability; VIF: Variance inflation factor.

Hactl. Without the organizational ability to translate real-time data into operational efficiencies, information itself can delay the decision-making process for overload.¹¹

Therefore, the absence of the direct effect means that

traceability does not directly serve as a performance driver in air cargo logistics. There is a significant threshold of capability for its value. H3 is not a failure of assumption but rather reveals the applicable boundaries of DCT in extremely dynamic scenarios.

Table 3. Discriminant validity: Fornel–Larcker criterion

Parameter	Agility	OP	Traceability	Training
Agility	0.806			
OP	0.697	0.843		
Traceability	0.650	0.582	0.804	
Training	0.568	0.640	0.596	0.824

Abbreviation: OP: Operational performance.

Table 4. Heterotrait–monotrait criterion

Parameter	Agility	OP	Traceability	Training
Agility				
OP	0.824			
Traceability	0.766	0.664		
Training	0.678	0.742	0.696	

Abbreviation: OP: Operational performance.

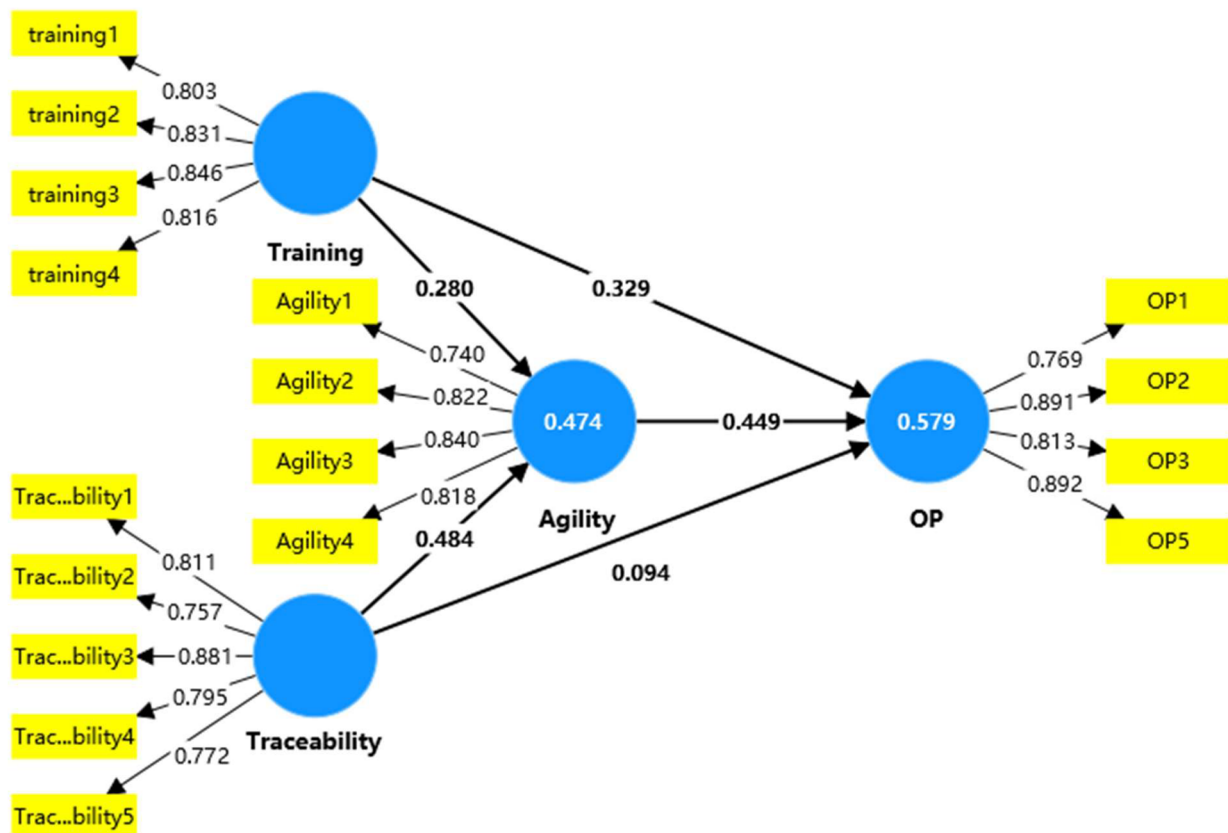


Figure 2. Structural model
Abbreviation: OP: Operational performance.

Table 5. Model explanatory power and predictive relevance

Parameter	R^2	Adjusted R^2	Blindfolding (Q^2)
Agility	0.474	0.458	0.289
OP	0.579	0.559	0.384

Abbreviation: OP: Operational performance.

Table 6. Direct effect results

Hypothesis	β	S.E.	t	p	Results
H1: Training $\rightarrow$ OP	0.329	0.114	2.893	0.004**	Supported
H2: Training $\rightarrow$ Agility	0.280	0.109	2.559	0.011**	Supported
H3: Traceability $\rightarrow$ OP	0.094	0.111	0.850	0.396	Rejected
H4: Traceability $\rightarrow$ Agility	0.484	0.110	4.419	<0.001***	Supported
H5: Agility $\rightarrow$ OP	0.449	0.122	3.676	<0.001***	Supported

Notes: β : Path coefficient; * $p < 0.05$ ($t > 1.645$); ** $p < 0.01$ ($t > 2.326$); *** $p < 0.001$ ($t > 3.090$).

Abbreviations: OP: Operational performance; S.E.: Standard error.

Table 7. Specific indirect effect

Hypothesis	β	S.E.	t	p	CI [2.05–97.5%]	Results
H6a: Training $\rightarrow$ Agility $\rightarrow$ OP	0.126	0.063	1.980	0.048*	[0.020, 0.264]	Supported
H6b: Traceability $\rightarrow$ Agility $\rightarrow$ OP	0.217	0.075	2.889	0.004**	[0.084, 0.377]	Supported

Notes: β : Path coefficient; * $p < 0.05$ ($t > 1.645$); ** $p < 0.01$ ($t > 2.326$).

Abbreviations: OP: Operational performance; S.E.: Standard error.

5.2. The relationship between training, traceability, and agility

Hypotheses H2 ($\beta = 0.280$, $t = 2.559$, $p = 0.011$) and H4 ($\beta = 0.484$, $t = 4.419$, $p < 0.001$) showed that both training and traceability significantly enhance organizational agility. Moreover, traceability exerts a stronger effect on agility than training does. This finding supports the view of Akhtar *et al.*¹⁹, based on the theory of organizational information processing, that the use of real-time information enhances operational agility by strengthening an organization's dynamic response capabilities. In the Hactl context, COSAC-Plus, AWRS, and LCS constitute the digital nerve of the organization, enabling managers to perceive cargo detention, flight changes, and handling bottlenecks in real time. Similarly, Hong *et al.*² found that digital tracking and information sharing are the core antecedents of agility in the Incheon Aviation Hub. In contrast, while training can improve agility, its role is more in human capital, whereas traceability provides real-time situational awareness at the system level, with greater scale and response speed in a multi-agent and uncertain air cargo environment.

5.3. The mediating role of agility

Agility positively affected OP in air cargo terminal operations (H5: $\beta = 0.449$, $t = 3.676$, $p < 0.001$). In a time-constrained environment, such responsiveness directly translates into improved operational outcomes. This result provides further validation of the DCT, which emphasizes that a firm's capability deployment outweighs its resource possessions.³¹ In the air cargo context, agility acts as the mediating mechanism that transforms information availability into OP.

The most valuable finding of this study lies in the asymmetric mediating effect of agility, particularly the mediation paths of H6a ($\beta = 0.126$, $t = 1.980$, $p < 0.05$) and H6b ($\beta = 0.217$, $t = 2.889$, $p < 0.01$). Specifically, agility fully mediates the relationship between traceability and OP, while partially mediating the relationship between training and OP. This asymmetric mediation pattern highlights that human resources and technological resources follow distinct transformation pathways.

These asymmetric paths are related to the existing literature. Riaz *et al.*²³ proposed a sequence of mediating

chains from Industry 4.0 to traceability, visibility, resilience, and performance, emphasizing that technical resources need to develop multiple capabilities to achieve performance. Khan *et al.*²⁸ found that traceability affects inventory management through transparency. This study further refines the finding: in the dynamic environment of an air cargo terminal, the impact of traceability on performance can be transmitted through operational agility. Agility is not a secondary path; it is the necessary mechanism through which technical resources translate into performance. In the meantime, training has two roles: directly improving OP and enhancing it through agility. In other words, employees can directly apply learned skills to improve operational efficiency and indirectly enhance performance by strengthening adaptability. This finding is consistent with Dubey *et al.*'s¹¹ viewpoint that big data resources must be combined with organizational dynamic capabilities to produce performance. This study expands its scope conditions from manufacturing to air cargo services. Furthermore, it identifies the mediating role of agility on conversion paths.

5.4. Theoretical contribution

Through the lens of RBV, training represents a valuable human capital resource that can generate performance gains in the absence of higher-order capabilities. This finding is associated with prior studies that highlight the importance of employees' competence in improving operational outcomes in logistics companies. However, the effect also indicates that training alone may not fully unlock its performance. This competitive capability should be embedded in adaptive operational processes. Hactl's employee training is a structured and scenario-based capability development process. In the context of Hactl, logistics information systems and operational systems serve multiple airline customers. The training aims not to enable employees to proficiently handle standardized operational procedures, but rather to address specific data and customs declaration requirements.

Furthermore, the contribution of this study is to examine the transmission mechanism from resource to capability, and to performance. Specifically, training allows a partial direct performance path, while traceability requires full competency mediation. This finding highlights that digital resources need to be combined with organizational capabilities to produce performance. It provides new empirical evidence for the scope of DCT in dynamic situations. In addition, this study enriches the micro-level understanding of dynamic capabilities by integrating the RBV and DCT frameworks to explain how traceability empowers agility by reducing environmental uncertainty.

5.5. Managerial implications

For air cargo terminal managers, this study proposes three recommendations: first, traceability investments should be evaluated based on their agility and enabling potential, rather than simply pursuing the complexity of data capture. Second, the training program should shift from simply operational skills to embedded agile development. In this way, employees can leverage their resources to transform performance within a limited time. Third, the air cargo logistics industry needs to prioritize collaborative standard systems across air cargo terminals, rather than upgrading their systems in isolation. Hactl operates COSAC-Plus and ACAS. They show that the hybrid model of systems and standardized governance can effectively balance customized compliance with internal operational consistency.

5.6. Limitations

This study has some limitations that suggest directions for future research. PLS-SEM is suitable for small-sample exploratory studies, but the results from a company (Hactl) may not generalize to others. Future studies could test the model with multiple cargo terminals, logistics providers, and geographic contexts to strengthen external validity. Secondly, the use of cross-sectional, self-reported data may also limit causal interpretation. Although Harman's single-factor test was used to reduce bias, further statistical checks or longitudinal research would provide stronger causal evidence. Future studies can dive into the system data or delivery records to make the study more specific. Thirdly, OP was measured through managerial perceptions. Including objective or multi-source data in future studies would make the findings more robust. Additionally, agility was treated as a first-order construct in this study. Future research could examine it as a higher-order construct, separating its components into sensing, seizing, and reconfiguring to see how training and traceability influence each stage. Lastly, exploring possible non-linear effects or thresholds in the relationship between sources and agility could provide further insights. Addressing these points will deepen understanding of digital transformation in air cargo operations that rely heavily on assets and real-time information.

6. Conclusion

This study integrates RBV and DCT to explore how training and traceability affect OP through operational agility, using Hactl as a case study. PLS-SEM analysis revealed three core findings. First, training has both direct and indirect effects on OP, whereas traceability affects OP only indirectly through agility, indicating that the two types of resources follow different transformation paths. Second,

the promotion effect of traceability on operational agility is significantly stronger than that of training, revealing the core position of digital perception infrastructure in high-speed air cargo logistics platforms. Third, operational agility completely mediates the relationship between traceability and OP, while it only partially mediates the relationship between training and OP. These findings extend the scope of information resources and supply chain performance from manufacturing to air cargo scenarios.

Acknowledgments

The authors thank the Hactl personnel for their participation in this field research.

Funding

This study was supported by two research grants awarded to Chunhui Li: the Research Project of Guangdong Provincial Department of Education (grant number 2025WQNCX089), titled “Research on Sustainable Development Evaluation of ESG-based Listed Shipping Enterprises under the ‘Dual Carbon’ Goal,” and the Research Project of China Society of Logistics and China Federation of Logistics and Purchasing (grant number 2025CSLKT3-440), titled “Research on Low-carbon Path Optimization and Synergy Mechanism of Regional Multimodal Transport Network.”

Conflict of interest

The authors declare that they have no competing interests.

Author contributions

Conceptualization: Peiyun Yu

Formal analysis: All authors

Investigation: Peiyun Yu, Junping Huang

Methodology: Peiyun Yu

Writing–original draft: Peiyun Yu

Writing–review & editing: All authors

Ethics approval and consent to participate

Participants were informed of the academic purpose and anonymity before starting the questionnaire, which serves as documented informed consent.

Consent for publication

All respondents participating in interview discussions were informed, in writing and orally, that the research results would be published. No specific consent for publishing quotes was given. However, all respondents taking part in the study are anonymous.

Availability of data

Data are available from the corresponding author upon

reasonable request.

Further disclosure

During the preparation of this manuscript, the authors used DeepSeek-V3.1 (DeepSeek AI, 2025), Kimi K2.5 (Moonshot AI, 2025), ChatGPT-5.2 (OpenAI, 2025), and Grammarly (Grammarly, Inc., 2025) for structure development and language editing.

References

1. Hactl praises HKIA for holding top airport slot. 2025. Available from: <https://www.hactl.com/en/media/news-press/press-release/hactl-praises-hkia-for-holding-top-airport-slot/> [Last accessed on May 9, 2026].
2. Hong SJ, Kim W, Hiatt B. Examining airport agility at air cargo hub airports. *J Air Transp Manag.* 2025;122:102710. doi: 10.1016/j.jairtraman.2024.102710
3. Pattnaik S, Pattnaik S. Relationships Between Green Supply Chain Drivers, Triple Bottom Line Sustainability and Operational Performance: An Empirical Investigation in The UK Manufacturing Supply Chain. *Oper Supply Chain Manag.* 2019;12(4):198–211. doi: 10.31387/oscm0390243
4. Jahangir S, Xie R, Iqbal A, Hussain M. The influence of sustainable human resource management practices on logistics agility: The mediating role of artificial intelligence. *Sustainability.* 2025;17(7):3099. doi: 10.3390/su17073099
5. Yiu CY, Ng KKH, Yu SCM, Yu CW. Sustaining aviation workforce after the pandemic: Evidence from Hong Kong aviation students toward skills, specialised training, and career prospects through a mixed-method approach. *Transp Policy.* 2022;128:179–192. doi: 10.1016/j.tranpol.2022.09.020
6. Chakraborty A, Rani MV. A robust hybrid multicriteria decision-making approach to barriers of AI adoption in air cargo: Addressing interdependencies, prioritizing challenges, and proposing strategic solutions. *IEEE Trans Eng Manag.* 2026;73:2456–2469. doi: 10.1109/TEM.2026.3671804
7. Ivanov D, Sethi S, Dolgui A, Sokolov B. A survey on control theory applications to operational systems, supply chain management, and Industry 4.0. *Annu Rev Control.* 2018;46:134–147. doi: 10.1016/j.arcontrol.2018.10.014
8. Khan SAR, Yu Z. Assessing the eco-environmental performance: an PLS-SEM approach with practice-based view. *Int J Logist Res Appl.* 2021;24(3):303–321. doi: 10.1080/13675567.2020.1754773

9. Grzybowska K, Awasthi A, Sawhney R, eds. *Sustainable Logistics and Production in Industry 4.0: New Opportunities and Challenges*. Springer Science and Business Media LLC. 2020.
doi: 10.1007/978-3-030-33369-0
10. Adenigbo AJ, Mageto J, Luke R, Sijuwade O. Effect of Employee Training in the Air Cargo Logistics Industry in Nigeria. *Lect Notes Netw Syst*. 2024;145-156.
doi: 10.1007/978-3-031-68628-3_14
11. Dubey R, Gunasekaran A, Childe SJ, Blome C, Papadopoulos T. Big Data and Predictive Analytics and Manufacturing Performance: Integrating Institutional Theory, Resource-Based View and Big Data Culture. *Brit J Manag*. 2019;30(2):341-361.
doi: 10.1111/1467-8551.12355
12. Naghshineh B, Carvalho H. The implications of additive manufacturing technology adoption for supply chain resilience: A systematic search and review. *Int J Prod Econ*. 2022;247:108387.
doi: 10.1016/j.ijpe.2021.108387
13. Lau CW, Liu J, Ma X, Talluri S. Performance analysis of a blockchain-based messaging system implementation for air cargo supply chains. *Int J Prod Res*. 2025;63(14):5428-5451.
doi: 10.1080/00207543.2024.2407903
14. Helfat CE, Kaul A, Ketchen Jr. DJ, Barney JB, Chatain O, Singh H. Renewing the resource-based view: New contexts, new concepts, and new methods. *Strateg Manag J*. 2023;44(6):1357-1390.
doi: 10.1002/smj.3500
15. Wernerfelt B. A resource-based view of the firm. *Strateg Manag J*. 1984;5(2):171-180.
doi: 10.1002/smj.4250050207
16. Teece DJ, Pisano G, Shuen A. Dynamic capabilities and strategic management. *Strateg Manag J*. 1997;18(7):509-533.
doi: 10.1002/(SICI)1097-0266(199708)18:7<509::AID-SMJ882>3.0.CO;2-Z
17. Aslam H, Khan AQ, Rashid K, Rehman S ur. Achieving supply chain resilience: The role of supply chain ambidexterity and supply chain agility. *J Manuf Technol Manag*. 2020;31(6):1185-1204.
doi: 10.1108/JMTM-07-2019-0263
18. Baah C, Agyeman DO, Acquah ISK, et al. Effect of information sharing in supply chains: understanding the roles of supply chain visibility, agility, collaboration on supply chain performance. *Benchmarking Int J*. 2021;29(2):434-455.
doi: 10.1108/BIJ-08-2020-0453
19. Akhtar P, Ghouri AM, Saha M, Khan MR, Shamim S, Nallaluthan K. Industrial Digitization, the Use of Real-Time Information, and Operational Agility: Digital and Information Perspectives for Supply Chain Resilience. *IEEE T Eng Manag*. 2024;71:10387-10397.
doi: 10.1109/TEM.2022.3182479
20. Pham NT, Phan QPT, Tuckova Z, Vo N, Nguyen LHL. Enhancing the organizational citizenship behavior for the environment: the roles of green training and organizational culture. *Manag Mark*. 2018;13(4):1174-1189.
doi: 10.2478/mmcks-2018-0030
21. Xie X, Zhu Q. Exploring an innovative pivot: How green training can spur corporate sustainability performance. *Bus Strateg Environ*. 2020;29(6):2432-2449.
doi: 10.1002/bse.2512
22. Ozkan OS, Kuru SA, Uzum B, Ulu O. Enhancing prosocial behavior in the aviation industry through responsible leadership and importance of ethics and social responsibility: examining a moderated mediation model. *Lead Org Dev J*. 2024;45(2):208-230.
doi: 10.1108/LODJ-10-2022-0481
23. Riaz A, Rehman HM, Sohail A, Rehman M. Industry 4.0 supply chain nexus: sequential mediating effects of traceability, visibility and resilience on performance. *Asia Pac J Market Logist*. 2025;37(4):842-860.
doi: 10.1108/APJML-02-2024-0202
24. Ma JY, Shi L, Kang TW. The Effect of Digital Transformation on the Pharmaceutical Sustainable Supply Chain Performance: The Mediating Role of Information Sharing and Traceability Using Structural Equation Modeling. *Sustainability*. 2023;15(1):649.
doi: 10.3390/su15010649
25. Zhou X, Lu H, Kumar Mangla S. The impact of digital traceability on sustainability performance: Investigating the roles of sustainability-oriented innovation and supply chain learning. *Supply Chain Manag Int J*. 2024;29(3):497-522.
doi: 10.1108/SCM-01-2023-0047
26. Egwuonwu A, Mordi C, Egwuonwu A, Uadiale O. The influence of blockchains and internet of things on global value chain. *Strateg Change*. 2022;31(1):45-55.
doi: 10.1002/jsc.2484
27. Agyabeng-Mensah Y, Afum E, Acquah ISK, Dacosta E, Baah C, Ahenkorah E. The role of green logistics management practices, supply chain traceability and logistics ecocentricity in sustainability performance. *Int J Logist Manag*. 2021;32(2):538-566.
doi: 10.1108/IJLM-05-2020-0187
28. Khan M, Alshahrani AN, Jacquemod J. Digital Platforms and Supply Chain Traceability for Robust Information and Effective Inventory Management: The Mediating Role of Transparency. *Logistics*. 2023;7(2):25.

- doi: 10.3390/logistics7020025
29. Readdy P, Alaeddini M, Gunasekaran A, Lavastre O, Shahzad M. Unveiling the impact of Industry 4.0 on supply chain performance: the mediating role of integration and visibility. *Prod Plan Control*. 2026;37(1):45-66.
doi: 10.1080/09537287.2024.2440454
 30. Ramos E, Patrucco AS, Chavez M. Dynamic capabilities in the “new normal”: a study of organizational flexibility, integration and agility in the Peruvian coffee supply chain. *Supply Chain Manag Int J*. 2023;28(1):55-73.
doi: 10.1108/SCM-12-2020-0620
 31. Teece DJ. Explicating dynamic capabilities: The nature and microfoundations of (sustainable) enterprise performance. *Strateg Manag J*. 2007;28(13):1319-1350.
doi: 10.1002/smj.640
 32. Hautala-Kankaanpää T. The impact of digitalization on firm performance: examining the role of digital culture and the effect of supply chain capability. *Bus Process Manag J*. 2022;28(8):90-109.
doi: 10.1108/BPMJ-03-2022-0122
 33. Inman RA, Green KW. Lean and green combine to impact environmental and operational performance. *Int J Prod Res*. 2018;56(14):4802-4818.
doi: 10.1080/00207543.2018.1447705
 34. Lange A. Does cargo matter? The impact of air cargo operations on departure on-time performance for combination carriers. *Transp Res Pt A Policy Pract*. 2019;119:214-223.
doi: 10.1016/j.tra.2018.10.005
 35. Xu Y, Li JB, Chu CC, Dinca G. Impact of COVID-19 on transportation and logistics: a case of China. *Ekon Istraz*. 2022;35(1):2386-2404.
doi: 10.1080/1331677X.2021.1947339
 36. Dey PK, Chowdhury S, Abadie A, Vann Yaroson E, Sarkar S. Artificial intelligence-driven supply chain resilience in Vietnamese manufacturing small- and medium-sized enterprises. *Int J Prod Res*. 2024;62(15):5417-5456.
doi: 10.1080/00207543.2023.2179859
 37. Bargouthi MI. *An Empirical Investigation of the Impact of Supply Chain Agility on Supply Chain Risk Management and Firm Performance*. Ph.D Dissertation. Al-Quds University. 2023. Available from: <https://www.proquest.com/dissertations/docview/2842672339/abstract/D738073F68E344A4PQ/2> [Last accessed on January 22, 2024].
 38. Lopes de Sousa Jabbour AB, Chiappetta Jabbour CJ, Choi TM, Latan H. ‘Better together’: Evidence on the joint adoption of circular economy and industry 4.0 technologies. *Int J Prod Econ*. 2022;252.
doi: 10.1016/j.ijpe.2022.108581
 39. Dubey R, Gunasekaran A, Foropon CRH. Improving information alignment and coordination in humanitarian supply chain through blockchain technology. *J Enterp Inf Manag*. 2024;37(3):805-827.
doi: 10.1108/JEIM-07-2022-0251
 40. Al-Khatib AW. Internet of things, big data analytics and operational performance: the mediating effect of supply chain visibility. *J Manuf Technol Mana*. 2023;34(1):1-24.
doi: 10.1108/JMTM-08-2022-0310
 41. Cammarano A, Aquilone G, Varriale V, Michelino F, Caputo M. The potential of open innovation platforms: driving sustainable development goals through digital collaboration. *Innovation*. 2026;28(1):37-60.
doi: 10.1080/14479338.2024.2421015
 42. Kamble S, Rana NP, Gupta S, Belhadi A, Sharma R, Kulkarni P. An effectuation and causation perspective on the role of design thinking practices and digital capabilities in platform-based ventures. *Technol Forecast Soc Change*. 2023;193.
doi: 10.1016/j.techfore.2023.122646
 43. Hair J, Hult GTM, Ringle C, Sarstedt M. *A Primer on Partial Least Squares Structural Equation Modeling (PLS-SEM), 2nd Edition*. SAGE; 2017.
 44. Podsakoff PM, MacKenzie SB, Lee JY, Podsakoff NP. Common method biases in behavioral research: A critical review of the literature and recommended remedies. *J Appl Psychol*. 2003;88(5):879-903.
doi: 10.1037/0021-9010.88.5.879
 45. Lindell MK, Whitney DJ. Accounting for common method variance in cross-sectional research designs. *J Appl Psychol*. 2001;86(1):114-121.
doi: 10.1037/0021-9010.86.1.114
 46. Hair JF, ed. *A Primer on Partial Least Squares Structural Equations Modeling (PLS-SEM)*. SAGE; 2014.
 47. Fornell C, Larcker DF. Evaluating structural equation models with unobservable variables and measurement error. *J Mark Res*. 1981;18(1):39-50.
doi: 10.2307/3151312
 48. Henseler J, Ringle CM, Sinkovics RR. The use of partial least squares path modeling in international marketing. In: *New Challenges to International Marketing*. Emerald Group Publishing Limited; 2009.
 49. Stone M. Cross-Validatory choice and assessment of statistical predictions. *J R Stat Soc Ser B*. 1974;36(2):111-133.
doi: 0.1111/j.2517-6161.1974.tb00994.x
 50. Geisser S. The predictive sample reuse method with applications. *J Am Stat Assoc*. 1975;70(350):320-328.
doi: 10.1080/01621459.1975.10479865