“Logistics infrastructure development along Vietnam’s East–West Economic Corridor: The moderating role of international economic integration”

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LOGISTICS INFRASTRUCTURE DEVELOPMENT ALONG VIETNAM'S EAST–WEST ECONOMIC CORRIDOR: THE MODERATING ROLE OF INTERNATIONAL ECONOMIC INTEGRATION

Abstract

This study examines the relationships among institutional support, investment capacity, regional planning and linkage, digital transformation, and logistics infrastructure development along the Vietnamese segment of the East–West Economic Corridor, together with the moderating role of international economic integration. Using purposive sampling, data were collected from November 2025 to March 2026 through online and in-person questionnaires administered to managers and professionals from government agencies, logistics service providers, and infrastructure actors in Quang Tri province, Hue city, Da Nang city, and other relevant locations. Respondents had direct professional involvement in the planning, financing, implementation, operation, management, or assessment of logistics infrastructure. After data screening, 298 valid responses were analyzed using partial least squares structural equation modeling. Institutional support (β = 0.287), digital transformation (β = 0.271), investment capacity (β = 0.242), and regional planning and linkage (β = 0.133) were positively and significantly associated with logistics infrastructure development, and the model explained 57.8% of its variance. International economic integration weakened the positive relationships between institutional support and logistics infrastructure development (β = –0.126) and between investment capacity and logistics infrastructure development (β = –0.110). In contrast, international economic integration strengthened the positive relationship between digital transformation and logistics infrastructure development (β = 0.106), while its moderating effect on the relationship between regional planning and linkage and logistics infrastructure development was not statistically significant (β = –0.051, p = 0.268). Therefore, international economic integration is not uniformly enabling, as its implications depend on institutional alignment, financing adaptability, and digital readiness.

Keywords cross-border logistics, economic corridors, digitalization, institutional governance, investment capacity, regional connectivity, Vietnam

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INTRODUCTION

In the context of deepening international economic integration and growing pressure for regional connectivity, logistics infrastructure development has become an essential condition for improving trade efficiency, reducing transport costs, and strengthening territorial competitiveness. Beyond its traditional role in freight mobility, logistics infrastructure increasingly functions as a strategic platform that supports supply chain coordination, market accessibility, and cross-border economic interactions. For developing and emerging economies, the effectiveness of logistics infrastructure is widely recognized as a key factor shaping trade performance and regional development (Arvis et al., 2023).

This issue is particularly relevant to the East–West Economic Corridor (EWEC), one of the most important cooperation frameworks in the Greater Mekong Subregion. The corridor was established to enhance cross-border connectivity and to transform transport routes into broader economic corridors linking Myanmar, Thailand, Lao PDR, and Vietnam (ADB, 2010). For Vietnam, the EWEC is strategically important because it connects the central region with inland markets, neighboring economies, major seaports, and international trade flows. However, the transformation of transport connectivity into sustained logistics infrastructure development has remained uneven. Physical connectivity alone does not ensure that infrastructure along the corridor will be consistently upgraded, spatially coordinated, adequately financed, institutionally supported, or technologically modernized.

The scientific problem arises from the fact that the development of logistics infrastructure in a cross-border corridor is not driven solely by physical investment. This development emerges from the interaction of institutional support, financing capacity, regional planning and linkage, digital transformation, and the wider conditions created by international economic integration. These conditions operate across administrative boundaries, infrastructure nodes, public and private organizations, and cross-border economic networks. Their combined operation makes corridor-level infrastructure development conceptually different from national logistics performance or firm-level logistics capability.

Within the Vietnamese segment of the EWEC, it remains unclear why similar improvements in physical connectivity may yield different levels of infrastructure advancement, continuity, and modernization. In particular, the extent to which institutional, financial, spatial, and digital conditions are associated with logistics infrastructure development, and whether international economic integration strengthens or constrains these relationships, remains unclear. The resulting research gap is therefore the absence of an integrated corridor-level explanation of how these structural conditions and integration dynamics jointly relate to logistics infrastructure development along the Vietnamese segment of the EWEC.

1. LITERATURE REVIEW AND HYPOTHESES

Understanding logistics infrastructure development as the advancement, upgrading, and modernization of infrastructure over time requires a framework that extends beyond the accumulation of physical assets. In corridor economies, such development is shaped by governance arrangements, investment capacity, spatial coordination, technological capabilities, and integration with cross-border markets. Accordingly, this review focuses on five corridor-level conditions: institutional support, investment capacity, regional planning and linkage, digital transformation, and international economic integration.

Infrastructure and trade research indicates that development outcomes depend not only on transport facilities but also on the institutional and coordination environments in which they operate (North, 1990; Hoekman & Nicita, 2011; Francois & Manchin, 2013). Logistics infrastructure functions as an interconnected system of transport facilities, storage capacity, border gateways, and information linkages, making institutional quality and regulatory alignment particularly important in multi-jurisdictional corridors such as the East–West Economic Corridor (EWEC) (ADB, 2010; Arvis et al., 2023; Rodrigue, 2024). The resource-based view and the dynamic capabilities perspective provide complementary lenses by emphasizing the availability, coordination, and effective deployment of resources and capabilities (Barney, 1991; Teece, 2007). Although developed primarily at the firm level, this logic is applicable to corridor-level infrastructure development, where institutional support, financing, regional coordination, and digital capabilities represent distinct enabling conditions. In this study, logistics infrastructure development refers to the perceived overall advancement, sustained improvement, and modernization of logistics infrastructure along the Vietnamese segment of the EWEC during 2021–2025. This construct captures change over time rather than the current adequacy of infrastructure or the operational performance of individual logistics services.

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Institutional support is defined as the extent to which public authorities provide a stable, consistent, timely, and facilitative environment for logistics infrastructure development (North, 1990). Institutional support reflects public-sector commitment, continuity of support, timely assistance, and effective responses to institutional and administrative issues. Unlike regional planning and linkage, which capture corridor-wide spatial coordination, and investment capacity, which captures financing capacity, institutional support reflects the quality and continuity of the public-sector environment. Stable institutional arrangements reduce uncertainty and facilitate infrastructure implementation (North, 1990), while regulatory quality and administrative efficiency influence trade costs and logistics activities supported by infrastructure (Francois & Manchin, 2013; Hoekman & Nicita, 2011; Portugal-Perez & Wilson, 2012). Evidence from Vietnam also highlights the importance of regulation and policy prioritization for logistics development (Dang & Yeo, 2018), while institutional limitations have been identified as constraints along the Vietnamese segment of the EWEC (Can et al., 2026). Because the transition from transport connectivity to a functioning economic corridor depends on supporting institutions and coordinated implementation (ADB, 2010; Banomyong, 2008), stronger institutional support is expected to be positively associated with logistics infrastructure development.

Investment capacity refers to the perceived ability of relevant public and private actors to secure and sustain financing for logistics infrastructure development (United Nations Department of Economic and Social Affairs, 2023; Meng et al., 2024; World Bank, 2025). The construct captures overall financing capacity rather than dependence on a particular source and may involve public investment, private capital, public–private partnerships, foreign direct investment, and credit. The effectiveness of investment capacity depends on whether financing is sufficient, timely, stable, adaptable, and reliable throughout project implementation. This capacity is critical because logistics infrastructure is capital-intensive and requires sustained financing across planning, construction, upgrading, and operation (Can & Bui, 2026). Developing economies continue to face substantial infrastructure needs and constrained access to affordable finance, while public, private, blended-finance, and guarantee mechanisms remain important for resource mobilization (United Nations Department of Economic and Social Affairs, 2023; Meng et al., 2024; World Bank, 2025). In corridor economies, financing must support interconnected transport links, border facilities, and logistics nodes across multiple jurisdictions rather than isolated projects (ADB, 2010; Srivastava, 2011). A stronger capacity to secure, sustain, and adjust financing is therefore expected to be positively associated with logistics infrastructure development.

Regional planning and linkage refer to the coherence of infrastructure planning and connections among major economic and logistics nodes within a corridor system (Brunner, 2013; Srivastava, 2011). In this study, regional planning and linkage capture the extent to which logistics infrastructure plans across EWEC localities pursue common corridor-wide objectives, remain mutually aligned, follow coordinated project sequencing, and support integrated connections among major logistics nodes (ADB, 2010, 2023; Can et al., 2026). Such coordination is important because multijurisdictional and multimodal corridors involve multiple authorities, infrastructure systems, and territorial interests (Vining et al., 2023). Economic corridor development, therefore, requires an area-based, multisector approach that aligns individual investments with broader spatial and regional priorities (ADB, 2023). The value of a corridor arises from connections and network effects among economic nodes rather than isolated infrastructure assets (Brunner, 2013). Along the Vietnamese segment of the EWEC, fragmented planning, dispersed investment, and weak interregional coordination may result in disconnected or poorly sequenced projects (Can et al., 2026). Greater coherence in corridor-wide planning and linkages is therefore expected to be positively associated with logistics infrastructure development.

Digital transformation refers to the integration of digital technologies and data-based processes into organizational activities, information exchange, coordination, and decision-making (Bharadwaj et al., 2013; Cichosz et al., 2020). In this study, digital transformation is defined as the degree to which digital systems, connected data exchange, integrated processes, real-time operational informa-

tion, and data analytics are embedded in logistics infrastructure planning and operations along the Vietnamese segment of the EWEC (Can & Bui, 2026; Nguyen et al., 2025). Digitalization can enhance visibility, process integration, coordination, and responsiveness across logistics systems (Cichosz et al., 2020; da Silva et al., 2023; Helo & Thai, 2024; Lu & Taghipour, 2025). These capabilities are particularly relevant to cross-border corridors, where public agencies, private operators, border gateways, and logistics nodes must exchange information across organizational and territorial boundaries. Connected systems, real-time data, and analytics can therefore improve the coordination and utilization of dispersed infrastructure assets (Can & Bui, 2026). Recent evidence from Central Vietnam similarly emphasizes digitalized planning, logistics data sharing, and the broader application of digital solutions (Nguyen et al., 2025). A higher degree of digital integration is consequently expected to be positively associated with logistics infrastructure development.

Beyond the four direct relationships, international economic integration is conceptualized as a contextual condition that may strengthen or weaken the contribution of each enabling factor to logistics infrastructure development. International economic integration refers to the extent to which economic activities are embedded in cross-border trade, investment, production, and market networks (Baldwin, 2016; Francois & Manchin, 2013). In this study, international economic integration captures the degree to which economic and logistics activities along the Vietnamese segment of the EWEC are connected to regional and international markets and integrated into cross-border production and logistics networks (ADB, 2010; Baldwin, 2016). Such integration is reflected in intensive cross-border trade and logistics activities, participation in regional production networks, and prominent international trade and investment linkages. Deeper integration increases the requirements placed on logistics infrastructure, institutions, border processes, information continuity, and coordination across jurisdictions (Arvis et al., 2023; Francois & Manchin, 2013). A functioning economic corridor requires not only physical connectivity but also coordinated institutions, investment, logistics services, and cross-border implementation mechanisms (ADB, 2010). International economic integration may therefore change the strength of the relationships between institutional support, investment capacity, regional planning and linkage, and digital transformation and logistics infrastructure development.

Several mechanisms explain this potential moderating role. First, stronger integration increases the need for timely public support and effective responses to cross-border administrative issues. Stronger integration may enhance the contribution of institutional support but may also reveal inconsistencies between domestic institutional arrangements and cross-border requirements (Hoekman & Nicita, 2011; Portugal-Perez & Wilson, 2012). Second, deeper cross-border economic activity can increase infrastructure demand and financing requirements. Where financing is sufficient and adaptable, greater integration may strengthen the relationship between investment capacity and logistics infrastructure development. Conversely, when infrastructure demand grows faster than financing capacity, the relationship may weaken (ADB, 2010). Third, stronger integration can heighten the importance of aligned plans, coordinated project sequencing, and connections among corridor nodes. However, fragmented local priorities and administrative boundaries may prevent stronger integration from strengthening the relationship between regional planning and linkage and logistics infrastructure development (Srivastava, 2011). Fourth, stronger integration increases the need for timely information exchange, shipment visibility, and operational synchronization. The contribution of digital transformation to logistics infrastructure development may consequently become stronger, although differences in digital readiness, system compatibility, and data standards may constrain this relationship (Helo & Thai, 2024). International economic integration is therefore expected to exert a contingent rather than uniform moderating influence across the four relationships.

Existing research nevertheless remains fragmented regarding the joint relationships of institutional support, investment capacity, regional planning and linkage, and digital transformation with logistics infrastructure development in cross-border economic corridors. Evidence is also limited on whether international economic integration

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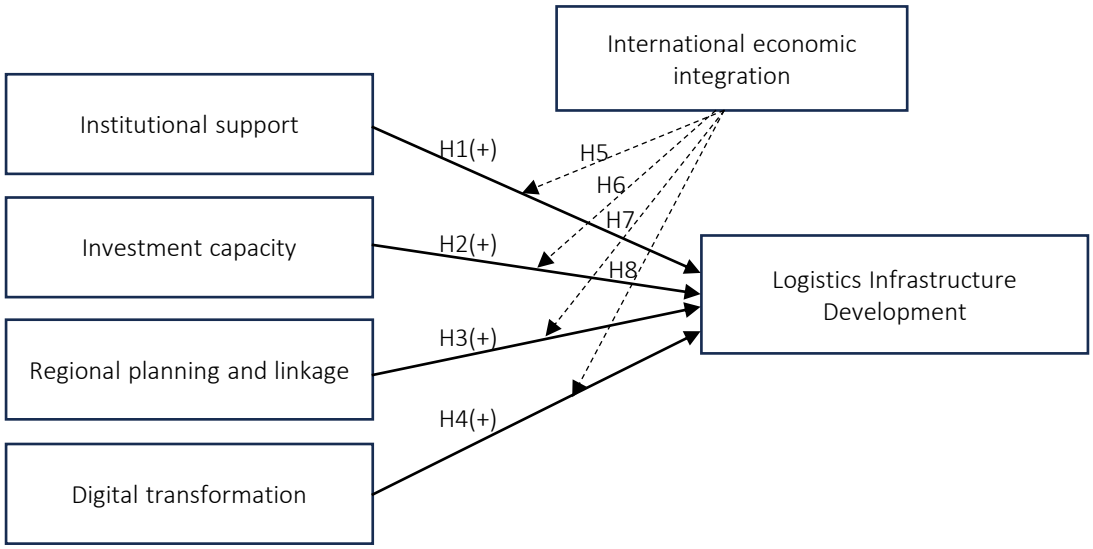

Figure 1. Proposed research framework

strengthens or weakens these relationships along the Vietnamese segment of the EWEC.

This study therefore examines the four hypothesized positive relationships and assesses whether international economic integration changes their strength. Because the theoretical mechanisms allow either strengthening or weakening effects, the moderation hypotheses are formulated without specifying a direction. The proposed research framework is presented in Figure 1. The hypotheses are as follows:

H1: Institutional support is positively associated with logistics infrastructure development along the Vietnamese segment of the EWEC.

H2: Investment capacity is positively associated with logistics infrastructure development along the Vietnamese segment of the EWEC.

H3: Regional planning and linkage are positively associated with logistics infrastructure development along the Vietnamese segment of the EWEC.

H4: Digital transformation is positively associated with logistics infrastructure development along the Vietnamese segment of the EWEC.

H5: International economic integration moderates the relationship between institutional support and logistics infrastructure development along the Vietnamese segment of the EWEC.

H6: International economic integration moderates the relationship between investment capacity and logistics infrastructure development along the Vietnamese segment of the EWEC.

H7: International economic integration moderates the relationship between regional planning and linkage and logistics infrastructure development along the Vietnamese segment of the EWEC.

H8: International economic integration moderates the relationship between digital transformation and logistics infrastructure development along the Vietnamese segment of the EWEC.

2. METHOD

This study adopts a quantitative research design, employing a structured survey to examine the determinants of logistics infrastructure development along the Vietnamese segment of the East–West Economic Corridor (EWEC) and to assess the moderating role of international economic integration. The study uses a cross-sectional survey design, although the respondents' assessments refer to conditions and changes during the 2021–

2025 period. This approach is appropriate because the core constructs, namely institutional support, investment capacity, regional planning and linkage, digital transformation, international economic integration, and logistics infrastructure development, are latent and partly perceptual in nature. These constructs capture institutional conditions, financial capacity, coordination mechanisms, and technological capabilities associated with infrastructure development, which cannot be adequately captured using secondary data alone. Therefore, standardized multi-item scales are required to measure respondents' perceptions and professional assessments regarding logistics infrastructure development within the corridor system. The individual respondent constitutes the unit of observation, whereas the measurement items capture perceived conditions at the corridor level.

The proposed research framework was assessed using partial least squares structural equation modeling (PLS-SEM). This method is particularly suitable for studies involving multiple latent constructs and complex structural relationships, including moderating effects, and is widely applied in logistics and supply chain research for prediction-oriented models and theory development. PLS-SEM also enables the simultaneous assessment of measurement model reliability and validity and the estimation of relationships among latent constructs (Hair et al., 2019).

Data analysis was conducted using SmartPLS 4.1, following a two-step assessment procedure comprising the measurement and structural models (Hair et al., 2022; Ringle et al., 2024). The measurement model assessment focused on indicator loadings, internal consistency reliability (Cronbach's alpha), composite reliability, convergent validity (average variance extracted [AVE]), and discriminant validity (heterotrait–monotrait ratio [HTMT]). The structural model was assessed by examining collinearity through variance inflation factors (VIFs), path coefficients, the coefficient of determination (R^2), and effect sizes (f^2). The moderating effects were specified for the relationships between each of the four predictor constructs (institutional support, investment capacity, regional planning and linkage, and digital transformation) and logistics infrastructure development. SmartPLS automatically generated the corresponding interaction terms and included the constituent main effect of international economic integration on logistics infrastructure development as required for moderation estimation. The interaction effects were estimated using the two-stage approach. Bootstrapping with 5,000 resamples was applied to assess the statistical significance of the direct and moderating effects (Hair et al., 2022).

To examine potential heterogeneity across stakeholder groups, the sample was classified into government agencies, logistics service providers, and infrastructure actors. Measurement invariance was assessed using the measurement invariance of composite models (MICOM) procedure. Configural invariance was ensured by applying identical indicators, data treatment procedures, model specifications, and estimation settings across the groups. Compositional invariance and the equality of composite means and variances were subsequently evaluated. After measurement invariance was established, a permutation-based multi-group analysis was conducted to compare the structural path coefficients across the three stakeholder groups. Pairwise comparisons were performed between government agencies and infrastructure actors, government agencies and logistics service providers, and infrastructure actors and logistics service providers, using 5,000 permutations and a significance level of 0.05.

The target population consisted of stakeholders with direct professional knowledge of logistics infrastructure development and logistics operations along the Vietnamese segment of the EWEC. Because corridor-based logistics infrastructure is shaped by multiple actors, a non-probability purposive sampling strategy was adopted to obtain informed assessments from relevant stakeholder groups. In accordance with the respondent categories specified in the questionnaire, the participants were managers and professionals from government agencies, logistics service providers, and infrastructure actors. The infrastructure-actor group included infrastructure investors or developers, contractors, and operators, representing interconnected roles in infrastructure investment, construction, and operation. These groups represent key actors involved in policy implementation, administrative coordination, infrastructure planning, logistics service provision, financing, investment, construction, and infrastructure operation within the corridor. Respondents were eligible to participate only if they

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had been directly involved in the planning, financing, implementation, operation, management, or professional assessment of logistics infrastructure or logistics activities along the Vietnamese segment of the EWEC and were sufficiently familiar with corridor conditions and changes during 2021–2025. This stakeholder-based sampling approach was appropriate because the study examines system-level and partly perceptual constructs requiring assessments from actors familiar with the institutional and operational dimensions of logistics infrastructure development.

The survey was conducted along the Vietnamese segment of the EWEC, covering Quang Tri province, Hue city, Da Nang city, and other relevant locations along the corridor. A structured questionnaire was administered between November 2025 and March 2026 via both online and in-person distribution to facilitate access for eligible respondents involved in logistics, transport, and infrastructure-related activities. Before the main survey, the draft questionnaire was reviewed by 11 experts from businesses and universities. The experts commented on the clarity of the statements, the appropriateness of the wording, and the contextual relevance of the measurement items to logistics infrastructure development along the Vietnamese segment of the EWEC. Their feedback was used to refine and finalize the questionnaire before its formal administration. The expert review was conducted separately from the main respondent sample.

Participation was entirely voluntary, and respondents were free to decline to answer any individual question or to discontinue the survey at any time. All data were collected anonymously and used solely for academic purposes. The findings were analyzed and reported only in aggregate form to protect the confidentiality of the respondents and their organizations. The questionnaire items were developed and contextually adapted based on the conceptual definitions and prior literature review, with wording refined to ensure relevance to the EWEC context in Vietnam. Each construct was measured using five reflective items on a five-point Likert scale ranging from 1 (strongly disagree) to 5 (strongly agree). To reduce the risk of common method bias, procedural remedies including anonymity assurance, voluntary participation, clear instructions, and neutral item wording were applied during questionnaire development and administration (Podsakoff et al., 2003). The complete survey instrument and item wording are provided in Appendix A.

A total of 312 questionnaires were collected. After screening for missing information, incomplete responses, and inconsistent response patterns, 14 questionnaires were excluded, resulting in 298 valid responses for the final analysis. This represents a valid-response retention rate of approximately 95.5%. As a preliminary assessment of sample adequacy, the 10-times rule was applied to the largest number of structural relationships directed at the endogenous construct. Because logistics infrastructure development received eight hypothesized relationships, comprising four main effects and four interaction effects, this rule indicated a minimum sample size of 80 observations. The final sample of

Table 1. Sample characteristics

Characteristic	Category	Frequency	Percentage (%)
Work experience	Less than 5 years	26	8.72
	5–10 years	147	49.33
	More than 10 years	125	41.95
Type of organization	Government agencies	74	24.83
	Logistics service providers	129	43.29
	Infrastructure actors	95	31.88
Current position	Senior manager/leader	61	20.47
	Middle manager	92	30.87
	Specialist/professional staff	145	48.66
Location of current work	Quang Tri province	79	26.51
	Hue city	87	29.19
	Da Nang city	116	38.93
	Other relevant locations	16	5.37

Note: n = 298.

298 respondents substantially exceeded this threshold and was therefore considered adequate for estimating the proposed PLS-SEM model and testing the hypothesized relationships (Hair et al., 2022).

The descriptive characteristics of the sample are presented in Table 1. Regarding work experience, 91.28% of respondents had at least 5 years of relevant professional experience. Specifically, 49.33% reported between five and ten years of experience, while 41.95% had more than ten years of experience. Only 8.72% had less than five years of experience. This profile indicates that the large majority of respondents possessed substantial professional experience relevant to assessing logistics infrastructure conditions and changes along the corridor. Regarding organizational type, logistics service providers accounted for the largest share, at 43.29%, followed by infrastructure actors (31.88%) and government agencies (24.83%). The participation of these three organizational groups enabled the study to incorporate perspectives from actors involved in infrastructure governance, investment, construction, operation, and logistics service provision.

In terms of current position, specialists and professional staff represented the largest proportion of the sample at 48.66%, followed by middle managers at 30.87% and senior managers or leaders at 20.47%. Thus, more than half of the respondents occupied managerial positions, while the remaining respondents provided professional and operational perspectives. Regarding work location, Da Nang city accounted for the largest share of respondents at 38.93%, followed by Hue city at 29.19% and Quang Tri province at 26.51%. Respondents working in other relevant locations accounted for 5.37% of the sample. This geographical distribution provided coverage of the principal Vietnamese localities associated with logistics, transport, and infrastructure activities along the

Table 2. Reliability and convergent validity

No.	Construct	Indicator	Outer loading	α	CR	AVE
1	Institutional support (IS)	IS1	0.823	0.865	0.903	0.652
		IS2	0.715			
		IS3	0.778			
		IS4	0.823			
		IS5	0.888			
2	Investment capacity (IC)	IC1	0.797	0.835	0.883	0.601
		IC2	0.740			
		IC3	0.753			
		IC4	0.780			
		IC5	0.803			
3	Regional planning and linkage (RP)	RP1	0.793	0.868	0.904	0.654
		RP2	0.816			
		RP3	0.730			
		RP4	0.883			
		RP5	0.814			
4	Digital transformation (DT)	DT1	0.851	0.899	0.926	0.715
		DT2	0.817			
		DT3	0.736			
		DT4	0.885			
		DT5	0.925			
5	Logistics infrastructure development (LID)	LID1	0.849	0.848	0.891	0.622
		LID2	0.773			
		LID3	0.731			
		LID4	0.815			
		LID5	0.770			
6	International economic integration (IEI)	IEI1	0.856	0.900	0.926	0.717
		IEI2	0.819			
		IEI3	0.754			
		IEI4	0.879			
		IEI5	0.916			

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EWEC. Overall, the sample composition supports the assessments' informational relevance and breadth.

3. RESULTS

The reliability and convergent validity of the measurement model were assessed using outer loadings, Cronbach's alpha (α), composite reliability (CR), and average variance extracted (AVE), following established PLS-SEM guidelines (Hair et al., 2022). The results are presented in Table 2.

With respect to indicator reliability, all outer loadings range from 0.715 to 0.925 and therefore exceed the recommended threshold of 0.70 (Hair et al., 2022), indicating adequate indicator reliability across all reflective measurement models. Internal consistency reliability is also established, with Cronbach's alpha values ranging from 0.835 to 0.900 and CR values ranging from 0.883 to 0.926, all of which exceed the recommended minimum value of 0.70.

Convergent validity is supported by AVE values ranging from 0.601 to 0.717, exceeding the recommended threshold of 0.50 (Hair et al., 2022). Accordingly, each construct explains more than half of the variance in its respective indicators. Digital transformation and international economic integration exhibit the highest AVE values, at 0.715 and 0.717, respectively. The remaining constructs also meet the required reliability and convergent validity criteria. Taken together, these results support proceeding to the assessment of discriminant validity and the structural model.

Discriminant validity was examined using the HTMT criterion, which provides a more stringent assessment of construct distinctiveness (Henseler et al., 2015). As shown in Table 3, all HTMT values range from 0.187 to 0.614, which are well below the recommended threshold of 0.85 (Hair et al., 2022). These results confirm that discriminant validity is established and that the constructs are empirically distinct from one another.

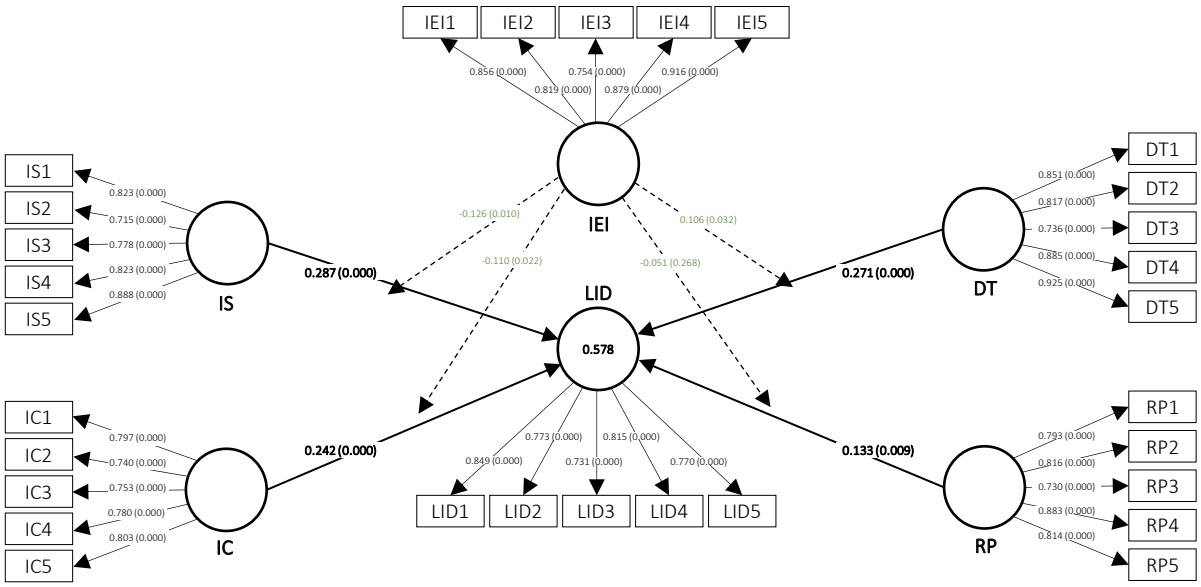
The structural model was assessed using path coefficients, variance inflation factors (VIFs), and bootstrapping with 5,000 resamples to evaluate the statistical significance of the proposed relationships (Hair et al., 2022). As shown in Table 4, all VIF values range from 1.253 to 1.562, well below the recommended critical thresholds and indicating no problematic collinearity among the predictor constructs. All four hypothesized direct relationships are positive and statistically significant, providing support for H1–H4. Institutional support (IS) ($\beta = 0.287$, $p < 0.001$), investment capacity (IC) ($\beta = 0.242$, $p < 0.001$), regional planning and linkage (RP) ($\beta = 0.133$, $p = 0.009$), and digital transformation (DT) ($\beta = 0.271$, $p < 0.001$) are positively associated with logistics infrastructure development. In addition, the constituent main effect of international economic integration on logistics infrastructure development is also positive and statistically significant ($\beta = 0.154$, $p = 0.004$), although it was not separately hypothesized. This path was included as a lower-order component required for estimating the interaction effects. The confirmed research framework based on these estimates is presented in Figure 2.

The moderating effects of international economic integration (IEI) vary in direction and statistical significance across the four hypothesized relationships. Specifically, IEI negatively moderates the relationship between institutional support (IS) and logistics infrastructure development (LID) ($\beta = -0.126$, $p = 0.010$) and the relationship between

Table 3. Discriminant validity (HTMT)

	DT	IC	IEI	IS	LID	RP
DT						
IC	0.383					
IEI	0.559	0.376				
IS	0.339	0.328	0.422			
LID	0.595	0.562	0.593	0.614		
RP	0.384	0.187	0.427	0.375	0.482	

Note: IS = Institutional support; IC = Investment capacity; RP = Regional planning and linkage; DT = Digital transformation; LID = Logistics infrastructure development; IEI = International economic integration.



Note: IS = Institutional support; IC = Investment capacity; RP = Regional planning and linkage; DT = Digital transformation; LID = Logistics infrastructure development; IEI = International economic integration.

Figure 2. Confirmed research framework

Table 4. Structural model results

Hypothesis	Relationship	β	VIF	p-value	Conclusion
H1	IS → LID	0.287	1.338	< 0.001	Supported
H2	IC → LID	0.242	1.264	< 0.001	Supported
H3	RP → LID	0.133	1.285	0.009	Supported
H4	DT → LID	0.271	1.519	< 0.001	Supported
H5	IEI × IS → LID	–0.126	1.267	0.010	Supported (negative)
H6	IEI × IC → LID	–0.110	1.253	0.022	Supported (negative)
H7	IEI × RP → LID	–0.051	1.254	0.268	Not supported
H8	IEI × DT → LID	0.106	1.366	0.032	Supported (positive)

Note: IS = Institutional support; IC = Investment capacity; RP = Regional planning and linkage; DT = Digital transformation; LID = Logistics infrastructure development; IEI = International economic integration.

investment capacity (IC) and logistics infrastructure development (LID) (β = –0.110, p = 0.022). Thus, H5 and H6 are supported, with both interaction effects operating in a negative direction. The moderating effect of IEI on the relationship between regional planning and linkage (RP) and LID is not statistically significant (β = –0.051, p = 0.268); therefore, H7 is not supported. In contrast, IEI positively moderates the relationship between digital transformation (DT) and LID (β = 0.106, p = 0.032), providing support for H8.

The coefficient of determination (R^2) was used to assess the model's explanatory power. As shown in Table 5, the R^2 value for LID is 0.578, with an adjusted R^2 of 0.565. Thus, the predictors and interaction terms included in the structural model jointly explain 57.8% of the variance in logistics infrastructure development. According to commonly applied PLS-SEM guidelines, this result indicates a moderate level of explanatory power for the endogenous construct (Hair et al., 2022).

Table 5. Coefficient of determination (R^2)

Endogenous variable	R^2	Adjusted R^2
Logistics infrastructure development	0.578	0.565

Effect size (f^2) was examined to assess the incremental contribution of each predictor and interaction term to the explained variance of LID. The results are presented in Table 6.

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Table 6. Effect sizes (f2)

Relationship	f^2
IS → LID	0.146
IC → LID	0.110
RP → LID	0.033
DT → LID	0.115
IEI → LID	0.036
IEI × IS → LID	0.030
IEI × IC → LID	0.024
IEI × RP → LID	0.005
IEI × DT → LID	0.020

Note: IS = Institutional support; IC = Investment capacity; RP = Regional planning and linkage; DT = Digital transformation; LID = Logistics infrastructure development; IEI = International economic integration.

Among the direct relationships, institutional support makes the largest incremental contribution to the explained variance in LID (f^2 = 0.146), followed by digital transformation (f^2 = 0.115) and investment capacity (f^2 = 0.110). Regional planning and linkage (f^2 = 0.033) and international economic integration (f^2 = 0.036) make smaller contributions. Based on Cohen's (2013) conventional benchmarks of 0.02, 0.15, and 0.35 for small, medium, and large effect sizes, respectively, the direct effects are generally small, although the effect of institutional support (f^2 = 0.146) approaches the medium-effect threshold. The interaction effects are also small, with f^2 values of 0.030 for IEI × IS, 0.024 for IEI × IC, and 0.020 for IEI × DT. The IEI × RP interaction has a negligible effect size (f^2 = 0.005), consistent with its statistically insignificant path coefficient. Overall, the effect-size results indicate that the model's explanatory power is distributed across several predictors rather than being dominated by a single relationship.

Full measurement invariance was established for all constructs in each of the three pairwise stakeholder-group comparisons, thereby supporting meaningful comparisons of the structural path coefficients. The complete MICOM results for the three pairwise comparisons are reported in Appendix B (Tables B1–B3), while the complete permutation-based multigroup analysis results are reported in Appendix C (Tables C1-C3). As shown in Table 7, most structural relationships did not differ significantly across government agencies, logistics service providers, and infrastructure actors. A statistically significant difference was identified only in the relationship between institutional support and logistics infrastructure development when government agencies were compared with infrastructure actors. This relationship was stronger for government agencies (β = 0.356) than for infrastructure actors (β = 0.096), with a coefficient difference of 0.260 (p = 0.028). No significant structural differences were found between government agencies and logistics service providers or between infrastructure actors and logistics service providers.

Overall, the results indicate that the pooled structural model was broadly stable across stakeholder groups, although limited heterogeneity was observed in the institutional-support relationship.

4. DISCUSSION

This study's findings provide important insights into the structural determinants of logistics infrastructure development in corridor-based economies and the conditional role of international economic integration. Overall, the results support a systemic, corridor-level understanding of logistics infrastructure development, in which institutional, financial, spatial, and technological conditions operate jointly rather than as isolated macro-level factors. These results are consistent with the systemic perspective emphasized in prior studies on logistics and trade infrastructure (Arvis et al., 2023; Francois & Manchin, 2013).

Table 7. Summary of measurement invariance and permutation-based MGA

Pairwise comparison	MICOM result	Significant difference in path coefficients	Group coefficients	Difference	p-value
GA vs. IA	Full measurement invariance	IS → LID	0.356 vs. 0.096	0.260	0.028
GA vs. LSP	Full measurement invariance	No significant differences	–	–	–
IA vs. LSP	Full measurement invariance	No significant differences	–	–	–

Note: All other pairwise differences in the direct and moderating relationships were statistically insignificant at the 5% level. GA = government agencies; LSP = logistics service providers; IA = infrastructure actors.

The results indicate that institutional support, investment capacity, regional planning and linkage, and digital transformation are all positively and statistically significantly associated with logistics infrastructure development. This finding aligns with previous research suggesting that infrastructure effectiveness depends not only on physical investment but also on governance quality, financial resources, and coordination mechanisms (North, 1990; ADB, 2010; Portugal-Perez & Wilson, 2012). Among these factors, institutional support and digital transformation exhibit the strongest relationships with logistics infrastructure development. The strong role of digital transformation aligns with recent studies emphasizing that digitalization enhances visibility, coordination, and integration in logistics systems, particularly in complex and fragmented environments (Cichosz et al., 2020; Helo & Thai, 2024). Similarly, the significant contribution of institutional support reinforces earlier findings that regulatory quality, policy coordination, and administrative efficiency are critical for reducing trade frictions and improving logistics performance (Hoekman & Nicita, 2011; Dang & Yeo, 2018).

The moderating effects of international economic integration reveal a nuanced and asymmetric pattern. While previous research generally emphasizes the enabling role of economic integration in trade and infrastructure development (Francois & Manchin, 2013), the present findings show that its conditional influence varies across the institutional, financial, planning, and digital relationships examined in the model. Specifically, international economic integration negatively moderates the relationships between institutional support and logistics infrastructure development and between investment capacity and logistics infrastructure development. The negative interaction coefficients indicate that the two positive relationships become weaker as international economic integration increases. This finding contrasts with the conventional expectation that integration strengthens institutional effectiveness and investment outcomes. One possible explanation is that deeper integration exposes institutional inconsistencies, regulatory misalignment, and coordination gaps across jurisdictions, as highlighted in corridor-based development studies (ADB, 2010). Similarly, integration may increase the scale and complexity of infrastructure financing requirements and reveal mismatches between available financial capacity and expanding cross-border demand, thereby weakening the extent to which investment capacity is translated into logistics infrastructure development. International economic integration may therefore operate as a stress mechanism that exposes structural limitations rather than uniformly reinforcing existing institutional and financial capabilities.

In contrast, international economic integration positively moderates the relationship between digital transformation and logistics infrastructure development. This finding is consistent with studies emphasizing that digital technologies play a critical enabling role in integrated logistics systems by facilitating real-time information exchange, coordination, and traceability (Cichosz et al., 2020; Helo & Thai, 2024). Under stronger integration conditions, the need for cross-border synchronization increases, making digital transformation more consequential for the advancement, coordination, and modernization of logistics infrastructure along the corridor.

The moderating effect of international economic integration on regional planning and linkage is not statistically significant. This finding does not diminish the importance of regional planning and linkage, whose direct relationship with logistics infrastructure development remains positive and statistically significant. Rather, it indicates that the strength of this relationship does not change significantly across different levels of international economic integration. Despite its theoretical importance in corridor development (Srivastava, 2011; Brunner, 2013), regional planning may remain constrained by institutional fragmentation and administrative boundaries. As a result, deeper integration alone may not be sufficient to strengthen the contribution of regional planning and linkage to infrastructure development without corresponding improvements in cross-border governance and coordination mechanisms.

The stakeholder-group analysis further supports the general robustness of the structural results. Full measurement invariance was established

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for all constructs in each of the three pairwise comparisons, and most structural relationships did not differ significantly across stakeholder groups. The only significant difference was observed in the relationship between institutional support and logistics infrastructure development, which was stronger for government agencies than for infrastructure actors. This limited heterogeneity suggests that the perceived relevance of institutional support may differ between public-sector respondents and actors directly involved in infrastructure investment, construction, and operation, while the broad stability of the remaining relationships supports the use of the pooled model. Taken together, these findings extend corridor-level infrastructure research by showing that international economic integration conditions structural relationships asymmetrically, with its implications depending on institutional alignment, financial adaptability, coordination capacity, and technological readiness.

CONCLUSION

This study examines the determinants of logistics infrastructure development along the Vietnamese segment of the East–West Economic Corridor (EWEC), with a focus on the moderating role of international economic integration. The results show that institutional support, investment capacity, regional planning and linkage, and digital transformation are all positively and significantly associated with logistics infrastructure development. Among these conditions, institutional support and digital transformation exhibit the strongest relationships.

International economic integration exerts an asymmetric moderating role. International economic integration weakens the positive relationships of institutional support and investment capacity with logistics infrastructure development, while strengthening the positive relationship between digital transformation and logistics infrastructure development. No statistically significant moderating effect is observed in the relationship between regional planning and linkage and logistics infrastructure development. These results indicate that international economic integration should not be understood as a uniformly enabling condition, as its implications vary across the structural capabilities that support infrastructure development.

From a policy perspective, improving infrastructure along the Vietnamese segment of the EWEC requires a more supportive and coordinated institutional environment, stronger and more adaptable financing capacity, coherent corridor-wide planning, and greater emphasis on digital transformation. In particular, policy efforts should focus on strengthening public-sector coordination, ensuring the timely and sustained mobilization of financial resources for viable infrastructure projects, improving interregional planning mechanisms, and accelerating the adoption of connected digital systems, interoperable data-exchange mechanisms, real-time operational information, and data analytics across logistics nodes. These priorities are especially important as deeper international economic integration increases the institutional, financial, coordination, and technological requirements placed on the corridor's logistics infrastructure system.

This study is limited by its cross-sectional design and focus on the Vietnamese segment of the corridor. Because the analysis is based on perceptual assessments collected through purposive sampling, the findings should not be interpreted as establishing causal relationships or automatically generalized to all stakeholder populations and economic corridors. Future research could adopt longitudinal approaches, combine perceptual measures with objective infrastructure and trade indicators, and conduct comparative analyses across different segments or economic corridors to examine the temporal and contextual stability of the identified relationships.

AUTHOR CONTRIBUTIONS

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Writing – review & editing: Can Tat Linh, Tuan The Tran, Nguyen Hung Cuong, Trinh Thi Thu Huong, Vu Tuan Anh.

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APPENDIX A. SURVEY

Dear Participant,

This survey is part of an academic study examining the relationships between institutional support, investment capacity, regional planning and linkage, digital transformation, international economic integration, and logistics infrastructure development along the Vietnamese segment of the East–West Economic Corridor (EWEC).

Your participation will contribute to a better understanding of the conditions associated with logistics infrastructure development in the context of regional connectivity and cross-border economic activities.

Participation is voluntary. You may decline to answer any question or discontinue the survey at any time. All responses will be kept confidential and used solely for academic purposes. Findings will be reported only in aggregated form, and no individual respondent or organization will be identifiable.

Thank you for your time and cooperation.

PART 1: Respondent profile

1. Gender:

☐ Male
☐ Female

2. Age:

☐ Under 30
☐ 30 – 40
☐ 41 – 50
☐ Over 50

3. Type of organization:

☐ Government agency
☐ Logistics service provider
☐ Infrastructure actor (investor/developer, contractor, or operator)

4. Current position:

☐ Senior manager/leader
☐ Middle manager
☐ Specialist/professional staff

5. Years of relevant professional experience in logistics infrastructure, transport, logistics operations, corridor development, or related fields:

☐ Less than 5 years
☐ 5 – 10 years
☐ More than 10 years

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6. Location of current work:

☐ Quang Tri province
☐ Hue city
☐ Da Nang city
☐ Other (please specify): ……

7. Have you been directly involved in the planning, financing, implementation, operation, management, or professional assessment of logistics infrastructure or logistics activities along the Vietnamese segment of the EWEC?

☐ Yes (proceed to question 8)
☐ No (end the survey)

8. Are you sufficiently familiar with conditions and changes along the Vietnamese segment of the EWEC during 2021–2025 to provide an informed assessment?

☐ Yes (proceed to Part 2)
☐ No (end the survey)

PART 2: Assessment of conditions related to logistics infrastructure development

Please indicate the extent to which you agree with each statement based on your direct professional knowledge and experience. Unless otherwise specified, all statements refer to conditions along the Vietnamese segment of the EWEC during the 2021–2025 period. Responses are measured on a five-point Likert scale, where 1 indicates *strong disagreement* and 5 indicates *strong agreement*.

No.	Statements	Code	1	2	3	4	5
	1. Institutional support (IS)						
1.1	Public authorities demonstrated clear commitment to logistics infrastructure development along the corridor.	IS1					
1.2	Public authorities maintained consistent support for logistics infrastructure development over time.	IS2					
1.3	Public authorities provided timely assistance when logistics infrastructure initiatives encountered institutional or administrative obstacles.	IS3					
1.4	Public authorities effectively addressed institutional issues affecting logistics infrastructure initiatives.	IS4					
1.5	Overall, the institutional environment was supportive of logistics infrastructure development along the corridor.	IS5					
	2. Investment capacity (IC)						
2.1	Sufficient financing could be secured for viable logistics infrastructure projects.	IC1					
2.2	Financing for logistics infrastructure projects was available when it was required.	IC2					
2.3	Funding for logistics infrastructure projects remained stable throughout project implementation.	IC3					
2.4	Additional financing could be mobilized when additional project funding needs arose.	IC4					
2.5	Overall, financing capacity for logistics infrastructure development was reliable.	IC5					
	3. Regional planning and linkage (RP)						
3.1	Logistics infrastructure planning across EWEC localities followed common corridor-wide objectives.	RP1					
3.2	Logistics infrastructure plans of different EWEC localities were mutually aligned.	RP2					
3.3	The sequencing of major logistics infrastructure initiatives was coordinated across EWEC localities.	RP3					
3.4	Connections among major logistics nodes were planned as parts of an integrated corridor network.	RP4					
3.5	Overall, regional planning supported coherent logistics infrastructure linkages throughout the corridor.	RP5					
	4. Digital transformation (DT)						
4.1	Digital systems were routinely used in logistics infrastructure operations along the corridor.	DT1					

No.	Statements	Code	1	2	3	4	5
4.2	Organizations involved in corridor logistics exchanged operational data through connected digital systems.	DT2					
4.3	Digital processes were integrated across major logistics nodes along the corridor.	DT3					
4.4	Real-time digital information was routinely used to coordinate logistics operations.	DT4					
4.5	Data analytics were routinely used to support logistics infrastructure planning and operational decisions.	DT5					
	5. Logistics infrastructure development (LID)						
5.1	Logistics infrastructure along the Vietnamese segment of the EWEC advanced substantially during 2021–2025.	LID1					
5.2	By 2025, the level of logistics infrastructure development along the corridor was clearly higher than in 2021.	LID2					
5.3	Logistics infrastructure improvements were broadly evident along the Vietnamese segment of the EWEC during 2021–2025.	LID3					
5.4	Improvements in logistics infrastructure were sustained throughout the 2021–2025 period.	LID4					
5.5	Logistics infrastructure along the corridor became substantially more modern during 2021–2025.	LID5					
	6. International economic integration (IEI)						
6.1	Economic and logistics activities along the corridor were strongly connected to regional and international markets.	IEI1					
6.2	Cross-border trade and logistics activities along the corridor were intensive.	IEI2					
6.3	Organizations operating along the corridor were strongly embedded in regional production and supply networks.	IEI3					
6.4	International trade and investment linkages were prominent in economic activities along the corridor.	IEI4					
6.5	Overall, the Vietnamese segment of the EWEC operated as a highly integrated cross-border economic space.	IEI5					

Thank you for your participation.

APPENDIX B

Table B1. MICOM results: Government agencies versus Infrastructure actors

Construct	Step 2 p-value	Step 3a p-value	Step 3b p-value	Invariance conclusion
DT	0.247	0.268	0.650	Full invariance
IC	0.931	0.241	0.884	Full invariance
IEI	0.720	0.804	0.425	Full invariance
IS	0.180	0.693	0.599	Full invariance
LID	0.962	0.683	0.651	Full invariance
RP	0.694	0.641	0.384	Full invariance

Note: IS = Institutional support; IC = Investment capacity; RP = Regional planning and linkage; DT = Digital transformation; LID = Logistics infrastructure development; IEI = International economic integration.

Table B2. MICOM results: Government agencies versus Logistics service providers

Construct	Step 2 p-value	Step 3a p-value	Step 3b p-value	Invariance conclusion
DT	0.885	0.772	0.401	Full invariance
IC	0.725	0.775	0.102	Full invariance
IEI	0.525	0.198	0.455	Full invariance
IS	0.834	0.747	0.736	Full invariance
LID	0.144	0.865	0.138	Full invariance
RP	0.484	0.501	0.308	Full invariance

Note: IS = Institutional support; IC = Investment capacity; RP = Regional planning and linkage; DT = Digital transformation; LID = Logistics infrastructure development; IEI = International economic integration.

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Table B3. MICOM results: Logistics service providers versus Infrastructure actors

Construct	Step 2 p-value	Step 3a p-value	Step 3b p-value	Invariance conclusion
DT	0.265	0.115	0.813	Full invariance
IC	0.154	0.291	0.113	Full invariance
IEI	0.652	0.259	0.993	Full invariance
IS	0.449	0.922	0.827	Full invariance
LID	0.302	0.498	0.304	Full invariance
RP	0.956	0.930	0.649	Full invariance

Note: IS = Institutional support; IC = Investment capacity; RP = Regional planning and linkage; DT = Digital transformation; LID = Logistics infrastructure development; IEI = International economic integration.

APPENDIX C

Table C1. Government agencies versus Infrastructure actors

Relationship	Government agencies	Infrastructure actors	Difference	2.5%	97.5%	p-value
DT → LID	0.335	0.336	–0.001	–0.260	0.273	0.993
IC → LID	0.273	0.383	–0.110	–0.227	0.224	0.349
IEI → LID	0.094	0.163	–0.069	–0.271	0.267	0.625
IEI × DT → LID	0.198	0.004	0.194	–0.321	0.301	0.230
IEI × IC → LID	0.044	–0.135	0.179	–0.265	0.264	0.188
IEI × IS → LID	–0.082	–0.094	0.012	–0.257	0.249	0.932
IEI × RP → LID	–0.118	–0.044	–0.074	–0.282	0.290	0.620
IS → LID	0.356	0.096	0.260	–0.227	0.229	0.028
RP → LID	0.112	0.136	–0.024	–0.260	0.252	0.864

Note: IS = Institutional support; IC = Investment capacity; RP = Regional planning and linkage; DT = Digital transformation; LID = Logistics infrastructure development; IEI = International economic integration.

Table C2. Government agencies versus Logistics service providers

Relationship	Government agencies	Logistics service providers	Difference	2.5%	97.5%	p–value
DT → LID	0.335	0.238	0.098	–0.245	0.270	0.458
IC → LID	0.273	0.254	0.019	–0.227	0.226	0.310
IEI → LID	0.094	0.178	–0.084	–0.286	0.275	0.553
IEI × DT → LID	0.198	0.146	0.052	–0.258	0.238	0.673
IEI × IC → LID	0.044	–0.173	0.217	–0.254	0.252	0.102
IEI × IS → LID	–0.082	–0.149	0.067	–0.233	0.230	0.609
IEI × RP → LID	–0.118	–0.042	–0.076	–0.222	0.218	0.505
IS → LID	0.356	0.281	0.075	–0.211	0.203	0.972
RP → LID	0.112	0.130	–0.018	–0.267	0.279	0.914

Note: IS = Institutional support; IC = Investment capacity; RP = Regional planning and linkage; DT = Digital transformation; LID = Logistics infrastructure development; IEI = International economic integration.

Table C3. Infrastructure actors versus Logistics service providers

Relationship	Infrastructure actors	Logistics service providers	Difference	2.5%	97.5%	p–value
DT → LID	0.336	0.238	0.099	–0.261	0.274	0.485
IC → LID	0.383	0.254	0.129	–0.216	0.204	0.302
IEI → LID	0.163	0.178	–0.015	–0.282	0.262	0.912
IEI × DT → LID	0.004	0.146	–0.142	–0.258	0.261	0.278
IEI × IC → LID	–0.135	–0.173	0.037	–0.244	0.260	0.773
IEI × IS → LID	–0.094	–0.149	0.055	–0.257	0.265	0.686
IEI × RP → LID	–0.044	–0.042	–0.002	–0.232	0.244	0.986
IS → LID	0.096	0.281	–0.185	–0.205	0.206	0.106
RP → LID	0.136	0.130	0.006	–0.235	0.243	0.964

Note: IS = Institutional support; IC = Investment capacity; RP = Regional planning and linkage; DT = Digital transformation; LID = Logistics infrastructure development; IEI = International economic integration.