

Multidimensional seaport connectivity and competitiveness: evidence from Ho Chi Minh City, Vietnam

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Abstract

Purpose – This study evaluates the impact of multidimensional seaport connectivity, which consists of hinterland connectivity (SHC), maritime connectivity (SMC), digital connectivity (DCN) and sustainable connectivity (SUC), on customer satisfaction and seaport competitiveness. Furthermore, it assesses the moderating effect of government institutional support (GIS) on these relationships.

Design/methodology/approach – A mixed-method approach was adopted, combining a literature review, expert interviews and a quantitative survey. Data were collected from 406 enterprises involved in port-related logistic activities in Vietnam. Partial least squares structural equation modeling was employed to test the proposed relationships and moderation effects.

Findings – The results reveal that hinterland connectivity, digital connectivity and sustainable connectivity positively influence both customer satisfaction and seaport competitiveness. In contrast, maritime connectivity has a significant direct effect on competitiveness but does not directly affect customer satisfaction. The moderating effect of GIS was insignificant in most relationships, except for sustainable connectivity, where GIS moderated the relationship so the positive impact on customer satisfaction persisted across levels, although with reduced magnitude at higher GIS.

Originality/value – This study develops a novel conceptualization of seaport connectivity by introducing a multidimensional framework beyond the traditional focus on hinterland and maritime connectivity. It defines and incorporates digital connectivity and sustainable connectivity as two new strategic dimensions. This reflects current demands of digitalization and sustainability in port development and offers guidance for policymakers in formulating integrated connectivity strategies and institutional support.

Keywords Hinterland connectivity, Maritime connectivity, Digital connectivity, Sustainable connectivity, Seaport connectivity, Competitiveness

Paper type Research article

1. Introduction

Seaports are not merely physical interfaces between land and sea. They play a central role in global logistics systems and international supply chains. Acting as integrated platforms, ports serve multiple strategic functions, including cargo transshipment, container handling, production support and the delivery of value-added logistic services. In the context of accelerating globalization and increasing competition, the extent of seaport connectivity, which refers to the port's linkages with transportation infrastructure and participants in the supply chain, has become a vital factor that shapes both operational efficiency and the competitive position of ports.

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In Vietnam, the seaport system in Ho Chi Minh City (HCMC) plays a pivotal role in facilitating international trade, owing to its strategic position along major maritime routes that connect East Asia with Europe, the Middle East and North America. As the largest seaport cluster in the country in terms of cargo throughput and economic significance, it accommodates diverse cargo types through key facilities such as Cat Lai Terminal, Hiep Phuoc Port and specialized terminals for container, bulk and liquid cargo. These ports serve dual roles as gateway and transshipment hubs, forming the backbone of maritime trade for the Southern Key Economic Region. In this study, the research scope covers the entire HCMC seaport cluster, including its principal container and general cargo terminals. Nevertheless, the system continues to face significant challenges, including fragmented and unsynchronized infrastructure, limited automation and internal inefficiencies driven by competition among small-scale terminals. These characteristics make HCMC's seaport system a compelling context for examining the multidimensional nature of port connectivity and its implications for competitiveness.

In recent years, the relationship between seaport connectivity and competitiveness has received increasing attention from scholars (Jouili, 2019; IDB, 2013; Parola *et al.*, 2017; Yu *et al.*, 2023). To provide a comprehensive and updated overview of related research directions, this study conducted a bibliographic coupling analysis based on 391 articles written in English and indexed in the Scopus database. The findings reveal that studies on port competitiveness are grouped into eight main research themes, among which topics related to connectivity such as port connectivity, port choice and network analysis have become particularly prominent since 2020.

However, most previous studies have primarily focused on hinterland and maritime connectivity from a physical or operator-oriented perspective, without fully reflecting the evolving requirements of modern port systems in the context of digital transformation and sustainable development. Moreover, the specific mechanisms through which port connectivity influences competitiveness, especially via customer satisfaction, remain underexplored in existing quantitative models.

To address this research gap, the present study aims to develop and empirically test a multidimensional model of seaport connectivity, encompassing four key dimensions: hinterland connectivity, maritime connectivity, digital connectivity and sustainable connectivity. The model investigates the impact of these connectivity dimensions on customer satisfaction and port competitiveness. In addition, the study examines the moderating role of government institutional support (GIS) in these relationships, with a particular focus on emerging seaport markets such as Vietnam.

The remainder of the paper is structured as follows: [Section 2](#) reviews the relevant literature and defines key concepts. [Section 3](#) outlines the research methodology. [Section 4](#) presents the empirical results. [Section 5](#) discusses the findings and proposes policy implications. [Section 6](#) concludes the study, highlighting its limitations and suggesting directions for future research.

2. Literature reviews and research model

2.1 Research concepts

2.1.1 Seaport connectivity. In the field of transportation, connectivity refers to the ease of access between network nodes and the efficiency of moving goods or people from origin to destination, regardless of mode (Rietveld, 1995; Paleari *et al.*, 2010). In freight transport, it is closely tied to market accessibility. Despite its acknowledged significance, measuring connectivity remains complex due to the varying objectives of related investments (ESCAP, 2019).

Extending the general concept of connectivity to the maritime context, several studies have identified seaport connectivity as a key indicator of a port's position within the container shipping network, measured by transport time and capacity (Jiang *et al.*, 2015) and reflecting its ability to attract frequent services to various global destinations (Jouili, 2019; IDB, 2013). Many studies conceptualize seaport connectivity in two dimensions: hinterland connectivity and maritime connectivity. Together with port efficiency, these dimensions enhance

accessibility and significantly contribute to port competitiveness (Arvis *et al.*, 2018; Indriastiwi *et al.*, 2021; Parola *et al.*, 2017; Yu *et al.*, 2023).

The hinterland dimension depends on multimodal networks extending from ports into inland areas (Arvis *et al.*, 2018; Parola *et al.*, 2017; Wang *et al.*, 2016) or on integration with key logistics nodes within the hinterland (Álvarez-SanJaime *et al.*, 2015; Deshmukh and Song, 2023; Hien *et al.*, 2025). It is often described in two layers: directly linked nodes via rails, roads or inland waterways and indirectly linked nodes through intermediary hubs (Deshmukh and Song, 2023).

The maritime dimension depends largely on shipping lines' port selection decisions (Martinez-Moya *et al.*, 2024; Low *et al.*, 2009) and encompasses both port–carrier linkages and inter-port networks, which reflect the extent to which a port is connected to others within the global shipping network (Arvis *et al.*, 2018; Indriastiwi *et al.*, 2021).

However, the two aforementioned dimensions mainly focus on physical connectivity, which is no longer sufficient to address the evolving demands on port systems in the era of digital transformation and sustainable development. Recent studies have highlighted that digital connectivity is essential for optimizing operations, reducing costs and improving service performance at seaports (Carlan *et al.*, 2017; Heilig *et al.*, 2017; Karlsson *et al.*, 2023). For ports, aligning digital strategies among stakeholders across multiple levels can create synergetic effects and strengthen overall connectivity (Heilig *et al.*, 2017; Karlsson *et al.*, 2023; Lind *et al.*, 2020).

In practice, logistic firms and ports are increasingly adopting solutions such as online booking systems, vessel traffic management platforms and IoT-enabled technologies to streamline operations. Digital connectivity also entails developing real-time data-sharing platforms among ports, shipping lines, inland carriers and cargo owners (Heilig *et al.*, 2017; Paraskevas *et al.*, 2024; Zeng *et al.*, 2025). Higher levels of digitalization enable faster customer interaction, greater transparency and reduced waiting times, thereby improving user experience and enhancing port competitiveness (Karlsson *et al.*, 2023; Paraskevas *et al.*, 2024).

In parallel, growing environmental regulations and sustainability demands have brought sustainable connectivity to the forefront of seaport development. This dimension extends beyond port operations to include interactions with inland and maritime transport systems (Alamouh *et al.*, 2021; Laxe *et al.*, 2017; Oh *et al.*, 2018; Roh *et al.*, 2016). Ports play a pivotal role in greening supply chains (Asgari *et al.*, 2015; Notteboom *et al.*, 2020), accelerating environmental upgrades (Poulsen *et al.*, 2018) and integrating sustainability across environmental, economic and social domains (Stoddart *et al.*, 2011; Mensah and Enu-Kwesi, 2018; Koberg and Longoni, 2019). Practical measures include shore power, low-emission transport modes and traffic flow planning to reduce congestion and carbon emissions (Acciaro *et al.*, 2014; Lam and Notteboom, 2014; Rogosic *et al.*, 2025). Integrating such measures not only meets environmental policy requirements but also strengthens a port's appeal to shipping lines and customers prioritizing sustainability in supply chain decisions.

Therefore, in order to align with emerging trends in logistics and maritime transport, it is essential to expand the concept of seaport connectivity into a multidimensional framework. This should include hinterland connectivity, maritime connectivity, digital connectivity and sustainable connectivity, thereby fully reflecting the central role of seaports within modern logistic networks.

2.1.2 Customer satisfaction. Customer satisfaction can be defined as an overall emotional response that arises from comparing pre-service expectations and post-service experiences. This perspective is supported by foundational studies, which suggest that satisfaction occurs when service outcomes meet or exceed customer expectations (Oliver, 1993; Thai, 2016; Yeo *et al.*, 2015). Service pricing plays a significant role in shaping perceptions of service quality, satisfaction and perceived value (Roh *et al.*, 2025). Satisfied customers are more likely to become brand advocates, recommend a company's services to others and contribute to its distinctiveness in a competitive market. This favorable market environment serves as a foundation for sustained growth and long-term success (Brunner *et al.*, 2025).

2.1.3 Seaport competitiveness. Seaport competitiveness is a complex issue that cannot always be fully explained through easily identifiable and quantifiable factors (Notteboom, 2009). From a macroeconomic perspective, seaport competitiveness is often defined in terms of a port's relative position compared to other ports and its contribution to the socioeconomic development of the surrounding region (Huybrechts *et al.*, 2002; Meersman *et al.*, 2009). This approach emphasizes the port's role as a catalyst for regional value creation and serves as a foundation for policy-making in port system development.

However, from a micro-level perspective, particularly from the viewpoint of customers and supply chain stakeholders, seaport competitiveness is closely associated with the ability of a port to optimize total logistics costs (De Martino, 2018). Ports that can minimize transportation costs, time and risks throughout the logistics chain tend to be favored as port-of-call choices. Accordingly, seaport competitiveness is also defined as a port's ability to provide efficient and reliable services that meet domestic and international market expectations at a reasonable cost (Da Cruz, 2012; Kaliszewski *et al.*, 2020; Yeo and Song, 2006).

Based on the literature reviewed, studies on seaport connectivity have mainly addressed its physical aspects, namely hinterlands and maritime dimensions, with limited attention to digital and sustainable dimensions in developing countries. Empirical evidence on how connectivity influences competitiveness through customer satisfaction is scarce and the moderating role of GIS is rarely examined. Quantitative studies from Southeast Asian ports, particularly HCMC, are also limited. These gaps call for a comprehensive, multidimensional approach that better reflects the complexity of modern port systems.

2.2 Hypothesis development

2.2.1 The relationship between seaport connectivity and seaport competitiveness. The structure conduct performance (SCP) paradigm has long served as a foundational framework in the study of market organization and business strategy, particularly in explaining how firms compete with one another. SCP is commonly adopted as a theoretical basis for formulating competition policy (Ferguson and Ferguson, 1994). This model was later extended by Grover and Dresner (2022), who incorporated the dimension of competitiveness and emphasized the influence of multiple stakeholders such as suppliers, customers and regulatory authorities on corporate behavior. This extended approach has been applied in the maritime sector, notably in the study by Yap and Yang (2024), which explored how the behavior of shipping lines influences the competitiveness of container ports.

In this context, maritime connectivity is recognized as a crucial factor that contributes to enhancing seaport competitiveness by attracting more shipping services and expanding linkages with destination ports (Kannika *et al.*, 2019; Lam and Yap, 2011; Martinez-Moya *et al.*, 2024). At the same time, hinterland connectivity has long played a strategic role in strengthening a port's ability to serve its inland markets, thereby improving operational efficiency and competitive standing (Deshmukh and Song, 2023; Pietrzak *et al.*, 2020; Tarkowski *et al.*, 2021; Tovar and Wall, 2022).

In addition to these traditional dimensions, digital connectivity is increasingly seen as an essential element for port competitiveness (Heilig *et al.*, 2017). Higher levels of digital connectivity can reduce inefficiencies and resource waste by enabling better coordination, more streamlined operations and quicker responses to changes. These improvements support more sustainable growth in competitiveness (Heilig *et al.*, 2017; Karlsson *et al.*, 2023). Moreover, ports must also strike a balance between commercial and economic expansion and environmental and social sustainability in order to maintain long-term competitiveness (Alamouh *et al.*, 2021; Lind *et al.*, 2020; Stein and Acciaro, 2020).

Accordingly, the following hypotheses are proposed:

H1a. Hinterland connectivity has a positive effect on seaport competitiveness.

H2a. Maritime connectivity has a positive effect on seaport competitiveness.

H3a. Digital connectivity has a positive effect on seaport competitiveness.

H4a. Sustainable connectivity has a positive effect on seaport competitiveness.

2.2.2 The relationship between seaport connectivity and customer satisfaction. According to stakeholder theory, organizations must take into account the interests and expectations of various stakeholder groups when formulating and implementing strategic decisions (Freeman and Reed, 1983). These interests represent a diverse set of needs, expectations and values that organizations are expected to address (Harrison and John, 1994).

In the context of intensifying competition, many ports have adopted a customer-centric approach, placing emphasis on communication and collaboration between logistics service providers and inland shippers (Yeo *et al.*, 2015). This approach aims to enhance both productivity and the overall customer experience. Ports that maintain efficient hinterland connections and establish strong linkages with other ports are generally perceived by customers as more convenient and reliable within the supply chain (Roh *et al.*, 2025). In addition, high levels of digitalization – including single-window systems, real-time data access and supply chain integration – have been shown to improve transparency and transactional efficiency, thereby enhancing customer satisfaction (Brunner *et al.*, 2025; Lee *et al.*, 2016; Roh *et al.*, 2025). Furthermore, corporate social responsibility initiatives undertaken by port authorities can enhance the port's public image, which in turn positively influences service quality and customer satisfaction (Thai, 2016; Alamoush *et al.*, 2021).

Based on the above arguments, the following hypotheses are proposed:

H1b. Hinterland connectivity has a positive effect on customer satisfaction.

H2b. Maritime connectivity has a positive effect on customer satisfaction.

H3b. Digital connectivity has a positive effect on customer satisfaction.

H4b. Sustainable connectivity has a positive effect on customer satisfaction.

2.2.3 The relationship between customer satisfaction and seaport competitiveness. According to stakeholder theory, fulfilling the expectations and needs of customers is a prerequisite for improving organizational performance and gaining a competitive advantage (Freeman *et al.*, 2010). As seaports increasingly serve as critical nodes within global supply chains, customer satisfaction, which includes the perspectives of shippers, shipping lines and logistics service providers, has become an essential factor in sustaining long-term competitiveness.

Studies on customer satisfaction have primarily focused on its outcomes, such as customer retention, positive word-of-mouth and reduced switching behavior. These studies consistently highlight a strong association between satisfaction and competitiveness (Baumann *et al.*, 2012; Chen, 2015; Curtis *et al.*, 2011; Gil-Saura *et al.*, 2018; Kumar *et al.*, 2013; Suchanek and Kralova, 2019). In service industries, customer satisfaction is often regarded as a critical input that strengthens brand perception and attracts new clients, thereby expanding market share (Lee *et al.*, 2016; McKinney *et al.*, 2002; Subramanian *et al.*, 2014). When seaports accelerate digital transformation and deliver services aligned with customer expectations, customer satisfaction tends to increase, thereby enhancing port image, strengthening competitive advantage and broadening market reach (Lee *et al.*, 2016). These findings suggest that customer satisfaction may serve as a strategic lever in promoting seaport competitiveness (Almofeez *et al.*, 2024).

Based on this reasoning, the following hypothesis is proposed:

H5. Customer satisfaction has a positive effect on seaport competitiveness.

2.2.4 The moderating role of government institutional support in the relationship between seaport connectivity and customer satisfaction. GIS is recognized as a critical moderating factor that enhances the effectiveness of multiple dimensions of seaport connectivity. These

dimensions include hinterland connectivity, maritime connectivity, digital connectivity and sustainable connectivity, all of which influence customer satisfaction. Based on stakeholder theory (Freeman, 1984), a seaport functions not only as an economic actor but also as a multi-stakeholder service system in which the government plays an essential role in balancing interests and improving service quality from the perspective of the customer.

Supportive government policies such as infrastructure development, streamlined regulatory environments, reduction of administrative barriers and promotion of regional coordination can make connectivity efforts more efficient and more oriented toward user satisfaction (Sandee, 2016; Salvetat and Géraudel, 2012). These factors are particularly critical as customer satisfaction increasingly depends on convenience, service transparency and environmentally responsible logistics.

From the perspective of resource dependence theory (Pfeffer and Salancik, 1978), seaports rely on external institutional conditions to convert resources such as transportation infrastructure, digital innovation and green logistics into value for customers. Government initiatives in the form of investment incentives, digitalization programs or policy prioritization can empower ports to provide better service experiences and thereby increase customer satisfaction (Alamouh *et al.*, 2021; Van Hamme and Strale, 2012; Wiradanti, 2019).

Based on this reasoning, the following hypotheses are proposed:

- H6a.* GIS enhances the positive effect of hinterland connectivity on customer satisfaction.
- H6b.* GIS enhances the positive effect of maritime connectivity on customer satisfaction.
- H6c.* GIS enhances the positive effect of digital connectivity on customer satisfaction.
- H6d.* GIS enhances the positive effect of sustainable connectivity on customer satisfaction.

The conceptual model developed based on this framework and hypotheses is summarized in Figure 1.

3. Methodology

3.1 Scales

The measurement scales used in this study were adapted from prior research and revised to suit the specific context of seaports in emerging markets such as Vietnam. The revision process was conducted through consultation with ten experts in seaport operations, logistics and supply chain management to ensure content validity and reliability.

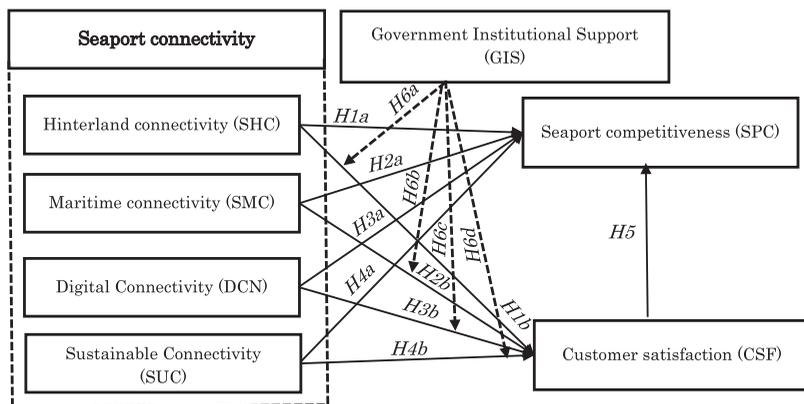


Figure 1. Proposed research model. **Source(s):** Authors' compilation

Specifically, the scales for hinterland connectivity and maritime connectivity included three observed items each, adapted from the studies of [Arvis et al. \(2018\)](#) and [Martinez-Moya et al. \(2024\)](#). The customer satisfaction scale (four observed items) and seaport competitiveness scale (three observed items) were developed based on the work of [Lee et al. \(2016\)](#), ensuring their appropriateness for container port operations in the Vietnamese context.

The digital connectivity scale was constructed using both theoretical and practical foundations proposed by [Lee et al. \(2016\)](#) and [Heilig et al. \(2017\)](#). Expert feedback was incorporated to reflect the extent of digital technology adoption in port-related connectivity. A total of seven observed items were developed for this construct and are detailed in [Appendix](#).

Similarly, the sustainable connectivity scale was newly developed with six observed items, drawing on studies by [Alamouh et al. \(2021\)](#) and [Notteboom et al. \(2020\)](#) and further refined through expert input. This scale reflects the capacity for sustainable connectivity from both environmental and social perspectives.

Finally, due to the limited availability of standardized scales for GIS in the context of logistics and port systems, a new five-item scale was proposed. This was developed based on the study by [Wiradanti \(2019\)](#) and refined through expert consultation.

All observed items are presented in detail in [Table A1 \(Appendix\)](#). The survey questionnaire was developed based on the aforementioned measurement scales, using a five-point Likert scale. The instrument was refined through expert consultation to ensure clarity and contextual relevance. In addition to the main constructs, the questionnaire included general questions regarding the respondents' professional role and organizational characteristics.

3.2 Data collection

This study targeted professionals from firms that use seaport services in HCMC. Regarding sample size, [Tabachnick et al. \(2007\)](#) suggested that a sample size of 50 is considered very poor, 100 is poor, 200 is fairly good, 300 is good and 1,000 is excellent. With 31 measurement items used in the questionnaire, the minimum required sample size was determined using the 10-to-1 ratio rule ([Hair et al., 2019](#)), resulting in a target of at least 310 respondents. This number falls within the "good" category according to [Tabachnick et al. \(2007\)](#). To ensure sufficient data collection and mitigate potential risks such as incomplete or invalid responses, a total of 495 questionnaires were distributed and collected. Among them, 406 valid responses were retained for analysis.

A non-probability sampling method combined with the snowball technique was employed, primarily through face-to-face interviews, to reach respondents with in-depth expertise in the field. The final sample showed a broad distribution of experience levels: 13.79% of participants had more than 20 years of professional experience, 46.55% had between 11 and 20 years and 39.66% had between 5 and 10 years in the maritime transport industry. This indicates a high degree of representativeness and reliability of the data for the research objectives. The demographics of the respondents are summarized in [Table 1](#).

3.3 Measures

In recent years, structural equation modeling (SEM) has become one of the most widely applied research techniques across various fields due to its flexibility in modeling relationships between independent and dependent variables. Two major approaches are commonly used: covariance-based SEM and partial least squares SEM. In cases where the theoretical framework has not yet been well established, scholars are encouraged to consider partial least squares structural equation modeling (PLS-SEM) as a viable alternative to covariance-based SEM. This approach is particularly valuable when the primary objective is prediction and the identification of key target constructs ([Hair et al., 2019](#)).

Table 1. Statistical summary of the official research sample ($n = 406$)

Classification criteria	Sample size	%	Classification criteria	Sample size	%
<i>Gender</i>			<i>Experience</i>		
Male	317	78	5–10 years	161	39.66
Female	89	22	11–20 years	189	46.55
<i>Age</i>			>20 years	56	13.79
<30	27	6.65	<i>Type of enterprise</i>		
30–35	191	47.04	Shipping Company	37	9.11
36–45	114	28.08	Forwarding Company	284	69.95
>45	74	18.23	Management Officials of Departments	26	6.41
<i>Educational level</i>			Exporter/Importer	59	14.53
Vocational/College	34	8.37	<i>Enterprise size</i>		
University	227	55.91	≥50 employees	142	35
Postgraduate	130	32.02	<50 employees	264	65
Other	15	3.70			

Source(s): Authors' compilation

In this study, data were analyzed using the partial least squares approach, implemented through SmartPLS version 3.2.8. The bootstrapping procedure was performed using 5,000 subsamples to estimate the statistical significance of the path coefficients. The implementation of PLS-SEM followed a two-step procedure. First, the reliability and validity of the measurement model were assessed. Second, the explanatory power and path coefficients of the structural model were evaluated.

4. Results

4.1 Measurement model assessment

The reliability of each observed variable was assessed using the outer loading coefficient. A loading value of 0.70 or higher is considered acceptable, indicating that the item significantly contributes to its respective latent construct. Indicators with loading values below 0.40 should be completely removed from the model. In such cases, model respecification should be conducted iteratively until all measurement quality criteria are met (Hair *et al.*, 2019).

In the initial analysis, four indicators (DCN3, DCN6, SUC5 and SUC6) had outer loading values below the acceptable threshold (0.130, 0.243, 0.145 and 0.115 respectively) and were thus removed from the model. The indicator SUC3 had a loading of 0.646, which is slightly below the 0.70 threshold. However, based on its content relevance and conceptual appropriateness, it was retained in the model. Following these adjustments, the measurement model was re-estimated to improve reliability and ensure convergent and discriminant validity.

As shown in Table 2, the Cronbach's alpha values of the constructs range from 0.735 to 0.865 and composite reliability (CR) values fall between 0.848 and 0.902, all exceeding the recommended threshold of 0.70. These results confirm that the model satisfies the reliability criteria (Nunnally and Bernstein, 1994). Additionally, all constructs demonstrate an average variance extracted (AVE) greater than 0.50, indicating adequate convergent validity (Fornell and Larcker, 1981). Therefore, the measurement model meets the reliability and validity requirements.

Discriminant validity refers to the extent to which constructs are distinct and not highly correlated with one another (Fornell and Larcker, 1981). A modern approach to assess discriminant validity is the heterotrait–monotrait ratio of correlations (HTMT), as recommended by Henseler *et al.* (2015). The HTMT has been proposed by many scholars as a more reliable alternative to the square root of the average variance extracted (Hair *et al.*,

Table 2. The reliability and convergent validity of the constructs

Construct	Cronbach's alpha	CR	AVE
Customer satisfaction (CSF)	0.850	0.899	0.689
Digital connectivity (DCN)	0.865	0.902	0.648
DCN*GIS	1.000	1.000	1.000
Government institutional support (GIS)	0.840	0.886	0.611
Hinterland connectivity (SHC)	0.793	0.878	0.706
SHC*GIS	1.000	1.000	1.000
Maritime connectivity (SMC)	0.735	0.848	0.651
SMC*GIS	1.000	1.000	1.000
Seaport competitiveness (SPC)	0.832	0.899	0.748
Sustainable connectivity (SUC)	0.815	0.877	0.643
SUC*GIS	1.000	1.000	1.000

Note(s): The moderating interaction terms were generated using the product indicator approach. As each interaction construct contains only one indicator, the reliability and validity values (Cronbach's Alpha, CR and AVE) are automatically set to 1.000 and are not interpreted further

Source(s): Authors' compilation

2019). When two constructs are considered to be clearly distinct, the HTMT value should be below the threshold of 0.90 (Henseler *et al.*, 2015). As shown in Table 3, all HTMT values fall below this threshold, indicating that the measurement scales used in this study satisfy the requirement for discriminant validity. Therefore, the constructs in this study meet both convergent and discriminant validity criteria.

4.2 Structural model assessment

To assess multicollinearity and the overall model fit, the variance inflation factor (VIF) and standardized root mean square residual (SRMR) values were examined. As shown in Table 4, exogenous variables are listed in the rows and endogenous variables in the columns. All VIF values range from 1.065 to 1.609, which are well below the recommended threshold of 3. This indicates that multicollinearity is not a concern in the model (Hair *et al.*, 2019). In addition, the SRMR value was found to be 0.068, which is lower than the commonly accepted cutoff of 0.08, confirming that the model has a good fit (Henseler *et al.*, 2016).

The explanatory power of the model was assessed using the coefficient of determination (R^2). The results indicate that the R^2 value for customer satisfaction (CSF) was 0.159 and for

Table 3. HTMT criterion for discriminant validity assessment

Construct	CSF	DCN	DCN*GIS	GIS	SHC	SHC*GIS	SMC	SMC*GIS	SPC	SUC	SUC*GIS
CSF											
DCN	0.266										
DCN*GIS	0.048	0.244									
GIS	0.286	0.241	0.108								
SHC	0.265	0.244	0.106	0.133							
SHC*GIS	0.051	0.109	0.276	0.104	0.129						
SMC	0.218	0.225	0.189	0.732	0.143	0.049					
SMC*GIS	0.082	0.162	0.139	0.065	0.039	0.076	0.216				
SPC	0.542	0.560	0.166	0.386	0.465	0.137	0.386	0.095			
SUC	0.288	0.198	0.110	0.135	0.234	0.085	0.146	0.020	0.485		
SUC*GIS	0.110	0.061	0.177	0.105	0.054	0.224	0.035	0.130	0.134	0.051	

Source(s): Authors' compilation

Table 4. Multicollinearity assessment results

Construct	CSF	SPC
CSF		1.159
DCN	1.170	1.114
DCN*GIS	1.171	
GIS	1.581	
SHC	1.085	1.100
SHC*GIS	1.141	
SMC	1.609	1.064
SMC*GIS	1.107	
SPC		
SUC	1.065	1.102
SUC*GIS	1.098	

Source(s): Authors' compilation

seaport competitiveness (SPC) it was 0.486. According to the classification thresholds proposed by [Cohen \(2013\)](#), an R^2 value between 0.15 and below 0.35 suggests a moderate level of explanatory power, while a value of 0.35 or higher indicates a substantial level. Therefore, the research model demonstrates a reasonable explanatory power for customer satisfaction and a strong explanatory power for seaport competitiveness. This implies that the variations in customer satisfaction and seaport competitiveness are significantly explained by the independent variables.

Furthermore, the predictive capability of the model was examined through the blindfolding procedure using the Q^2 statistic. The results show that the Q^2 value for customer satisfaction was 0.114, which falls within the range of 0.02 to below 0.35, indicating a moderate predictive relevance. Meanwhile, the Q^2 value for seaport competitiveness was 0.358, exceeding the 0.35 threshold, thereby suggesting strong predictive relevance. According to [Chin \(2010\)](#), these results confirm that the model possesses good predictive power, especially in explaining the variance of seaport competitiveness.

The direct effects in the structural model were assessed using t -tests combined with the bootstrapping technique ($N = 5,000$). The results, presented in [Table 5](#), indicate that hypotheses [H1a](#), [H1b](#), [H2a](#), [H3a](#), [H3b](#), [H4a](#), [H4b](#) and [H5](#) are supported at the 5% significance

Table 5. Results of hypothesis testing

Hypothesis	Impact	Coefficient	P-value	Conclusion
H5	CSF → SPC	0.256	0.000	Accepted
H3b	DCN → CSF	0.123	0.012	Accepted
H3a	DCN → SPC	0.312	0.000	Accepted
H6c	DCN*GIS → CSF	0.040	0.372	Rejected
	GIS → CSF	0.222	0.002	
H1b	SHC → CSF	0.142	0.003	Accepted
H1a	SHC → SPC	0.199	0.000	Accepted
H6a	SHC*GIS → CSF	0.038	0.461	Rejected
H2b	SMC → CSF	-0.014	0.830	Rejected
H2a	SMC → SPC	0.152	0.000	Accepted
H6b	SMC*GIS → CSF	-0.042	0.356	Rejected
H4b	SUC → CSF	0.206	0.000	Accepted
H4a	SUC → SPC	0.244	0.000	Accepted
H6d	SUC*GIS → CSF	-0.119	0.043	Accepted

Source(s): Authors' compilation

level. Among these, the f^2 statistic reveals that the effect of digital connectivity (DCN) on seaport competitiveness (SPC) is the strongest ($f^2 = 0.172$), reflecting a moderate effect size according to the classification by Cohen (2013). The complete structural model results are shown in Figure 2.

Overall, the findings show that hinterland connectivity (SHC), maritime connectivity (SMC) and digital connectivity (DCN) exert positive influences on both customer satisfaction (CSF) and seaport competitiveness (SPC), while CSF plays a mediating role in enhancing port competitiveness.

With regard to sustainable connectivity (SUC), the results indicate a statistically significant impact on seaport competitiveness (SPC). However, the relationship between maritime connectivity (SMC) and customer satisfaction (CSF) does not reach statistical significance (p -value >0.05) and therefore, hypothesis H2b (SMC \rightarrow CSF) is not supported. Additionally, the f^2 value for this relationship was below 0.03, indicating a very weak effect size according to Cohen's (2013) guidelines.

Concerning the moderating role of GIS, only hypothesis H6d (SUC \times GIS \rightarrow CSF) is supported ($p < 0.05$), suggesting that GIS significantly moderates the relationship between sustainable connectivity and customer satisfaction. In contrast, hypotheses H6a, H6b and H6c are not supported as their p -values exceed the acceptable significance threshold. The specific moderating effect of GIS on the relationship between SUC and CSF is further illustrated in Figure 3.

5. Discussion

This study provides empirical evidence that multidimensional seaport connectivity (including hinterland, maritime, digital and sustainable aspects) has a significant influence on both customer satisfaction and seaport competitiveness. These relationships occur not only through direct effects but also indirectly through the mediating role of customer satisfaction, thereby

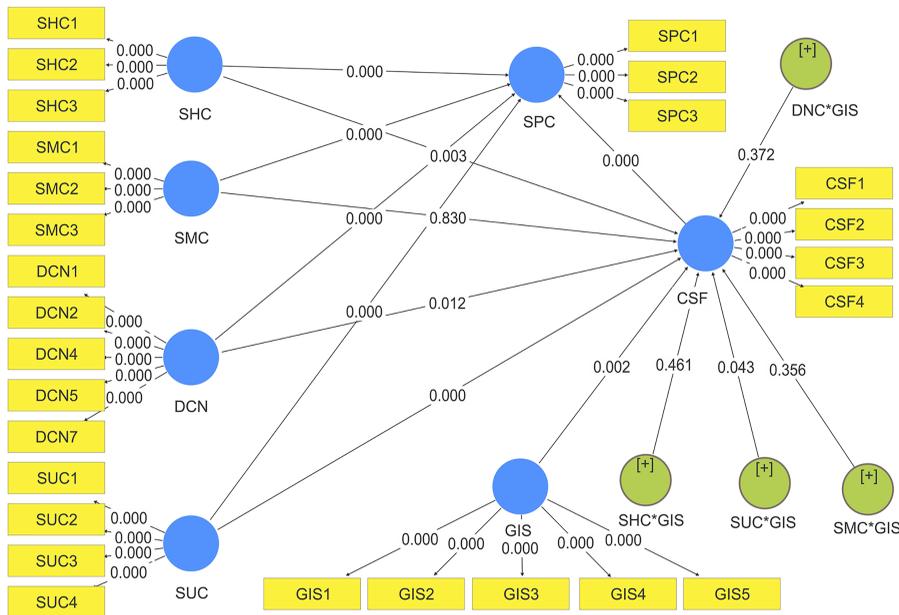


Figure 2. Estimated structural model. Source(s): Authors' compilation



Figure 3. GIS's moderation in the impact of SUC on CSF. **Source(s):** Authors' compilation

confirming the critical importance of connectivity in modern port development strategies. The inclusion of digital and sustainable connectivity has enriched the conceptualization of seaport connectivity, aligning with the ongoing trends of digital transformation and sustainable development in the global logistics sector.

From a policy and strategic perspective, the findings indicate that improving hinterland connectivity is a prerequisite for enhancing the port's ability to attract cargo from inland areas and for expanding its service reach. This forms the foundation for building sustainable competitive advantage, which is consistent with the direction proposed in earlier studies such as those by [Pietrzak et al. \(2020\)](#) and [Deshmukh and Song \(2023\)](#). A well-developed local logistic ecosystem enhances the value proposition of the port, improves the customer experience and helps retain strategic partners.

In parallel, the development of maritime connectivity requires not only an increase in the number of direct shipping services but also a greater focus on route quality, transshipment capacity and competitive transport costs. Upgrading infrastructure such as channel depth, berth capacity and modern cargo-handling systems is essential for accommodating larger vessels and maintaining a competitive edge. Without timely action, ports in HCMC risk being outcompeted by regional hubs such as Singapore, Laem Chabang or Port Klang in securing key shipping services. These findings are consistent with earlier studies by [Parola et al. \(2017\)](#) and [Martinez-Moya et al. \(2024\)](#), while also expanding the scope of maritime connectivity by incorporating factors such as the number of direct and transshipment services and the accessibility to diverse destination ports.

Digital connectivity demonstrates a strong influence on both customer satisfaction and seaport competitiveness. The digitalization of processes and real-time data sharing among shipping lines, customers and custom authorities not only reduces processing time but also enhances transparency and operational reliability. These factors are increasingly prioritized by customers when selecting logistic partners. The findings align with previous studies by [Roh et al. \(2025\)](#) and [Lee et al. \(2016\)](#), which emphasized the role of digital transformation in optimizing port operations.

Another significant contribution of this study lies in the formal incorporation of sustainable connectivity into the analytical model. This approach goes beyond environmental aspects to include social responsibility considerations. It aligns with global trends that emphasize integrating green objectives with operational efficiency and customer expectations. Initiatives such as the adoption of clean energy, cold ironing, partnerships with low-emission transport providers and the implementation of corporate social responsibility programs contribute not only to enhancing the port's brand image but also to improving customer satisfaction. These

findings support prior arguments made by Roh *et al.* (2025) and Notteboom *et al.* (2020) regarding the strategic role of ports in greening the supply chain.

However, one noteworthy observation from this study is that while maritime connectivity significantly influences seaport competitiveness, it does not have a clear impact on customer satisfaction. This suggests that customers may not be solely concerned with the number of maritime routes port offers. Rather, they expect that port services, such as administrative procedures and cost transparency, will be aligned with the level of connectivity. Without improvements in these supporting aspects, the value created by maritime connectivity may not be fully recognized by customers.

The non-significant moderating effects of GIS on the SHC – CSF (H6a), SMC – CSF (H6b) and DCN – CSF (H6c) relationships suggest that institutional interventions in Vietnam’s maritime sector primarily operate at the macro-policy level, such as infrastructure planning, regulatory reforms and investment incentives, rather than at the micro-operational level directly perceived by customers. In the context of HCMC, where the existing level of seaport – hinterland, maritime and digital connectivity is already relatively well-developed, additional policy support may generate diminishing returns for customer satisfaction. Furthermore, the influence of GIS on service experiences may be subject to temporal lags, with stronger effects likely to emerge in long-term competitiveness outcomes rather than in immediate satisfaction metrics.

In contrast, the moderating effect of GIS on the SUC – CSF relationship (H6d) was statistically significant, with a negative interaction coefficient ($\beta = -0.119, p = 0.043$). This indicates a dampening moderation: as GIS increases, the marginal effect of sustainable connectivity on customer satisfaction declines. Probing the interaction within the empirical range of GIS reveals that the SUC – CSF slope remains positive across all observed levels of GIS, although it is smaller at higher GIS. A plausible explanation is a substitution or ceiling effect: supportive policies may raise baseline sustainability practices and customer expectations, making additional SUC improvements less differentiating in terms of satisfaction. Practically, aligning emission-reduction initiatives, partnerships with low-emission carriers and corporate social responsibility programs with government support still yields positive gains in customer satisfaction, but with diminishing marginal returns at higher GIS levels.

These results suggest that institutional support acts as a stabilizing rather than an amplifying force: it helps maintain a positive SUC–CSF relationship across all observed support levels, even though the incremental benefit is smaller when GIS is high. For policymakers, this highlights the importance of designing support mechanisms that not only promote baseline sustainability adoption but also create room for ports to differentiate through advanced sustainable connectivity practices. In the context of increasing competition among regional port hubs, consistent implementation of connectivity strategies, especially in digital and sustainable aspects, is not only a development priority but also a foundation for building long-term competitive advantages that are difficult to replicate.

6. Conclusions

This study provides empirical evidence on the central role of seaport connectivity in enhancing customer satisfaction and port competitiveness. By developing a multidimensional conceptual model that includes hinterland connectivity, maritime connectivity, digital connectivity and sustainable connectivity, the study not only confirms the direct effects of each connectivity aspect but also clarifies the indirect mechanisms through customer satisfaction. The extension of the connectivity concept to include digital and sustainability elements reflects the direction of modern port development amid global integration and green transition.

The findings offer several practical implications, especially in formulating infrastructure investment strategies, developing service portfolios and designing institutional support

policies with a customer-oriented approach. Moreover, the study highlights the essential role of effective collaboration between governments and port operators in ensuring that connectivity initiatives, particularly those related to sustainability, align with environmental standards while improving service experience quality.

Nonetheless, the study has certain limitations. The data were collected at a single point in time and focused exclusively on Vietnam, with empirical evidence drawn from the seaport cluster in HCMC. While this context offers valuable insights into an emerging maritime market in Southeast Asia, it may not fully represent the operational realities of port systems in other countries, particularly those in developed economies or with different governance, regulatory and market structures. Therefore, caution should be exercised when generalizing the findings beyond the Vietnamese context. In addition, the study did not differentiate ports based on specific functions, cargo specialization or operational characteristics, which may influence connectivity–competitiveness relationships in other settings.

Future research may benefit from classifying ports by geographic location, national role and cargo type in order to better assess the practical relevance of each connectivity dimension. Furthermore, incorporating factors such as governance models, technological capabilities and the level of collaboration within the supply chain would enhance the generalizability and applicability of the proposed model.

Supplementary material

The supplementary material for this article can be found online.

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