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Effects of logistics service quality dimensions on customer satisfaction and loyalty: A second-order PLS-SEM approach

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ABSTRACT

This study examines the impact of logistics service quality (LSQ) on customer satisfaction and loyalty in the Red River Delta region of Vietnam, which is characterized by dense industrial activity and a relationship-oriented business culture. Although the multidimensional nature of LSQ is widely acknowledged, empirical evidence modeling it as a higher-order construct remains limited. To address this gap, LSQ is conceptualized as a second-order reflective construct comprising four theoretically grounded dimensions: outcome quality, process quality, information quality, and relationship quality. Data collected from 220 logistics professionals were analyzed using partial least squares structural equation modeling (PLS-SEM) through a disjoint two-stage approach. Methodological rigor was assessed through post-hoc power analysis, common method bias assessment, and multi-group analysis (MGA), which established full measurement invariance. The results show that LSQ is reliably reflected by the four proposed dimensions. The structural model results reveal that LSQ has a positive and statistically significant impact on customer satisfaction ($\beta = 0.737$; $p < 0.001$) and customer loyalty ($\beta = 0.257$; $p = 0.001$), with customer satisfaction playing a partial mediating role (VAF = 57.3%). These findings suggest that logistics companies operating in high-growth, collectivist industrial environments should prioritize information transparency and relationship quality alongside operational outcomes.

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1. Introduction

Logistics, which encompasses activities that facilitate the efficient flow of goods, has evolved from a supporting function into a strategic capability associated with firms' ability to create customer value and sustain competitive advantage (Fernandes et al., 2018; Gao et al., 2026). The effectiveness of logistics operations is assessed not only in terms of cost but also through timeliness, reliability, coordination, and responsiveness to customer needs (Mentzer et al., 2001; Uvet, 2020). In the context of e-commerce, omnichannel retailing, and increasingly complex supply chains, customers are concerned not only with the delivery of goods but also with delivery speed, order status, tracking information, error handling, and the quality of interactions with logistics service providers (Akıl and Ungan, 2022; Lin et al., 2023; Sorkun et al., 2020). Logistics service quality (LSQ) has therefore become a critical factor in research on customer behavior in logistics services. Numerous studies have shown that LSQ positively influences customer satisfaction (Le et al., 2020; Uvet, 2020), service reuse intention (Lin et al., 2023), repurchase intention in e-commerce, customer loyalty (Akıl and Ungan, 2022; Gupta et al., 2023), and customer retention (Minh et al., 2024). In particular, customer satisfaction often plays a significant mediating role in the relationship between LSQ and behavioral outcomes, such as loyalty, positive word of mouth, repurchase intention, and continued service use (Gupta et al., 2023; Lin et al., 2023; Prassida et al., 2024).

LSQ is widely recognized as a multidimensional concept that reflects customers' evaluations of the efficiency, reliability, and appropriateness of the logistics services they receive. However, to date, there remains no consensus on how LSQ should be measured, as the characteristics of logistics services may vary depending on the research context, service type, and customer segment (Mentzer et al., 2001;

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Thai, 2013). Recent review studies further confirm that LSQ does not have a universal measurement model applicable across all contexts; rather, it should be adapted to industry characteristics, logistics service types, and customer expectations (Arabelen and Kaya, 2021; Gao et al., 2026). Therefore, instead of viewing LSQ as a set of discrete factors, modeling it as a higher-order construct may better capture customers' overall perceptions of logistics service quality. This approach is also consistent with recommendations in PLS-SEM research regarding the use of higher-order constructs to represent complex, multidimensional concepts such as service quality (Sarstedt et al., 2019).

The mechanisms through which service quality affects customer behavior remain inconclusive. According to satisfaction theory, customers develop satisfaction by comparing their initial expectations with the actual perceived performance after service use (Oliver, 1980). Satisfaction then serves as an important antecedent of positive behavioral outcomes, such as continued service use, referrals, and relationship maintenance with the service provider. Zeithaml et al. (1996) also argued that service quality and satisfaction influence customers' behavioral intentions, including reuse intention, loyalty, and positive word of mouth. Numerous studies have confirmed that LSQ positively affects customer satisfaction and that satisfaction plays a crucial mediating role in the relationship between LSQ and behavioral outcomes, such as repurchase intention, customer retention, and loyalty (Akıl and Ungan, 2022; Gupta et al., 2023; Lin et al., 2023). However, LSQ may also directly affect loyalty or market outcomes, depending on the service context and customer characteristics (Carrillat et al., 2009). Therefore, the relationships among LSQ, customer satisfaction (SAT), and customer loyalty (LOY) require further examination in specific logistics contexts.

In Vietnam, research on logistics service quality has begun to attract scholarly attention, but it remains fragmented across specific sectors. Le et al. (2020) examined the quality of port logistics services at Cat Lai Port and found that factors such as reliability, responsiveness, assurance, tangibles, and empathy positively influence service quality and customer satisfaction. Minh et al. (2024) further demonstrated that LSQ dimensions play an important role in enhancing customer satisfaction and retention in the Vietnamese logistics service context. However, existing studies have primarily focused on individual service types, such as port logistics, e-commerce logistics, delivery services, and third-party logistics, while empirical evidence regarding the second-order LSQ model and the mechanism through which LSQ influences customer satisfaction and loyalty in key economic regions remains limited. The Red River Delta is characterized by a high level of logistics intensity, with a concentration of manufacturing and trading enterprises, distribution centers, warehouses, and supply chain support activities, as well as distinctive industrial and business characteristics. Specifically, the region hosts a dense network of major industrial zones that attract substantial foreign direct investment, requiring supply chains to operate with high responsiveness and operational accuracy. However, transportation infrastructure remains subject to congestion and connectivity limitations, creating considerable challenges for maintaining consistent process quality and service outcomes. Furthermore, the regional business environment is strongly influenced by relationship-oriented and collectivist cultural values, in which personal relationships, mutual trust, and communication flexibility play a vital role in business transactions. Under these conditions, the effects of LSQ on customer satisfaction and loyalty may differ from those observed in other contexts, with relationship quality and information transparency potentially compensating for infrastructure-related constraints. Therefore, clarifying how the region's cultural characteristics and industrial structure shape the LSQ–SAT–LOY relationship is important from both theoretical and practical perspectives.

Based on the research gaps identified above, this study pursues three main objectives. First, it examines the appropriateness of modeling LSQ as a second-order construct reflected by four first-order dimensions: outcome quality (OQ), process quality (PQ), information quality (IQ), and relationship quality (RQ). This approach builds on the view that LSQ is a multidimensional construct while capturing customers' overall perceptions of logistics service quality (Mentzer et al., 2001; Sarstedt et al., 2019; Thai, 2013). Second, this study investigates the direct effects of logistics service quality (LSQ) on customer satisfaction (SAT) and customer loyalty (LOY), drawing on prior evidence that LSQ is an important antecedent of satisfaction and positive behavioral outcomes (Akıl and Ungan, 2022; Gupta et al., 2023; Lin et al., 2023). Third, the study tests the mediating role of SAT in the relationship between LSQ and LOY, thereby clarifying whether logistics service quality influences loyalty primarily through satisfaction or whether it also exerts an independent direct effect. The findings are expected to contribute to the theoretical clarification of the multifaceted yet unified nature of LSQ, provide additional empirical evidence for the LSQ–SAT–LOY relationship chain in the context of the Red River Delta economic region, and offer managerial implications that help logistics firms identify service quality dimensions requiring priority improvement to enhance customer satisfaction and strengthen customer loyalty.

2. Literature review and research hypotheses

2.1. Logistics service quality

LSQ is regarded as a multidimensional concept that reflects customers' overall evaluations of the effectiveness, reliability, and relevance of the logistics services they receive (Mentzer et al., 2001;

Thai, 2013). This suggests that LSQ cannot be measured using a single indicator; rather, it should be conceptualized as a multidimensional construct that captures both the tangible and intangible aspects of logistics services. However, the existing literature has yet to reach full consensus on the measurement model of LSQ. Studies in multichannel retailing and e-commerce indicate that the relative importance of each LSQ dimension may vary depending on the service context, distribution channel, and customer characteristics (Cotarelo et al., 2021; Murfield et al., 2017). Arabelen and Kaya (2021) also argued that LSQ measures should be adapted to the characteristics of the industry and the type of logistics service, while Gao et al. (2026) emphasized that LSQ should be examined from a process-oriented perspective, linking customer expectations, service mechanisms, and service outcomes. Therefore, rather than mechanically applying a fixed scale, research on LSQ should adopt a measurement model that is appropriate to the specific research context.

In addition to measurement issues, many studies have confirmed the positive relationships among LSQ, customer satisfaction, and customer loyalty. LSQ dimensions generally exert positive effects on customer satisfaction, while satisfaction further influences reuse intention, repurchase intention, and loyalty (Ellitan, 2023; Gupta et al., 2023; Lin et al., 2023). However, the magnitude of the effects of individual LSQ dimensions is not entirely consistent. Certain dimensions, such as information quality, order quality, and discrepancy handling, may exert stronger influences on customer satisfaction, whereas the effects of other dimensions depend largely on the specific service context (Ellitan, 2023; Lin et al., 2023). Therefore, the LSQ–SAT–LOY relationship warrants further investigation across different logistics contexts.

2.2. First-order dimensions of LSQ

LSQ is a multidimensional construct in which customers' overall perceptions are formed through multiple aspects related to service outcomes, service processes, information provision, and interactions with service providers. Mentzer et al. (2001) conceptualized LSQ as comprising multiple dimensions, such as personnel contact quality, information quality, ordering procedures, order accuracy, order condition, discrepancy handling, and timeliness. Subsequent studies have further confirmed that LSQ does not have a single measurement structure applicable across all contexts; rather, it varies according to service type, customer characteristics, and the supply environment (Arabelen and Kaya, 2021; Gao et al., 2026; Thai, 2013). Arabelen and Kaya (2021) showed that common LSQ measurement domains include time, process, communication, tangibility, operational quality, and relationship quality, among which communication and customer orientation have received increasing attention in recent studies. Given the Red River Delta's strong emphasis on industrial supply chain efficiency and its business culture that highly values interpersonal relationships, the measurement of LSQ should comprehensively capture not only service outcomes and operational processes but also information transparency and interpersonal interactions. Accordingly, this study operationalizes LSQ through four core first-order dimensions: outcome quality (OQ), process quality (PQ), information quality (IQ), and relationship quality (RQ).

H1: Logistics service quality (LSQ) is a second-order construct that is positively reflected by OQ, PQ, IQ, and RQ

Outcome quality (OQ) reflects the extent to which logistics services generate outputs that meet customer expectations, including delivery of the right goods, in the right quantity, in good condition, on time, and with adequate product availability. This dimension is associated with the final service outcome that customers can directly observe after using the service. Factors such as order accuracy, order condition, order quality, availability, and timeliness are commonly used to measure the outcome quality of logistics services (Mentzer et al., 2001; Uvet, 2020). Bienstock et al. (1997) also conceptualized physical distribution service quality through three core dimensions: timeliness, availability, and condition, indicating that OQ constitutes an important foundation for evaluating logistics services. In the e-commerce context, order condition, order accuracy, and timeliness have also been shown to positively affect customer satisfaction and loyalty (Akıl and Ungan, 2022; Lin et al., 2023). Therefore, OQ is considered an important dimension that reflects overall LSQ. Accordingly, the following hypothesis is proposed:

H1a: Outcome quality (OQ) positively reflects overall LSQ.

Process quality (PQ) reflects the efficiency, convenience, consistency, and flexibility of the activities that customers experience during the logistics service delivery process. Unlike outcome quality (OQ), which focuses on the final service outcome, PQ emphasizes how the service is performed, including ordering procedures, order processing, delivery coordination, complaint resolution, and discrepancy handling. Mentzer et al. (2001) regarded ordering procedures and discrepancy handling as important dimensions in evaluating logistics service quality (LSQ). Gaudenzi et al. (2020) also synthesized LSQ in the B2B context through dimensions such as ordering procedures, order accuracy, order condition, discrepancy handling, and timeliness, emphasizing that these dimensions may generate customer satisfaction through different configurations rather than through a purely linear relationship. Effective discrepancy handling, rapid responsiveness, and stable process

management contribute to higher customer satisfaction, thereby promoting reuse intention and relationship maintenance with service providers (Ellitan, 2023; Lin et al., 2023). Therefore, PQ is expected to be an important dimension in shaping overall LSQ. Accordingly, the following hypothesis is proposed:

H1b: Process quality (PQ) positively reflects overall LSQ.

Information quality (IQ) reflects the accuracy, completeness, timeliness, accessibility, and usefulness of the information that logistics service providers provide to customers throughout the service delivery process. In logistics, information not only facilitates operations but also constitutes an important part of the service experience, as customers need to monitor order status, shipment progress, delivery schedules, documentation, and any emerging issues. Mentzer et al. (2001) identified information quality as a distinct dimension of LSQ. Subsequent studies have further extended IQ to include the ability to share operational information, retrieve order status, and use technology in service communication (Arabelen and Kaya, 2021; Uvet, 2020). Uvet (2020) showed that operational information sharing is a crucial component of the LSQ model and is measured through the ability to provide accurate, timely, standardized, and real-time information. Similarly, Lin et al. (2023) confirmed that information quality positively affects customer satisfaction and indirectly promotes service reuse intention. Therefore, IQ is considered an essential dimension of LSQ, particularly in a context where customers increasingly demand greater information transparency and service traceability. Accordingly, the following hypothesis is proposed:

H1c: Information quality (IQ) positively reflects overall LSQ.

Relationship quality (RQ) reflects the quality of interactions between customers and logistics service providers, including communication skills, service attitude, the ability to understand customer needs, problem-solving capability, trust building, and the maintenance of cooperative relationships. In the model proposed by Mentzer et al. (2001), personnel contact quality is regarded as a crucial dimension of LSQ, particularly in activities related to coordination, information exchange, and customer support. Relationship quality, or relational quality, emphasizes the service provider's ability to understand customer needs and deliver more appropriate services (Davis and Mentzer, 2006). Gupta et al. (2023) showed that personnel contact quality positively influences customer satisfaction, while Lin et al. (2023) confirmed that personnel contact quality is an important dimension of the LSQ model that affects customer satisfaction and service reuse intention. Although the effect of relationship quality on loyalty may vary depending on the specific service context, RQ still represents an indispensable dimension of LSQ, especially in B2B logistics, third-party logistics services, and long-term supply chain relationships. Therefore, the following hypothesis is proposed:

H1d: Relationship quality (RQ) positively reflects overall LSQ.

2.3. Customer satisfaction

Customer satisfaction in logistics services is understood as the extent to which customers perceive that logistics services meet or exceed their initial needs, expectations, and operational requirements. According to expectation–disconfirmation theory, satisfaction is formed when customers compare their pre-service expectations with the actual perceived performance after service use (Oliver, 1980). In the logistics context, satisfaction not only reflects customers' overall evaluations of the service provider but also indicates the extent to which the service effectively supports customers' operations through on-time delivery, reliability, reduced uncertainty in the delivery process, accurate information provision, and efficient handling of emerging issues.

Lin et al. (2023) showed that LSQ dimensions, including operational quality, resource quality, information quality, personnel contact quality, and customization quality, positively affect customer satisfaction, thereby promoting service reuse intention. Gupta et al. (2023) also confirmed that logistics service quality dimensions directly influence customer satisfaction and that satisfaction mediates the relationship between LSQ and loyalty. In the context of e-commerce, Vasić et al. (2021) emphasized that delivery time, reliability, logistics information, and product condition are important factors shaping customer satisfaction. Similarly, Ellitan (2023) indicated that LSQ dimensions positively affect satisfaction, although their indirect effects on loyalty may differ across quality dimensions. Studies on logistics outsourcing and supply chain services also reinforce the argument that service quality is a crucial antecedent of satisfaction and subsequent behavioral outcomes (Gil Saura et al., 2008; Juga et al., 2010).

Based on this reasoning, the following hypotheses are proposed:

H2: The first-order dimensions of LSQ positively affect customer satisfaction (SAT).
H2a: Outcome quality (OQ) positively affects customer satisfaction (SAT).
H2b: Process quality (PQ) positively affects customer satisfaction (SAT).
H2c: Information quality (IQ) positively affects customer satisfaction (SAT).
H2d: Relationship quality (RQ) positively affects customer satisfaction (SAT).
H3: Overall logistics service quality (LSQ) positively affects customer satisfaction (SAT).

2.4. Customer loyalty

Customer loyalty (LOY) in logistics services can be understood as a form of post-service behavioral intention, reflected in customers' tendency to continue using the service, repurchase, maintain relationships with the service provider, recommend the service to others, and avoid switching to alternative providers. According to Zeithaml et al. (1996), favorable customer behavioral responses to service quality include continued service use intention, positive word of mouth, recommendations to others, and relationship maintenance with the firm. In the logistics context, these behavioral responses are particularly important because provider selection decisions are often associated with operational reliability, coordination intensity, and switching costs within the supply chain. Juga et al. (2010) argued that perceived service quality in logistics outsourcing relationships affects customer satisfaction, which in turn fosters customer loyalty. Gil Saura et al. (2008) showed that LSQ serves as a foundation for the formation of satisfaction and loyalty in logistics service relationships. In the context of e-commerce, Akıl and Ungan (2022) confirmed that satisfaction positively affects customer loyalty, while Lin et al. (2023) showed that satisfaction promotes logistics service reuse intention. Gupta et al. (2023) further affirmed that satisfaction fully mediates the relationship between logistics service quality dimensions and loyalty. Recent studies also highlight the role of satisfaction in translating LSQ into behavioral outcomes, such as repurchase intention, positive word of mouth, and customer retention (Minh et al., 2024; Prassida et al., 2024).

Based on the above discussion, this study conceptualizes customer loyalty (LOY) as a behavioral intention reflecting customers' commitment to their logistics service providers. Although customer satisfaction is expected to play an important mediating role, the relationship between LSQ and customer loyalty is anticipated to involve partial mediation rather than full mediation. This expectation is grounded in the characteristics of B2B logistics services, where logistics service quality may directly sustain customer loyalty through alternative mechanisms even when customer satisfaction has not reached its highest level. For example, high switching costs associated with changing supply chain systems and the trust established through long-term business relationships may directly encourage customers to remain with their existing logistics service providers. Therefore, this study assumes that LSQ influences customer loyalty both directly and indirectly through customer satisfaction. Accordingly, the following hypotheses are proposed:

H4: Customer satisfaction (SAT) positively affects customer loyalty (LOY).
H5: Logistics service quality (LSQ) has a direct positive effect on customer loyalty (LOY).
H6: Customer satisfaction (SAT) mediates the relationship between overall LSQ and customer loyalty (LOY).

2.5. Research hypotheses and model

Based on a synthesis of theories on logistics service quality, this study proposes LSQ as a second-order construct reflected by four first-order dimensions: outcome quality (OQ), process quality (PQ), information quality (IQ), and relationship quality (RQ). This approach is consistent with the view that LSQ is a multidimensional construct in which customers' overall perceptions are formed through various aspects of logistics services (Mentzer et al., 2001; Thai, 2013). Recent studies also show that logistics service quality dimensions, such as operational quality, information quality, personnel contact quality, customization quality, and process-related factors, significantly influence customer satisfaction and behavioral outcomes (Gupta et al., 2023; Lin et al., 2023). Therefore, this study assumes that OQ, PQ, IQ, and RQ are first-order dimensions that reflect the overall perception of LSQ. Furthermore, previous studies have confirmed that LSQ is an important antecedent of satisfaction, reuse intention, and loyalty in logistics services (Akıl and Ungan, 2022; Juga et al., 2010). From a theoretical perspective, however, potential endogeneity concerns should also be acknowledged, as perceptions of LSQ and customer satisfaction may be simultaneously influenced by unobserved factors, such as firm reputation or prior relationship history. In this study, SAT is understood as the extent to which logistics services meet customer needs, reflecting customer satisfaction in the context of service use. Substantial empirical evidence suggests that satisfaction plays a mediating role in the relationship between LSQ and loyalty. However, the direct effect of LSQ on loyalty still needs to be examined in specific contexts (Ellitan, 2023; Gil Saura et al., 2008; Gupta et al., 2023). Therefore, this study simultaneously tests the relationships among LSQ, SAT, and LOY, including LSQ → SAT, SAT → LOY, and LSQ → LOY.

H1: Logistics service quality (LSQ) is a second-order construct that is positively reflected by OQ, PQ, IQ, and RQ.
H2: The first-order dimensions of LSQ positively affect customer satisfaction (SAT).
H3: Logistics service quality (LSQ) positively affects customer satisfaction (SAT).
H4: Customer satisfaction (SAT) positively affects customer loyalty (LOY).
H5: Logistics service quality (LSQ) has a direct positive effect on customer loyalty (LOY).
H6: Customer satisfaction (SAT) mediates the relationship between overall logistics service quality and customer loyalty.

Drawing on the literature review and the proposed hypotheses, the conceptual relationships

among logistics service quality, customer satisfaction, and customer loyalty are summarized in the research model presented in Fig. 1.

3. Research methodology

This study employs a cross-sectional quantitative research design to empirically examine the relationships among logistics service quality (LSQ), customer satisfaction (SAT), and customer loyalty (LOY) in the context of logistics service users in Vietnam's Red River Delta economic region. A quantitative design is appropriate for testing the proposed theoretical model, measuring latent variables, and quantifying the effects among the research constructs. This approach is also consistent with recent LSQ studies, in which structural models have been used to examine the relationships among logistics service quality dimensions, customer satisfaction, and customer behavioral outcomes (Gupta et al., 2023; Lin et al., 2023).

LSQ is conceptualized as a multidimensional construct that reflects customers' overall evaluations of logistics service quality. This approach builds on the foundational studies of Mentzer et al. (2001) and Thai (2013), in which LSQ encompasses not only delivery outcomes but also service processes, information quality, and interactions between customers and service providers. Customer satisfaction is grounded in the logic of expectation–disconfirmation theory, whereby customers form satisfaction judgments by comparing their initial expectations with actual perceived service performance (Oliver, 1980).

Customer loyalty is approached from the perspective of behavioral intentions, including the intention to continue using the service, maintain relationships with the provider, recommend the provider to others, and avoid switching to competitors. This is consistent with the perspective on the behavioral consequences of service quality proposed by Zeithaml et al. (1996).

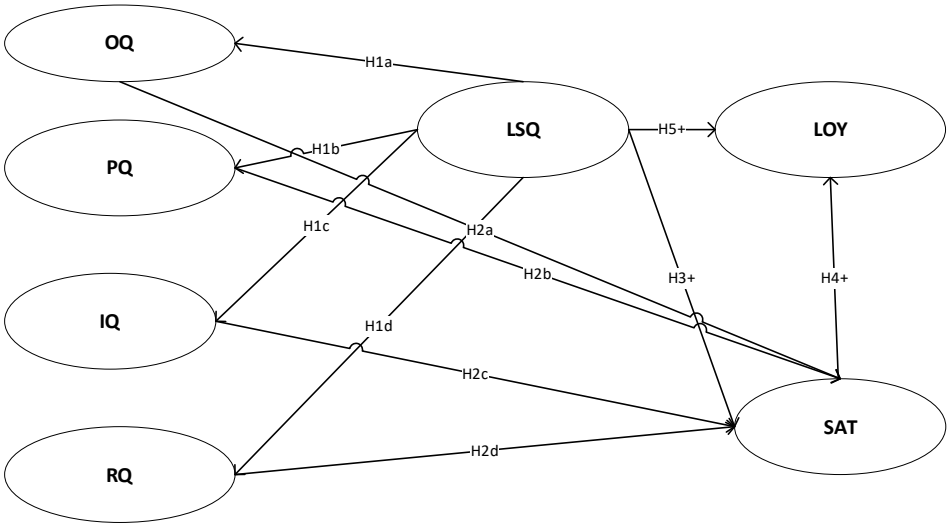


Fig. 1: Proposed research model

Research data were collected from customers and relevant stakeholders who had experience using, providing, or coordinating logistics services in the Red River Delta economic region. This region was selected to ensure contextual consistency, as it is characterized by a high concentration of manufacturing, trade, warehousing, goods distribution, and logistics activities that support supply chains. The survey respondents were individuals representing businesses who possessed sufficient knowledge and practical experience to evaluate logistics service quality, satisfaction levels, and loyalty toward logistics service providers. The survey was conducted from January to April 2026 using a structured questionnaire. A total of 355 initial responses were collected. Prior to analysis, the data were screened to ensure completeness, validity, and relevance to the research objectives. Specifically, 126 responses were excluded because of missing critical information or incomplete responses to the main measurement scales; 2 responses were removed because of duplication; and 7 responses were excluded because they did not meet the sampling criteria. After data cleaning, 220 valid responses were retained for the formal analysis. This sample size is considered adequate for studies using PLS-SEM, particularly when the model includes multiple latent variables and the research objectives are more explanatory and predictive than purely confirmatory (Hair et al., 2021).

The questionnaire was developed and adapted from scales that had been validated in previous studies. The LSQ measurement items were derived from common dimensions identified in the LSQ literature, including outcome quality, process quality, information quality, and relationship quality (Mentzer et al., 2001; Thai, 2013). The SAT and LOY scales were adapted from studies on customer satisfaction, reuse intention, and loyalty in logistics services (Akıl and Ungan, 2022; Gupta et al., 2023; Lin et al., 2023). The initial measurement instrument consisted of 28 observed variables measuring six constructs: outcome quality (OQ), process quality (PQ), information quality (IQ), relationship quality

(RQ), customer satisfaction (SAT), and customer loyalty (LOY). All observed variables were measured using a five-point Likert scale, ranging from 1 = "strongly disagree" to 5 = "strongly agree." Before the official survey, the questionnaire was reviewed in terms of content, wording, and relevance to the logistics context in the Red River Delta economic region to ensure the clarity and validity of the measurement scales. The collected data were coded and processed using IBM SPSS 25 and SmartPLS 4. SPSS was used for initial data-processing procedures, including checking for missing data, coding variables, generating descriptive statistics, and conducting a preliminary assessment of sample characteristics. SmartPLS 4 was used to assess the measurement model and structural model through partial least squares structural equation modeling (PLS-SEM). PLS-SEM was selected because it is suitable for explanatory and predictive research and allows for the efficient estimation of models with multiple latent variables, mediating relationships, and higher-order constructs (Hair et al., 2021). Furthermore, PLS-SEM is particularly appropriate for this study because LSQ is modeled as a reflective–reflective second-order construct reflected by four first-order dimensions: OQ, PQ, IQ, and RQ.

The estimation of the second-order LSQ construct was performed using the disjoint two-stage approach. This approach is recommended in PLS-SEM when modeling higher-order constructs, as it allows the scores of the first-order constructs to be estimated in the first stage and then used as indicators of the second-order construct in the second stage (Sarstedt et al., 2019). To test the statistical significance of the estimated coefficients, bootstrapping with 5,000 resamples was performed. This procedure enables the assessment of the stability and significance of the path coefficients, outer loadings, and mediating effects in the research model. The measurement model was evaluated based on scale reliability and validity. Specifically, indicator reliability was assessed using outer loadings; internal consistency reliability was evaluated using composite reliability (CR); convergent validity was examined using average variance extracted (AVE); and discriminant validity was assessed using the Fornell-Larcker criterion and the Heterotrait-Monotrait ratio (HTMT) (Fornell and Larcker, 1981; Henseler et al., 2015). The structural model was evaluated using standardized path coefficients (β), statistical significance levels, the coefficient of determination (R^2), predictive relevance (Q^2), and the variance inflation factor (VIF) to examine multicollinearity. These analytical procedures are consistent with current recommendations for reporting PLS-SEM results and help ensure the transparency, reliability, and replicability of the study.

To further ensure the robustness of the statistical conclusions, a post hoc power analysis was conducted using G*Power software. With a sample size of 220 and four predictor variables for the primary endogenous construct, the achieved statistical power (1 − β) exceeded 0.99. This value is substantially higher than the minimum threshold of 0.80 recommended for quantitative research (Cohen, 1988), providing strong evidence that the current sample size is more than sufficient to detect statistically meaningful effects in the proposed PLS-SEM structural model.

4. Results and discussion

4.1. Sample profile

After data cleaning, 220 valid responses were retained from the initial 355 responses, corresponding to a valid response rate of 62.0%. The survey sample consisted of various groups involved in logistics services, with firms using logistics services accounting for the largest proportion (39.5%). In terms of experience, the majority of respondents had used or collaborated with logistics service providers for 3–7 years (37.7%), indicating that the sample possessed an appropriate level of practical experience to evaluate service quality, satisfaction, and loyalty. Regarding service types, transportation was the most frequently reported category (62.3%), followed by freight forwarding (48.2%) and integrated logistics services (46.4%).

To assess the potential for non-response bias, the study compared early respondents (the first 25% of responses, n = 55) with late respondents (the last 25% of responses, n = 55), following the procedure recommended by Armstrong and Overton (1977). Independent-samples t-tests revealed no statistically significant differences in the mean values of the principal constructs, including LSQ ($t = -0.895$, $p = 0.373$), SAT ($t = -1.153$, $p = 0.252$), and LOY ($t = -0.609$, $p = 0.544$). Likewise, Chi-square tests indicated no significant differences between the two groups regarding demographic characteristics, such as organization type ($\chi^2 = 2.968$, $p = 0.227$) and length of service experience ($\chi^2 = 3.576$, $p = 0.311$). These findings suggest that non-response bias is unlikely to threaten the representativeness of the research sample. The sample profile and data screening results are presented in Table 1.

4.2. First-order measurement model

Because the data were collected using a cross-sectional self-report questionnaire, the study assessed the potential presence of common method bias before evaluating the measurement model. First, Harman's (1976) single-factor test was conducted in SPSS, showing that the first unrotated factor accounted for only 41.53% of the total variance, which is below the recommended threshold of 50%. Second, following the full collinearity assessment proposed by Kock (2015), the inner variance inflation factor (VIF) values among the latent constructs were examined within the PLS-SEM framework. The highest inner VIF value observed in the model was 2.188, well below the conservative

threshold of 3.3. Taken together, the results from both diagnostic procedures consistently indicate that common method bias is not a serious concern in this study.

Table 1: Sample profile and data screening results

Characteristics	Category	Frequency (n)	Percentage (%)
Organization type	Firms using logistics services	87	39.5
	Logistics service providers that also outsource logistics services	76	34.5
	Logistics service providers	45	20.5
	Others	12	5.5
Length of experience	Less than 1–3 years	62	28.2
	3–7 years	83	37.7
	More than 7 to less than 10 years	36	16.4
	10 years or more	39	17.7
Type of logistics service	Transportation	137	62.3
	Freight forwarding	106	48.2
	Integrated logistics services	102	46.4
	Warehousing	74	33.6
	Others	3	1.4

The study evaluated the first-order measurement models for six reflective constructs: outcome quality (OQ), process quality (PQ), information quality (IQ), relationship quality (RQ), customer satisfaction (SAT), and customer loyalty (LOY). As recommended in PLS-SEM, reflective measurement models should be validated in terms of indicator reliability, internal consistency reliability, and convergent validity before the structural model is assessed (Hair et al., 2021). Specifically, indicator reliability was assessed using outer loadings; internal consistency reliability was evaluated using Cronbach's alpha, rho_A, and composite reliability (CR); and convergent validity was examined using average variance extracted (AVE) (Fornell and Larcker, 1981; Hair et al., 2021).

The results presented in Table 2 show that all measurement items have outer loadings above the recommended threshold of 0.708, indicating that indicator reliability meets the required criteria (Hair et al., 2021). Specifically, the outer loadings range from 0.760 to 0.829 for OQ, from 0.745 to 0.844 for PQ, from 0.785 to 0.806 for IQ, from 0.768 to 0.805 for RQ, from 0.753 to 0.822 for SAT, and from 0.785 to 0.812 for LOY. These results indicate that the measurement items adequately reflect their respective latent constructs; therefore, no indicators needed to be removed during the evaluation of the first-order measurement model. The internal consistency reliability indicators also meet the accepted criteria. Cronbach's alpha values for the constructs ranged from 0.706 to 0.811, rho_A values ranged from 0.709 to 0.812, and composite reliability (CR) values ranged from 0.836 to 0.876. All these values exceeded the minimum threshold of 0.70, indicating that the scales demonstrate satisfactory internal consistency reliability (Hair et al., 2021). Furthermore, the AVE values of the constructs ranged from 0.619 to 0.641, all exceeding the threshold of 0.50. According to Fornell and Larcker (1981), this result indicates that each latent construct explains more than 50% of the variance in its corresponding measurement items, thereby confirming the convergent validity of the scales.

Overall, the evaluation results of the first-order measurement model indicate that all six constructs, OQ, PQ, IQ, RQ, SAT, and LOY, meet the requirements for indicator reliability, internal consistency reliability, and convergent validity. This provides the necessary empirical basis for estimating LSQ as a second-order construct in the subsequent analysis stage, while also ensuring that the first-order constructs possess sufficient reliability and measurement validity for inclusion in the structural model. Table 2 presents the results of indicator reliability, internal consistency reliability, and convergent validity for the first-order constructs.

Table 2: Indicator reliability, internal consistency reliability, and convergent validity of the first-order constructs

Construct	Indicator	Outer loading	Cronbach's alpha	rho_A	CR	AVE
OQ	OQ1	0.829	0.713	0.718	0.839	0.635
		0.800				
		0.760				
PQ	PQ1	0.745	0.706	0.709	0.836	0.631
		0.844				
		0.791				
IQ	IQ1	0.802	0.715	0.718	0.840	0.636
		0.785				
		0.806				
RQ	RQ1	0.778	0.795	0.798	0.867	0.619
		0.805				
		0.768				
SAT	SAT1	0.796	0.811	0.812	0.876	0.639
		0.753				
		0.822				
		0.809				
LOY	LOY1	0.813	0.720	0.721	0.843	0.641
		0.812				
		0.804				
		0.785				

4.3. Second-order measurement model

After the first-order constructs had met the requirements for reliability and convergent validity, the study proceeded to evaluate the second-order measurement model of logistics service quality (LSQ). Theoretically, LSQ is a multidimensional concept that reflects customers' overall perceptions of logistics service quality across various aspects, such as delivery outcomes, service processes, information quality, and interaction quality with service providers (Mentzer et al., 2001; Thai, 2013). Therefore, this study models LSQ as a higher-order reflective construct reflected by four first-order constructs: outcome quality (OQ), process quality (PQ), information quality (IQ), and relationship quality (RQ). According to Becker et al. (2012) and Sarstedt et al. (2019), when evaluating higher-order constructs in PLS-SEM, it is necessary to consider the loadings of first-order constructs on the second-order construct, while also assessing the reliability and convergent validity of the higher-order construct.

In this study, LSQ was estimated using the disjoint two-stage approach, consistent with recommendations for higher-order models in PLS-SEM (Sarstedt et al., 2019). The results presented in Table 3 show that all four first-order constructs positively and significantly reflect LSQ. Specifically, OQ has an outer loading of 0.815, t = 22.758, p < 0.001; PQ has an outer loading of 0.791, t = 19.160, p < 0.001; IQ has an outer loading of 0.853, t = 35.487, p < 0.001; and RQ has an outer loading of 0.866, t = 43.922, p < 0.001. In this context, RQ has the highest loading, indicating that relationship quality is the dimension that most strongly reflects the overall perception of LSQ in the research context.

The results presented in Table 4 further confirm the measurement quality of the second-order LSQ construct. Specifically, Cronbach's alpha was 0.852, rho_A was 0.861, composite reliability (CR) was 0.900, and average variance extracted (AVE) was 0.692. Table 3 presents the loadings of the first-order constructs on the second-order logistics service quality construct.

Table 3: Loadings of first-order constructs on LSQ

Second-order construct	First-order construct	Outer loading	t-value	p-value
LSQ	OQ	0.815	22.758	< 0.001
LSQ	PQ	0.791	19.160	< 0.001
LSQ	IQ	0.853	35.487	< 0.001
LSQ	RQ	0.866	43.922	< 0.001

All these values exceed the recommended thresholds, with CR exceeding 0.70, indicating satisfactory internal consistency reliability, and AVE exceeding 0.50, confirming the convergent validity of the second-order construct (Fornell and Larcker, 1981; Hair et al., 2021). Thus, LSQ can be considered a suitable and reliable second-order construct. Accordingly, hypotheses H1a, H1b, H1c, and H1d are supported. Table 4 presents the reliability and convergent validity results for the second-order logistics service quality construct.

Table 4: Reliability and convergent validity of the second-order LSQ construct

Construct	Cronbach's alpha	rho_A	CR	AVE
LSQ	0.852	0.861	0.900	0.692

To further strengthen the robustness of the measurement model, the suitability of modeling LSQ as a formative second-order construct was also considered as an alternative model specification. Nevertheless, the reflective–reflective specification was retained for two primary reasons. From a theoretical perspective, customers' overall perception of logistics service quality represents a general evaluative attitude that underlies their assessments of service outcomes, operational processes, information quality, and relationship quality. Accordingly, these first-order dimensions share a common conceptual domain and are expected to covary (Mentzer et al., 2001). From an empirical perspective, the correlation matrix among the four first-order constructs (OQ, PQ, IQ, and RQ) revealed strong and statistically significant positive correlations, ranging from 0.538 to 0.656, which is characteristic of a reflective measurement model. Modeling LSQ as a formative construct under such conditions could introduce substantial multicollinearity at the higher-order level and reduce the statistical significance of the indicator weights (Hair et al., 2021). Therefore, conceptualizing LSQ as a reflective second-order construct is supported by both theoretical reasoning and empirical evidence.

4.4. Discriminant validity

Discriminant validity was assessed to confirm that logistics service quality (LSQ), customer satisfaction (SAT), and customer loyalty (LOY) are conceptually and empirically distinct constructs. In this study, discriminant validity was examined using both the Fornell–Larcker criterion and the HTMT. According to Fornell and Larcker (1981), discriminant validity is established when the square root of the AVE for each construct is greater than its correlations with other constructs. However, because the Fornell–Larcker criterion may be less sensitive in detecting discriminant validity issues when constructs are highly correlated, HTMT was employed as a more rigorous supplementary criterion, as recommended by Henseler et al. (2015) and Hair et al. (2021). To assess whether the constructs were empirically distinct from one another, discriminant validity was examined using

the Fornell–Larcker criterion and the HTMT. The results are reported in Table 5.

Table 5: Discriminant validity: Fornell–Larcker criterion and HTMT ratio

Construct	LOY	LSQ	SAT
Fornell-Larcker criterion			
LOY	0.801	0.602	0.658
LSQ	0.602	0.832	0.737
SAT	0.658	0.737	0.800
HTMT ratio			
LOY	—	0.760	0.861
LSQ	0.760	—	0.883
SAT	0.861	0.883	—

The Fornell–Larcker results show that the diagonal values, corresponding to the square roots of AVE, are 0.801 for LOY, 0.832 for LSQ, and 0.800 for SAT. These values are all greater than the corresponding off-diagonal correlation coefficients, indicating that the three constructs achieve discriminant validity according to the Fornell-Larcker criterion. The HTMT results further support this conclusion, with HTMT values of 0.760 between LOY and LSQ, 0.861 between LOY and SAT, and 0.883 between LSQ and SAT. All values are below the threshold of 0.90, confirming that the constructs maintain an acceptable level of empirical distinctiveness (Hair et al., 2021; Henseler et al., 2015). Therefore, the research model demonstrates satisfactory discriminant validity and is suitable for subsequent structural model evaluation.

4.5. Structural model

After the first-order and second-order measurement models had met the required criteria, the study proceeded to evaluate the structural model to test the hypotheses regarding the effects of logistics service quality (LSQ), customer satisfaction (SAT), and customer loyalty (LOY). Following the recommendations of Hair et al. (2021), structural model evaluation in PLS-SEM should consider multicollinearity, standardized path coefficients, statistical significance, bootstrap confidence intervals, explanatory power, and the model's predictive capability. In this study, the coefficients were tested using bootstrapping with 5,000 resamples, and the detailed results were derived from the structural model analysis.

First, the first-order model was examined to assess the individual effects of the four LSQ dimensions on SAT. The results showed that the VIF values for OQ, PQ, IQ, and RQ in predicting SAT ranged from 1.781 to 2.178, all below the threshold of 3, indicating the absence of serious multicollinearity. All four dimensions had positive and statistically significant effects on SAT: OQ → SAT ($\beta = 0.193$, $t = 3.346$, $p = 0.001$), PQ → SAT ($\beta = 0.143$, $t = 2.355$, $p = 0.019$), IQ → SAT ($\beta = 0.219$, $t = 3.319$, $p = 0.001$), and RQ → SAT ($\beta = 0.322$, $t = 4.463$, $p < 0.001$). This finding provides important theoretical insights by demonstrating that relationship quality (RQ) is the strongest driver of customer satisfaction in the context of the Red River Delta. This result may be explained by the region's distinctive business culture, where corporate customers place considerable value on interpersonal interactions, mutual understanding, and flexibility in resolving operational issues rather than relying solely on standardized procedures. When transportation infrastructure or supply chain operations are disrupted by external factors, strong partnership relationships built on trust and responsive communication (RQ), together with transparent information sharing (IQ), can effectively compensate for deficiencies in service timeliness or process performance (OQ and PQ). The finding that RQ exerts the strongest influence on overall logistics service quality suggests that, in developing markets characterized by collectivist cultural values, LSQ should be viewed not only as a technical performance indicator but also as a process of building social trust between logistics partners. This interpretation is consistent with previous studies showing that operational quality, information quality, and personnel interaction quality constitute important antecedents of customer satisfaction (Gupta et al., 2023; Lin et al., 2023). To illustrate the relationships among the first-order constructs, the estimated structural model with standardized path coefficients is presented in Fig. 2. Table 6 presents the results of the first-order structural model assessment. The first-order model explains 54.6% of the variance in SAT ($R^2 = 0.546$; adjusted $R^2 = 0.538$) and 43.3% of the variance in LOY ($R^2 = 0.433$; adjusted $R^2 = 0.431$). These results indicate that the first-order dimensions of LSQ have substantial explanatory power for customer satisfaction, while SAT serves as an important antecedent of customer loyalty. To assess the explanatory power of the first-order structural model, the coefficients of determination (R^2) for the endogenous constructs were examined. The results are reported in Table 7.

For the second-order model, the test results show that LSQ has a positive and statistically significant effect on SAT ($\beta = 0.737$, $t = 16.490$, $p < 0.001$, 95% CI [0.637, 0.812]); therefore, H3 is supported. This result reinforces the argument that customers' overall perceptions of logistics service quality serve as a direct antecedent of satisfaction, which is consistent with empirical evidence in logistics and e-commerce contexts (Akıl and Ungan, 2022; Gupta et al., 2023; Lin et al., 2023).

Table 6: Results of the first-order structural model testing

Hypothesis	Relationship	β	t-value	p-value	95% CI [LLCI; ULCI]	VIF	Conclusion
H2a	OQ → SAT	0.193	3.346	0.001	[0.079; 0.303]	1.863	Supported
H2b	PQ → SAT	0.143	2.355	0.019	[0.026; 0.262]	1.781	Supported
H2c	IQ → SAT	0.219	3.319	0.001	[0.088; 0.350]	2.139	Supported
H2d	RQ → SAT	0.322	4.463	< 0.001	[0.183; 0.464]	2.178	Supported
H4	SAT → LOY	0.658	13.564	< 0.001	[0.554; 0.743]	1.000	Supported

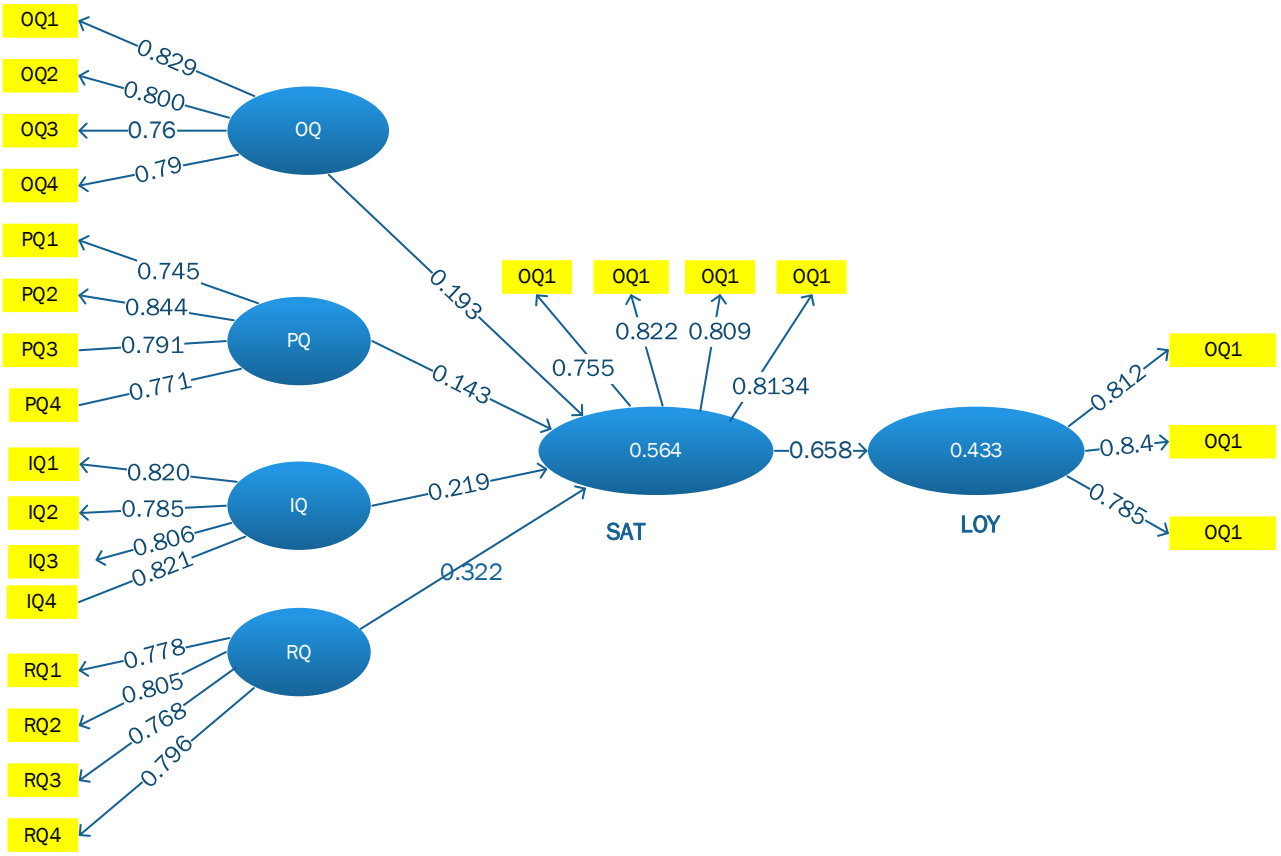


Fig. 2: First-order structural model

Table 7: Explanatory power of the first - order model

Endogenous construct	R^2	Adjusted R^2
SAT	0.546	0.538
LOY	0.433	0.431

SAT also has a positive and statistically significant effect on LOY (β = 0.469, t = 6.003, p < 0.001, 95% CI [0.308, 0.615]); therefore, H4 is supported. This indicates that the more satisfied customers are with logistics services, the more likely they are to continue using the service, maintain relationships with the service provider, and reselect the provider. This finding is consistent with the logic of behavioral consequences of satisfaction in service marketing (Oliver, 1980; Zeithaml et al., 1996). In addition, LSQ has a direct positive effect on LOY (β = 0.257, t = 3.441, p = 0.001, 95% CI [0.116, 0.407]); therefore, H5 is supported. At the same time, the indirect effect of LSQ on LOY through SAT is also statistically significant (β = 0.345, t = 5.368, p < 0.001, 95% CI [0.218, 0.471]). Because both the direct and indirect effects are significant, SAT partially mediates the relationship between LSQ and LOY; therefore, H6 is supported. This result is consistent with studies showing that satisfaction is an important mechanism through which logistics service quality is translated into customer loyalty, repurchase intention, and retention (Ellitan, 2023; Gupta et al., 2023; Minh et al., 2024). Table 8 presents the hypothesis-testing results for the second-order structural model.

Table 8: Hypothesis testing results for the second - order structural model

Hypothesis	Relationship	β	t-value	p-value	95% CI [LLCI; ULCI]	Decision
H3	LSQ → SAT	0.737	16.490	< 0.001	[0.637; 0.812]	Supported
H4	SAT → LOY	0.469	6.003	< 0.001	[0.308; 0.615]	Supported
H5	LSQ → LOY	0.257	3.441	0.001	[0.116; 0.407]	Supported
H6	LSQ → SAT → LOY	0.345	5.368	< 0.001	[0.218; 0.471]	Supported

Regarding explanatory and predictive power, LSQ explains 54.3% of the variance in SAT (R^2 = 0.543; adjusted R^2 = 0.541), while LSQ and SAT together explain 46.3% of the variance in LOY (R^2 = 0.463; adjusted R^2 = 0.458). The Q^2_predict values for SAT and LOY are 0.540 and 0.353, respectively, both exceeding 0, indicating that the model has predictive relevance for the endogenous constructs. Furthermore, the VIF values for the structural paths in the second-order model range from 1.000 to 2.188, which is below the recommended threshold, confirming the absence of serious multicollinearity (Hair et al., 2021). Table 9 presents the explanatory power, predictive relevance, and multicollinearity assessment of the second-order structural model.

Table 9: Explanatory power, predictive relevance, and multicollinearity assessment

Endogenous construct/relationship	R^2	Adjusted R^2	Q^2_predict	VIF
SAT	0.543	0.541	0.540	1.000
LOY	0.463	0.458	0.353	—
LSQ → LOY	—	—	—	2.188
SAT → LOY	—	—	—	2.188

Taken together, the above results show that hypotheses H2a, H2b, H2c, H2d, H3, H4, H5, and H6 are all supported. This confirms that LSQ has a strong effect on customer satisfaction and also influences customer loyalty both directly and indirectly through SAT.

4.6. Mediation analysis

This study examines the mediating role of customer satisfaction (SAT) in the relationship between overall logistics service quality (LSQ) and customer loyalty (LOY) by analyzing the direct, indirect, and total effects in PLS-SEM. According to Hair et al. (2021), mediation analysis in PLS-SEM should rely primarily on the statistical significance of the indirect effect, which is assessed using bootstrapping and confidence intervals to determine whether the mediating effect is significantly different from zero. In addition, the variance accounted for (VAF) value is used to assess the extent of mediation, although it should be interpreted in conjunction with the theoretical meaning and statistical significance of both direct and indirect effects (Nitzl et al., 2016).

The results show that the direct effect of LSQ on LOY is statistically significant, with β = 0.257, t = 3.441, p = 0.001, and a 95% confidence interval of [0.116, 0.407]. Similarly, the indirect effect of LSQ on LOY through SAT is also statistically significant, with β = 0.345, t = 5.368, p < 0.001, and a 95% confidence interval of [0.218, 0.471]. Table 10 presents the results of the mediation analysis.

Since the confidence interval for the indirect effect does not include zero, it can be concluded that SAT mediates the relationship between LSQ and LOY. The total effect of LSQ on LOY is β = 0.602, t = 11.819, p < 0.001, indicating that LSQ has a strong overall effect on customer loyalty. The VAF value was 57.3%, falling within the range of 20%–80%, which indicates that SAT partially mediates the relationship between LSQ and LOY (Nitzl et al., 2016). In other words, logistics service quality not only directly strengthens customer loyalty but also indirectly enhances LOY by increasing customer satisfaction. This result is consistent with previous studies suggesting that satisfaction is a key mechanism through which LSQ is translated into reuse intention, relationship maintenance, and loyalty. However, the direct effect of LSQ on loyalty may still exist in specific logistics contexts (Ellitan, 2023; Gupta et al., 2023; Lin et al., 2023). Following the confirmation of a statistically significant indirect effect, the variance accounted for (VAF) was calculated to determine the extent to which customer satisfaction mediates the relationship between logistics service quality and customer loyalty. The results are reported in Table 11. The results of the second-order structural model are presented in Fig. 3.

Table 10: Mediation analysis results

Relationship	Effect	β	t-value	p-value	95% CI [LLCI; ULCI]	Conclusion
LSQ → LOY	Direct effect	0.257	3.441	0.001	[0.116; 0.407]	Significant
LSQ → SAT → LOY	Indirect effect	0.345	5.368	< 0.001	[0.218; 0.471]	Significant
LSQ → LOY	Total effect	0.602	11.819	< 0.001	[0.497; 0.697]	Significant

Table 11: Variance accounted for (VAF)

Item	Formula	Value
Indirect effect	LSQ → SAT × SAT → LOY	0.345
Total effect	Direct effect + Indirect effect	0.602
VAF	Indirect effect / Total effect	0.573
VAF percentage	0.573 × 100	57.3%
Type of mediation	Based on VAF thresholds	Partial mediation

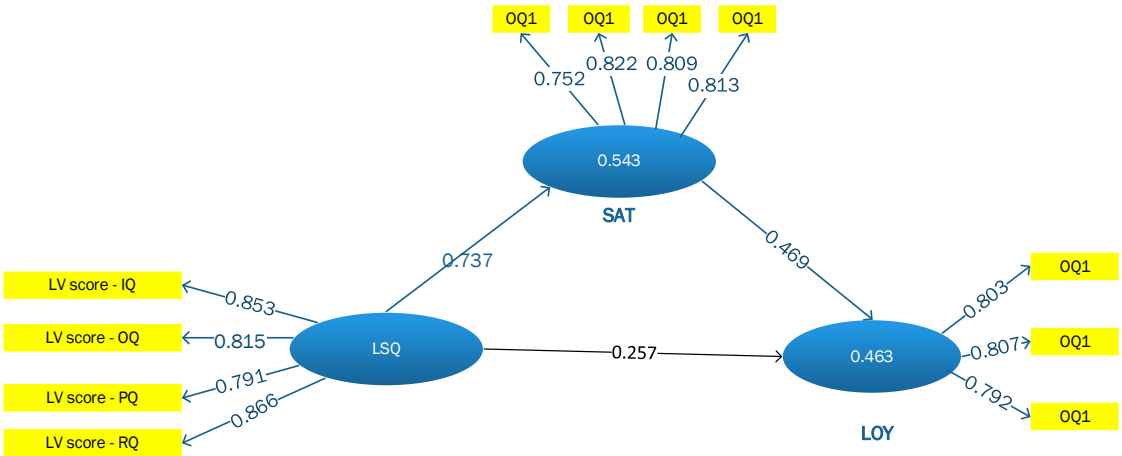


Fig. 3: Second-order structural model

4.7. Multi-group analysis

A multi-group analysis (MGA) was conducted to examine whether the structural relationships in the proposed model differed between firms using logistics services (n = 87) and logistics service providers (including both pure logistics service providers and providers that also outsource logistics

activities; total n = 121). Prior to conducting the MGA, the measurement invariance of composite models' procedure was performed to ensure that any observed differences in the structural relationships were not attributable to measurement bias. The measurement invariance of composite models results indicated no statistically significant differences in either the means or variances of the constructs across the two groups. Specifically, the mean differences for LSQ ($p = 0.241$), SAT ($p = 0.948$), and LOY ($p = 0.863$) were all non-significant ($p > 0.05$). Likewise, Levene's tests for equality of variances yielded p-values of 0.884, 0.588, and 0.141, respectively. These findings confirm full measurement invariance, indicating that the model satisfies the prerequisite for comparing structural path coefficients across groups.

The MGA results revealed no statistically significant differences in any of the structural relationships between logistics service users and logistics service providers. Specifically, the difference in the effect of LSQ on SAT between the two groups ($\Delta\beta = 0.068$) was not statistically significant ($t = -0.596$, $p = 0.552$). Similarly, the differences in the effects of LSQ on LOY ($\Delta\beta = 0.011$, $p = 0.950$) and SAT on LOY ($\Delta\beta = 0.061$, $p = 0.669$) were also non-significant. These findings indicate that the proposed research model demonstrates a high degree of consistency and generalizability across the two stakeholder groups. In other words, the LSQ–SAT–LOY mechanism remains robust and is equally applicable to both logistics service users (customers) and logistics service providers (supply-side partners) within the logistics supply chain in the Red River Delta region.

5. Discussion

This study conceptualized logistics service quality (LSQ) as a reflective–reflective second-order construct comprising outcome quality (OQ), process quality (PQ), information quality (IQ), and relationship quality (RQ). The results support this multidimensional view and indicate that customers perceive LSQ as an overall evaluation derived from operational outcomes, service processes, information provision, and relational interactions. This finding is consistent with the LSQ frameworks proposed by Mentzer et al. (2001) and Thai (2013). The measurement model confirmed that both the first-order and second-order constructs met the recommended reliability and validity criteria, supporting the higher-order specification of LSQ (Becker et al., 2012; Sarstedt et al., 2019). Among the four dimensions, RQ and IQ showed the highest loadings on LSQ, at 0.866 and 0.853, respectively. The prominence of RQ may reflect the relationship-oriented nature of business practices in Vietnam, where trust, responsiveness, and long-term cooperation are important in business-to-business logistics relationships. The strong role of IQ also highlights customers' need for accurate, timely, and transparent information, particularly in a region characterized by dense industrial activity and infrastructure constraints.

The structural results showed that LSQ had a strong positive effect on customer satisfaction ($\beta = 0.737$, $p < 0.001$), while satisfaction positively affected customer loyalty ($\beta = 0.469$, $p < 0.001$). LSQ also retained a significant direct effect on loyalty ($\beta = 0.257$, $p = 0.001$). These findings support the LSQ–SAT–LOY relationship and are consistent with service marketing theory, which suggests that perceived service quality shapes satisfaction and subsequent behavioral intentions (Oliver, 1980; Zeithaml et al., 1996). Customer satisfaction partially mediated the relationship between LSQ and loyalty, with a VAF value of 57.3%. This indicates that LSQ strengthens loyalty partly through satisfaction, while other mechanisms, such as trust, switching costs, prior relationship history, and operational dependence, may also influence customer retention. The model explained 54.3% of the variance in satisfaction and 46.3% of the variance in loyalty, indicating adequate explanatory power.

Overall, the study extends the LSQ literature by confirming the validity of a higher-order LSQ model and by showing that satisfaction is an important, but not exclusive, mechanism through which logistics service quality is translated into customer loyalty.

6. Conclusions

This study examined LSQ as a reflective–reflective second-order construct and assessed its effects on customer satisfaction and loyalty in the Red River Delta economic region. The findings confirmed the reliability and validity of the higher-order LSQ model and identified relationship quality and information quality as the strongest dimensions reflecting customers' overall evaluations of logistics services. LSQ had a strong positive effect on satisfaction, while satisfaction positively influenced loyalty. LSQ also maintained a significant direct effect on loyalty, and satisfaction partially mediated this relationship. These results confirm the relevance of the LSQ–SAT–LOY framework in the logistics service context. The study contributes to the literature by providing empirical support for a multidimensional higher-order LSQ model and by highlighting the importance of relational and informational aspects of logistics services in an emerging-market setting.

6.1. Managerial implications

The findings suggest that logistics service providers in the Red River Delta should prioritize both relationship quality and information quality. First, firms should strengthen customer relationship management by promoting personalized communication, rapid response, flexible problem solving, and long-term cooperation. Customer relationship management systems should support not only customer data management but also more effective interaction between employees and

business customers. Second, firms should improve information quality through real-time tracking, integrated logistics platforms, automated notifications, and transparent communication about shipment status and service disruptions. These measures can reduce uncertainty and improve customers' ability to coordinate their logistics activities. Third, digital information systems should be combined with strong relationship management. Technological transparency can improve operational visibility, while effective interpersonal communication can maintain trust when delays or service failures occur. Finally, managers should recognize that customer loyalty is influenced not only by satisfaction but also by trust, relationship continuity, operational integration, and switching costs. Therefore, logistics firms should adopt a long-term relationship strategy rather than relying solely on short-term satisfaction outcomes.

6.2. Limitations and future research directions

This study has several limitations. First, the data were collected only in the Red River Delta economic region. Therefore, the findings may not be fully generalizable to other regions of Vietnam or to countries with different logistics systems and business cultures. Future studies should expand the geographical scope and conduct cross-regional or cross-country comparisons. Second, the study used a cross-sectional design, which limits causal inference and does not capture changes in customer perceptions over time. Longitudinal research could provide a better understanding of how LSQ, satisfaction, and loyalty evolve during long-term business relationships. Third, satisfaction only partially mediated the relationship between LSQ and loyalty. Future studies should examine additional mediators, such as trust, perceived value, switching costs, relationship commitment, and service dependence. Finally, the study relied mainly on perceptual survey data. Future research could combine subjective evaluations with objective performance indicators, such as on-time delivery, order accuracy, complaint rates, service recovery time, and customer retention.

List of abbreviations

AVE	Average variance extracted
B2B	Business-to-business
CI	Confidence interval
CR	Composite reliability
HTMT	Heterotrait–Monotrait ratio
IQ	Information quality
LLCI	Lower limit of the confidence interval
LOY	Customer loyalty
LSQ	Logistics service quality
MGA	Multi-group analysis
OQ	Outcome quality
PLS-SEM	Partial least squares structural equation modeling
PQ	Process quality
RQ	Relationship quality
SAT	Customer satisfaction
SPSS	Statistical Package for the Social Sciences
ULCI	Upper limit of the confidence interval
VAF	Variance accounted for
VIF	Variance inflation factor

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Compliance with ethical standards

Ethical considerations

Participation in this study was entirely voluntary. Before completing the questionnaire, all respondents were informed about the purpose of the study, the academic use of the collected data, and the measures taken to protect the confidentiality of their responses. No personally identifiable or sensitive information was collected. Participants were free to decline or discontinue participation at any time without any adverse consequences. Informed consent was obtained from all participants before data collection.

Conflict of interest

The author(s) declared no potential conflicts of interest with respect to the research, authorship, and/or publication of this article.

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