

Analysis of Classification Society Service Quality Impact on Customer Loyalty Through Co-Creation, Co-Production in Shipbuilding Projects

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Abstract

This study investigates the impact of classification societies on customer loyalty in Indonesia's shipbuilding industry, focusing on service quality, co-creation, and co-production. Classification societies establish and enforce technical standards for ship design, construction, and operation. The research evaluates how service quality influences customer loyalty, mediated by co-creation and co-production. A quantitative approach was applied, collecting data from 200 customers of PT. Biro Klasifikasi Indonesia (BKI) and analyzing it using Partial Least Squares Structural Equation Modeling (PLS-SEM). The findings indicate a significant positive relationship between service quality and customer loyalty, with co-production exerting a stronger influence than co-creation. The study underscores the importance of effective collaboration and high-quality services in fostering trust and satisfaction. It offers valuable insights for classification societies to enhance strategies, particularly in providing responsive and reliable services.

A. INTRODUCTION

The maritime sector in Indonesia is experiencing substantial expansion, primarily driven by the increasing demand for nickel ore transportation. This growth has consequently amplified the necessity for ship classification and certification services. Classification societies perform a critical role in formulating and enforcing regulatory standards, monitoring compliance, and issuing certifications for vessels throughout their lifecycle, from initial planning to operational deployment¹. Despite the growing significance of classification societies, scholarly investigations into consumer behavior and loyalty concerning classification services remain scarce². Existing research has predominantly concentrated on technical aspects and risk management.

The level of competition among classification societies has intensified following the implementation of Minister of Transportation Regulation No. 61 of 2014³. To enhance customer retention, which remains below optimal levels, PT. Biro Klasifikasi Indonesia must prioritize service enhancements and strengthen collaborations with key stakeholders (PT. BKI, 2022). Within the shipbuilding ecosystem, co-creation and co-production serve fundamental functions. Co-creation occurs during the planning and design phase, involving shipyards, design consultants, shipowners, and classification societies⁴. Conversely, co-production takes place during the construction phase, necessitating close collaboration among shipyards, classification societies, and shipowners⁵. This study aims to examine the extent to which the service quality of classification societies, facilitated through co-creation and co-production processes, influences customer loyalty.

¹ F. Fulconis dan R Lissillour, "Toward a behavioral approach of international shipping: a study of the inter-organisational dynamics of maritime safety," *Journal of Shipping and Trade* 6, no. 1 (2021), <https://doi.org/https://doi.org/10.1186/s41072-021-00092-4>.

² L Kretschmann, "Leading indicators and maritime safety: predicting future risk with a machine learning approach," *Journal of Shipping and Trade* 5, no. 1 (2020), <https://doi.org/https://doi.org/10.1186/s41072-020-00071-1>.

³ A. Kholick dan T. S Kaihatu, "Analysis of the Effect of Service Quality on Corporate Image and Service Usage Decisions at PT. Biro Klasifikasi Indonesia (Persero)," *International Journal of Review Management Business and Entrepreneurship (RMBE)* 1, no. 2 (2021): 102-113, <https://doi.org/https://doi.org/10.37715/rmbe.v1i2.2418>.

⁴ M.-G. Manea dan E Manea, "Shipbuilding – An Analysis from the Perspective of Enterprise Resources Planning System," *World Journal of Engineering and Technology* 11, no. 1 (2023): 81-112, <https://doi.org/https://doi.org/10.4236/wjet.2023.111008>.

⁵ Manea dan Manea.

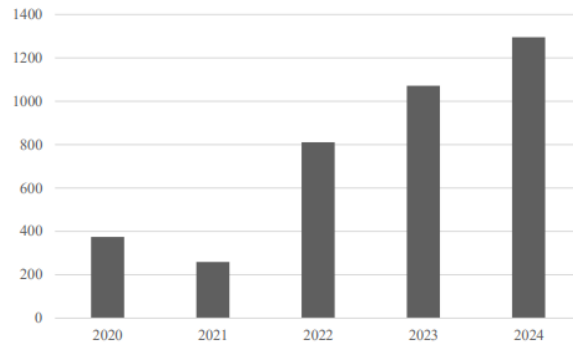


Figure 1. Chart of Naumber of Applications for Ship Admission at PT. BKI

Source: PT. BKI, 2024

Classification societies fulfill a critical function in maritime safety governance by strategically allocating resources and creating value, leveraging their government-conferred legitimacy as public service entities⁶. As entities entrusted with public service responsibilities, they must uphold a high standard of service quality, which is assessed based on the alignment between customer expectations and their perceived service performance. Service quality reflects an organization's overall excellence and encompasses critical attributes such as responsiveness, competence, empathy, and tangible aspects⁷. Additionally, service quality includes key elements such as operational efficiency, responsiveness, and reliability in addressing customer needs and resolving complaints⁸.

Empirical studies have identified a strong correlation between trust, service quality, and customer satisfaction, all of which significantly contribute to customer loyalty and repeat engagements⁹. This research adopts the SERVQUAL model, initially proposed by

⁶ Fulconis dan Lissillour, "Toward a behavioral approach of international shipping: a study of the inter-organisational dynamics of maritime safety."

⁷ Bkti Kumoro Widarso dan Denpharanto Agung Krisprimandoyo, "The Effect of Service Quality, Reputation, and Perceived Price on Purchase Decisions with Customer Satisfaction as an Intervening Variable (Study on Parents of Students at Ciputra School Surabaya)," *Sinergi : Jurnal Ilmiah Ilmu Manajemen* 13, no. 2 (2023): 83–94, <https://doi.org/10.25139/sng.v13i2.7103>.

⁸ T Threesya Nurbianto, A., Febry Christian, "MARKETING STRATEGIES THROUGH PRODUCT AWARENESS, SERVICE QUALITY AND PRODUCT QUALITY ASSURANCE ON CONSUMER PURCHASING DECISIONS," *Journal of Research and Community Service* 5, no. 4 (2024): 461–470, <https://doi.org/http://devotion.greenvest.co.id>.

⁹ E. Rantung, E. Harianto, dan U Ciputra, "As-Syirkah: Islamic Economics & Finacial Journal Pengaruh Kepercayaan dan Kualitas Pelayanan Terhadap Minat Beli Ulang Melalui Kepuasan Pelanggan Sebagai Variabel Mediasi Pada SPBU di Makassar," *As-Syirkah: Islamic Economics & Finacial Journal* 3, no. 3 (2024): 1406–1423, <https://doi.org/https://doi.org/10.56672/assyirkah.v3i3.253>.

Parasuraman et al. (1985) and further developed by Parman & Susanto (2016) and Albuquerque & Ferreira (2022), to evaluate service quality across five fundamental dimensions: tangibles, reliability, responsiveness, assurance, and empathy¹⁰. These dimensions are essential in shaping customer perceptions and enhancing their overall experience with classification societies.

Consumer attitudes and purchasing power have undergone substantial transformations¹¹. Co-creation serves as a collaborative mechanism through which companies and consumers jointly generate value for products or services by exchanging knowledge and sharing experiences, ensuring alignment with market demands¹². This process necessitates active consumer participation in the fundamental development of products or services, influencing their final attributes based on user preferences. In industries that produce goods and services, customers play a critical role in shaping unique and meaningful service experiences, which directly affect perceived value¹³.

Empirical studies indicate that customer co-creation enhances perceived value, satisfaction, loyalty, and overall corporate performance¹⁴. Within the classification industry, co-creation involves collaboration among classification societies, shipowners, and operators¹⁵. Strong leadership support and motivation are expected to enhance performance, thereby benefiting the company¹⁶. This process integrates customer service

¹⁰ R. P. Albuquerque dan J. J Ferreira, "Service quality, loyalty, and co-creation behaviour: a customer perspective," *International Journal of Innovation Science* 14, no. 1 (2022): 157-176, <https://doi.org/https://doi.org/10.1108/IJIS-06-2021-0101>; A. Parasuraman, V. A. Zeithaml, dan L. L. Berry, "A Conceptual Model of Service Quality and Its Implications for Future Research," *Journal of Marketing* 49, no. 4 (1985): 41-50, <https://doi.org/https://doi.org/10.1177/002224298504900403>; Parman dan Susanto, "Analisis Pengaruh Kualitas Pelayanan, Kualitas Produk Dan Citra Merek Terhadap Kepuasan Pelanggan Dan Dampaknya Pada Loyalitas Pelanggan Waroeng Spesial Sambal," *Journal of Business Theory and Implementation* 7, no. 1 (2016), <https://doi.org/https://doi.org/https://doi.org/10.18196/jbti.v7i1.2549>.

¹¹ Akhmad Riduan et al., "Case Study on Public Service Responsibility Implementation in Surabaya via the Broadband Learning Centre Programme" 5, no. 2 (2024): 2789-2805.

¹² C. Tynan, S. McKechnie, dan C Chhuon, "Co-creating value for luxury brands," *Journal of Business Research* 63, no. 11 (2010): 1156-1163, <https://doi.org/https://doi.org/10.1016/j.jbusres.2009.10.012>.

¹³ C. K. Prahalad dan V Ramaswamy, "Co-creation experiences: The next practice in value creation," *Journal of Interactive Marketing* 18, no. 3 (2004): 5-14, <https://doi.org/https://doi.org/10.1002/dir.20015>.

¹⁴ A. A. Sadabadi dan Z Rahimi Rad, "How can Cross-sector Partnership Promote Social Innovation?," *Systemic Practice and Action Research* 35, no. 4 (2022): 471-490, <https://doi.org/https://doi.org/10.1007/s11213-021-09581-w>.

¹⁵ L.-B. Goh dan T Leung YIP, "A Way Forward for Ship Classification and Technical Services," 2014, <https://doi.org/https://doi.org/10.1016/j.ajsl.2014.04.003&domain=pdf>.

¹⁶ Putri Septaningtyas Hidayat, Siska Armawati Sufa, dan Eny Ratnasari, "PERAN DEPARTEMEN HUMAN RESOURCES DEVELOPMENT DALAM AKTIVITAS EMPLOYEE RELATIONS PADA BISNIS KELUARGA (Studi Kasus pada Royal Trawas Hotel & Cottages) THE ROLE OF THE DEPARTMENT OF

experiences by facilitating direct interactions between firms and consumers at the initial stages of project development. Key indicators of co-creation include ideation, design, development, and conceptualization, with anticipated outcomes such as innovation and customized solutions.

Co-production entails the active engagement of stakeholders in the development of products or services, focusing on the implementation of collaboratively designed solutions while ensuring efficient resource utilization¹⁷. In the business-to-business (B2B) sector, it aligns with service-dominant (S-D) logic, marking a transition from product-centered to service-oriented value creation. In the public sector, co-production extends beyond professional service delivery by incorporating citizen and community participation¹⁸. The process involves key stages production, implementation, delivery, and evaluation where efficiency and quality serve as critical performance indicators. This study explores the integration of co-creation and co-production in classification society services and their impact on customer value.

Customer loyalty represents a long-term commitment to repeatedly purchasing or prioritizing a specific product or service, regardless of external factors such as market competition and situational influences¹⁹. It is characterized by a strong intention to repurchase, sustained engagement with a preferred brand, and consumer attachment to a product or service²⁰. Key indicators of customer loyalty include brand preference, word-of-mouth recommendations, purchase frequency, repeat buying behavior, and purchasing capacity²¹. Loyal customers consistently favor a particular company over competitors and contribute to its long-term success. Brand loyalty is recognized as a

HUMAN RESOURCES DEVELOPMENT IN EMPLOYEE RELATIONS ACTIVITIES IN FAMILY BUSI," *Jurnal Spektrum Komunikasi* 9, no. 1 (2021): 45–66.

¹⁷ C. Vargas et al., "Co-creation, co-design and co-production for public health: a perspective on definitions and distinctions," *Public Health Research and Practice* 32, no. 2 (2022), <https://doi.org/https://doi.org/10.17061/PHRP3222211>.

¹⁸ T. Brandsen dan M Honingh, "Distinguishing Different Types of Coproduction: A Conceptual Analysis Based on the Classical Definitions," *Public Administration Review* 76, no. 3 (2016): 427–435, <https://doi.org/https://doi.org/10.1111/puar.12465>.

¹⁹ F. D. Wijono dan T. C Efrata, "Strengthening Customer Loyalty through Customer Engagement, Customer Experience, and Service Innovation," *Journal Entrepreneur Dan Entrepreneurship* 12, no. 2 (2023), <https://doi.org/https://doi.org/10.37715/jee.v12i2.4177>.

²⁰ H. S Nguyen, "The impact of value co-creation behavior on customer loyalty in the service domain," *Heliyon* 10, no. 9 (2024), <https://doi.org/https://doi.org/10.1016/j.heliyon.2024.e30278>.

²¹ Nguyen.

valuable corporate asset, as it fosters repeat transactions and encourages customer advocacy²².

As a key intermediary in the shipbuilding process, the classification body plays a vital role in facilitating co-creation and co-production by fostering collaboration among stakeholders, such as shipowners and shipyards, to strengthen customer loyalty. The conceptual framework outlines the relationships between variables and is visually represented in the accompanying diagram.

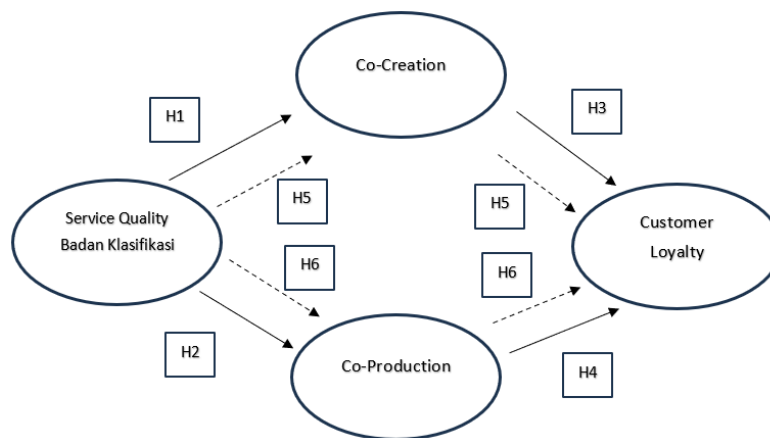


Figure 2. Model Framework

This study develops the following hypotheses based on the theoretical framework: The quality of services provided by classification societies, defined by clear regulatory guidelines, responsiveness, and surveyor expertise, fosters co-creation by enhancing trust and facilitating stakeholder collaboration²³. Empirical evidence indicates that superior service quality positively impacts corporate reputation and service adoption decisions²⁴, encouraging shipyards and shipowners to engage more actively in ship design and planning.

H1: The service quality of classification societies has a positive and significant impact on the co-creation process in shipbuilding design.

Furthermore, high service quality supports co-production by providing essential guidance throughout the shipbuilding process. Effective co-production requires close

²² E Hariyanto, "The Influence of Brand Experience Through Brand Trust and Brand Satisfaction Toward Brand Loyalty Consumer at Carl's Jr Surabaya," *In Petra Business & Management Review* 4, no. 2 (2018).

²³ Albuquerque dan Ferreira, "Service quality, loyalty, and co-creation behaviour: a customer perspective."

²⁴ Kholick dan Kaihatu, "Analysis of the Effect of Service Quality on Corporate Image and Service Usage Decisions at PT. Biro Klasifikasi Indonesia (Persero)."

cooperation among classification societies, shipyards, and shipowners to maintain construction quality²⁵. The expertise and responsiveness of surveyors further enhance this process.

H2: The service quality of classification societies has a positive and significant impact on the co-production process in shipbuilding design.

Co-creation strengthens customer loyalty by fostering stakeholder engagement and increasing perceived value. Research suggests that customer involvement in co-creation processes significantly contributes to long-term loyalty²⁶. In this context, active participation by shipyards and shipowners in ship design and planning enhances their commitment to classification societies.

H3: The co-creation process has a positive and significant impact on customer loyalty.

Similarly, effective co-production leads to the development of high-quality ships that meet customer expectations, thereby increasing satisfaction and reinforcing loyalty. Studies on value co-creation highlight the positive influence of co-production on customer loyalty in service-based industries²⁷. This study anticipates that successful co-production between classification societies and shipyards will improve satisfaction levels and strengthen customer loyalty.

H4: The co-production process has a positive and significant impact on customer loyalty.

Additionally, service quality influences customer loyalty not only directly but also indirectly through co-creation. In competitive markets, the recognition of value creation, facilitated by service quality and co-creation, serves as a critical determinant of business success²⁸. This suggests that high service quality in classification societies enhances customer loyalty by promoting co-creation.

H5: The service quality of classification societies influences customer loyalty through the co-creation process.

²⁵ Manea dan Manea, "Shipbuilding – An Analysis from the Perspective of Enterprise Resources Planning System."

²⁶ J. Wijaya dan D Putra, "Sinar Dharmayana Putra / Relationships between Service Quality, Brand Image, Customer Satisfaction, and Customer Loyalty of UC Makassar from Student's Perspective," *Journal Entrepreneur Dan Entrepreneurship* 12, no. 2 (2023): 107–120.

²⁷ Nguyen, "The impact of value co-creation behavior on customer loyalty in the service domain."

²⁸ C Diderich, "An axiomatic model towards understanding value creation and appropriation in demand-driven markets," *Journal of Strategy and Management* 17, no. 2 (2024): 375–390, <https://doi.org/https://doi.org/10.1108/JSMA-11-2023-0299>.

Service quality significantly enhances co-production, which subsequently strengthens customer loyalty. Research suggests that employee job satisfaction and commitment, shaped by an organization's service quality, directly impact customer-perceived value²⁹. In this study, improved service quality from classification societies is expected to facilitate co-production with shipyards, ultimately increasing customer loyalty.

H6: The service quality of classification societies influences customer loyalty through the co-production process.

B. RESEARCH METHODS

This study utilizes a quantitative research method with a causative approach to test the proposed hypotheses³⁰. Data were collected from BKI consumers, including shipyard companies, shipowners, ship operators, consultants, and service providers in ship inspection and maintenance. A purposive sampling technique was applied, selecting 200 respondents who had used BKI services within the last three years, based on the criteria established by Sujarweni (2014)³¹.

Data were gathered through a structured questionnaire comprising three sections: respondent identity, company demographics, and core questions assessing service quality, co-creation, co-production, and customer loyalty. Responses were measured using a Likert scale, following Willits et al. (2016), ranging from 1 (Strongly Disagree) to 5 (Strongly Agree)³².

²⁹ H. Charni, I. Brun, dan L Ricard, "Impact of employee job satisfaction and commitment on customer perceived value: An original perspective," *International Journal of Bank Marketing* 38, no. 3 (2020): 737–755, <https://doi.org/https://doi.org/10.1108/IJBM-03-2019-0097>.

³⁰ Kholick dan Kaihatu, "Analysis of the Effect of Service Quality on Corporate Image and Service Usage Decisions at PT. Biro Klasifikasi Indonesia (Persero)."

³¹ Wiratna Sujarweni, *Metodologi Penelitian : Lengkap, Praktis, dan Mudah Dipahami* (Pustaka Baru Press, 2014).

³² F. K. Willits, G. L. Theodori, dan A. E Luloff, "Another Look at Likert Scales," *Journal of Rural Social Sciences* 31, no. 3 (2016): 12–31, <https://egrove.olemiss.edu/jrss>.

Table 1. Operational Definition of Service Quality and Indicators.

Indicator	Questionnaire Statement
Tangible	SQ2: BKI's service facilities are easily accessible. SQ6: BKI provides services at any time as needed.
Reliable	SQ7: BKI employees are responsive in answering questions related to their services. SQ8: Drawing approval services are carried out quickly.
Assurance	SQ9: Ships that are certificated with PT BKI have a good guarantee of quality compared to those that are not certificated.
Emphaty	SQ12: BKI listens to customer complaints.

Table 2. Operational Definition of Co - Creation and Indicators

Indicator	Questionnaire Statement
Ideation	CC1: BKI is involved in ideation at the pre-design stage of the vessel through engineering consultancy services. CC2: BKI provides corrections to ship design drawings prior to production through drawing approval.
Design	CC4: BKI provides Rules and Guidance and ensures their application in ship design. CC7: BKI supports the development of the customer's human resources by improving qualifications through certification, training and audits for the customer.
Development	CC10: BKI is actively involved in the preparation of the TKDN concept for shipbuilding with stakeholders. CC12: BKI supports design innovations created by customers.
Innovation	CC13: BKI supports innovation in shipbuilding methods/manufacturing processes by customers.
Customized Solution	CC15: BKI provides service packages (block fees) that benefit customers in terms of costs..

Table 3. Operational Definition of Co - Production and Indicators

Indicator	Questionnaire Statement
Production	CP1: BKI is directly involved during the ship production process. CP2: During the production process there is active collaboration between all stakeholders (shipyard, owner, classification society, consultants). CP3: BKI is intensively involved in ensuring that standards are applied during shipbuilding.
Implementation	CP4: BKI is intensively involved in ensuring that the proposed ship design concept is properly executed. CP5: BKI is actively involved in ensuring that the ship is built according to the agreed sequence (procedure sequence). CP7: Ships cleared with BKI are more timely in completion.
Delivery	CP8: Vessels cleared with BKI are more timely in delivery.
Evaluation	CP9: BKI assists with product evaluation while under construction.
Efficiency	CP13: Work progress can run well if BKI surveyors are always present at every inspection.
Quality	CP14: The presence BKI is directly involved in ensuring the achievement of quality when the ship is built. CP15: Production errors are reduced BKI surveyors are present at every inspection.

Table 4. Operational Definition of Customer Loyalty and Indicators

Indicator	Questionnaire Statement
Preference For The Company	CL1: BKI is the first choice for classifying domestic vessels built. CL2: PT. BKI menjadi pilihan utama untuk melanjutkan klasifikasi saat kapal beroperasi.
Word-Of-Mouth (WOM)	CL4: Customers use the services of BKI from information obtained through other people (business associates). CL5: Customers often use BKI's services in the construction of new vessels.
Purchase Frequency	CL6: Customers often use BKI's services for periodic surveys of their vessels when they are already in operation.
Re-Purchase Decision	CL7: The customer will reuse BKI's classification services in its next shipbuilding project. CL8: The customer will reuse the classification services of BKI when the vessel is in operation. CL9: The customer uses BKI's services for ship classification.
Purchase Sequence	CL10: The customer uses the services of BKI for certification. CL 11: The customer uses the services of BKI for ISM-ISPS Code audits. CL 12: The customer uses the services of BKI for training.
Purchasing Power	CL 13: Customers do not mind the cost of survey/certification as long as they get good service from BKI. CL14: The customer does not mind the cost of the survey/certification as long as they get fast service from PT BKI.

This study utilized Partial Least Squares (PLS), a variance-based Structural Equation Modeling (SEM) approach, to analyze causal relationships between variables. As outlined by Ghazali and Latan (2015), PLS-SEM consists of two main sub-models: the measurement model (outer model), which evaluates the reliability and validity of observed variables, and the structural model (inner model), which examines the relationships between latent variables³³.

³³ I. Ghazali dan H Latan, *Partial least squares konsep, teknik dan aplikasi menggunakan program smartpls 3.0 untuk penelitian empiris*, 1st ed. (Badan Penerbit UNDIP, 2015).

C. RESULTS AND DISCUSSION

The analysis of questionnaire data indicates that shipping companies constitute the majority of BKI service users (57.8%), followed by shipyard companies (33.2%), with the remaining 9% comprising other shipbuilding support stakeholders. Most respondents have over five years of experience (62.1%), and 60.7% hold an undergraduate or diploma IV degree, suggesting a strong understanding of both technical and business aspects of classification in shipbuilding.

Descriptive statistical analysis reveals that the variables exhibit closely aligned mean and median values with a small standard deviation, indicating a symmetrical data distribution. Given the absence of a universal standard for presenting research findings, this study will outline general guidelines before detailing the reporting of descriptive statistics and hypothesis testing results.

Evaluation of the Measurement Model

The evaluation of the PLS-SEM model applies Confirmatory Factor Analysis (CFA) and reliability consistency tests, including Cronbach's Alpha and Composite Reliability, following Hair et al. (2021). These methods assess the validity and reliability of the measurement model. The analysis examines loading factor (LF) values to determine the representation of latent constructs, with LF values of ≥ 0.7 considered acceptable. The indicators for Co-Creation, Co-Production, Customer Loyalty, and Service Quality exceed this threshold, confirming their effectiveness in measuring the respective constructs.

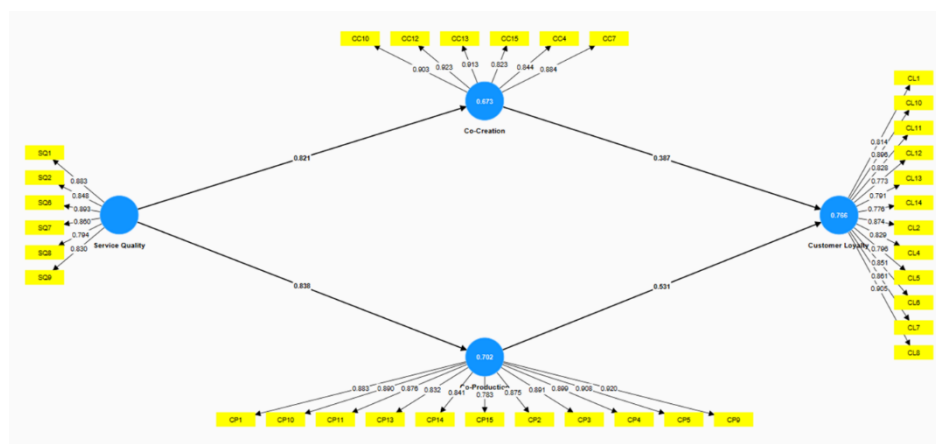


Figure 3. PLS - SEM Model

The assessment of internal consistency reliability involves analyzing composite reliability (CR) values to determine the reliability of variables. Henseler et al. (2009) set a minimum threshold of 0.7, while Hair et al. (2019) consider values between 0.6 and 0.7 acceptable³⁴. The analysis results indicate that composite reliability values range from 0.925 to 0.969 (rho_a) and from 0.941 to 0.972 (rho_c), confirming strong interrelation and consistency among construct items. Furthermore, Cronbach's Alpha values between 0.924 and 0.968 reinforce the high internal reliability of the constructs, as they approach the ideal value of 1.

Table 5. Composite Reliability.

Variable	Cronbach's alpha	Composite reliability (rho_a)	Composite reliability (rho_c)
Co-Creation	0.951	0.951	0.959
Co-Production	0.968	0.969	0.972
Customer Loyalty	0.965	0.966	0.969
Service Quality	0.924	0.925	0.941

Source: PLS Processed, 2024

The Average Variance Extracted (AVE) assesses the proportion of variance in a construct explained by its indicators. Hair et al. (2021) consider an AVE value of ≥ 0.50 acceptable³⁵. The analysis results indicate that AVE values range from 0.709 to 0.757, confirming that the indicators effectively explain the majority of variance within their respective constructs.

Table 6. Average Variance Extrated.

Variable	AVE
Co-Creation	0.744
Co-Production	0.757
Customer Loyalty	0.709
Service Quality	0.726

Source: PLS Processed, 2024

³⁴ J. Henseler, C. M. Ringle, dan R. R Sinkovics, "The use of partial least squares path modeling in international marketing," 2009, 277-319, [https://doi.org/https://doi.org/10.1108/S1474-7979\(2009\)0000020014](https://doi.org/https://doi.org/10.1108/S1474-7979(2009)0000020014); J. F. Hair et al., "When to use and how to report the results of PLS-SEM," *European Business Review* 31, no. 1 (2019): 2-24, <https://doi.org/https://doi.org/10.1108/EBR-11-2018-0203>.

³⁵ J. F. Hair et al., *Partial Least Squares Structural Equation Modeling (PLS-SEM) Using R* (Springer International Publishing, 2021), <https://doi.org/https://doi.org/10.1007/978-3-030-80519-7>.

Discriminant validity is assessed at both the indicator and variable levels. Cross-loadings confirm that each measurement item correlates more strongly with its respective construct than with others. At the variable level, the Fornell-Larcker Criterion and Heterotrait-Monotrait Ratio (HTMT) are applied. The Fornell-Larcker analysis demonstrates that the square root of the Average Variance Extracted (AVE) for each construct exceeds its correlations with other constructs, with values ranging from 0.842 to 0.870. HTMT values range from 0.826 to 0.897, aligning with the recommended threshold of less than 0.9³⁶. These findings confirm strong discriminant validity, ensuring that each construct remains distinct and does not exhibit excessive correlation with others.

Structural Model Evaluation

Ghozali and Latan (2015) highlight that the multicollinearity test assesses correlations among independent variables³⁷. The analysis verifies that all Variance Inflation Factor (VIF) values are below the established threshold of 5, thereby indicating the absence of multicollinearity within the model.

Hypothesis testing, conducted using bootstrapping and the mediation approach by Baron and Kenny, demonstrates that Service Quality significantly enhances Co-Creation (**H1**, $\beta = 0.841$, $t = 23.31$, $p < 0.05$) and strengthens Co-Production (**H2**, $\beta = 0.848$, $t = 20.89$, $p < 0.05$).

Additionally, Co-Creation positively influences Customer Loyalty (**H3**, $\beta = 0.309$, $t = 2.91$, $p = 0.004$), with a 95% confidence interval suggesting a 51.1% increase in customer loyalty through company participation in the design phase. Co-Production has a stronger impact on Customer Loyalty (**H4**, $\beta = 0.599$, $t = 6.12$, $p < 0.05$), with confidence intervals indicating an increase in customer loyalty between 40.6% and 79.4% due to enhanced collaboration during production.

³⁶ J. Henseler et al., "Common Beliefs and Reality About PLS: Comments on Rönkkö and Evermann (2013)," *Organizational Research Methods* 17, no. 2 (2014): 182–209, <https://doi.org/https://doi.org/10.1177/1094428114526928>.

³⁷ Ghozali dan Latan, *Partial least squares konsep, teknik dan aplikasi menggunakan program smartpls 3.0 untuk penelitian empiris*.

Table 7. Mean, STDEV, T-Values, P-Values.

Hypothesis		Original sample (O)	Sample mean (M)	Standard deviation (STDEV)	t-statistics (O/STDEV)	p- values
Co-Creation -> Customer Loyalty		0.309	0.306	0.106	2.903	0.004
Co-Production-> Customer Loyalty		0.599	0.602	0.098	6.118	0.00
Service Quality -> Co-Creation		0.841	0.841	0.036	23.308	0.00
Service Quality -> Co-Production		0.848	0.849	0.041	20.881	0.00

Source: PLS Processed, 2024

The mediation effect in hypothesis testing is assessed through the specific indirect effect, where a third variable mediates the relationship between two variables (Hair et al., 2021). In this study, Co-Creation and Co-Production serve as mediating variables. The analysis confirms that service quality significantly enhances customer loyalty through Co-Creation (H5, $p = 0.003 < 0.05$), indicating that higher service quality promotes greater engagement in collaborative design activities, ultimately strengthening customer loyalty. Similarly, service quality exerts a significant indirect effect on customer loyalty through Co-Production (H6, $p = 0.000 < 0.05$), suggesting that improved service quality encourages active participation in the production process, further reinforcing customer loyalty.

Table 8. Specific Indirect Effect.

Mediation Hypothesis	Original sample (O)	Sample mean (M)	Standard deviation (STDEV)	t-statistics (O/STDEV)	p- values
Service Quality -> Co-Creation -> Customer Loyalty	0.26	0.257	0.089	2.922	0.003
Service Quality -> Co-Production -> Customer Loyalty	0.508	0.513	0.093	5.464	0

Source: PLS Processed, 2024

The inner model analysis confirms a perfect correlation of 1.00 between each construct and itself. The findings demonstrate that Service Quality exerts a direct influence on both Co-Creation and Co-Production, which subsequently have a direct effect on Customer Loyalty.

The path coefficient between Service Quality and Co-Creation is 0.841, demonstrating a strong positive relationship, suggesting that improved service quality enhances co-creation. Similarly, the path coefficient of 0.848 between Service Quality and Co-Production indicates a strong positive association, implying that higher service quality fosters greater co-production. Furthermore, Co-Production (0.599) and Co-Creation (0.309) exhibit moderate yet positive path coefficients concerning Customer Loyalty, confirming that increased participation in co-creation and co-production contributes to higher customer loyalty.

Model Quality Evaluation

The R-square, or coefficient of determination, quantifies the proportion of variance in the dependent variables Co-Creation, Co-Production, and Customer Loyalty that the regression model accounts for. Its values range from 0 to 1, with higher values indicating greater explanatory power. According to Risher and Hair (2017), an R-square of 0.75 is considered high, 0.50 is moderate, and 0.25 is low³⁸.

Table 9. R-Square.

	R-square	R-square adjusted
Co-Creation	0.707	0.706
Co-Production	0.72	0.718
Customer Loyalty	0.77	0.768

Source: PLS Processed, 2024

The study reports high R-square values, exceeding 0.7 for Co-Creation, Co-Production, and Customer Loyalty, indicating that the model explains a substantial proportion of variance in these dependent variables. Specifically, Co-Production (0.720), Co-Creation (0.707), and Customer Loyalty (0.770) significantly contribute to understanding the classification society's engagement in the shipbuilding process.

³⁸ Jeff Risher dan Joe Hair, "The Robustness of PLS Across Disciplines," 1 Januari 2017.

The F-square analysis in the SEM-PLS model assesses effect size, measuring the influence of one latent construct on another. According to Cohen, values of 0.02, 0.15, and 0.35 indicate small, moderate, and strong effects, respectively. The results show that Co-Creation ($f^2 = 0.114$) and Co-Production ($f^2 = 0.427$) exert moderate effects on Customer Loyalty, while Service Quality has a substantial influence on both Co-Creation ($f^2 = 2.414$) and Co-Production ($f^2 = 2.568$). These findings highlight the critical role of service quality in shaping co-creation and co-production within the organization.

Table 10. F-Square.

	Co-Creation	Co-Production	Customer Loyalty
Co-Creation			0.114
Co-Production			0.427
Service Quality	2.414	2.568	

Source: PLS Processed, 2024

This study assesses the significance of the mediation variable using the mediation effect size upslon (v), following Cohen's (1992) guidelines in Gaskin et al. (2023)³⁹. A mediation effect size of 0.175 is classified as high, 0.075 as medium, and 0.01 as low. The analysis reveals that Service Quality mediates Co-Creation and Customer Loyalty with a v value of 0.07, indicating a mediation effect approaching the medium category. In contrast, Co-Production mediates the relationship between Service Quality and Customer Loyalty with a v value of 0.26, signifying a high and statistically significant mediation effect.

Furthermore, the Q-Square values for Co-Creation (0.519), Co-Production (0.535), and Customer Loyalty (0.537) confirm strong predictive capability. According to Hair et al. (2019), a Q^2 value greater than 0 signifies predictive relevance⁴⁰. The results confirm the model's strong predictive validity and reliability in explaining the relationships among the variables.

³⁹ P. B Gaskin, J., Ogbeibu, S., Lowry, *Demystifying Prediction in Mediation Research and the Use of Specific Indirect Effects and Indirect Effect Sizes*, Partial Le (Springer International Publishing, 2023), https://doi.org/https://doi.org/10.1007/978-3-031-37772-3_8.

⁴⁰ Hair et al., "When to use and how to report the results of PLS-SEM."

Table 11. Q-Square.

	SSO	SSE	Q ² (=1-SSE/SSO)
Co-Creation	1608	772.933	0.519
Co-Production	2211	1027.921	0.535
Customer Loyalty	2613	1208.527	0.537

Source: PLS Processed, 2024

The Standardized Root Mean Squared Residual (SRMR) test evaluates the model's goodness of fit by comparing the predicted correlation matrix with the observed correlation matrix. Lower SRMR values reflect a superior model fit, with values below 0.08 regarded as optimal and those below 0.10 considered acceptable⁴¹. The analysis shows an SRMR of 0.05 for the saturated model and 0.07 for the estimated model, confirming a strong model fit with the data.

Table 12. SRMR.

	Saturated model	Estimated model
SRMR	0.055	0.07
d_uls	2.206	3.587
d_G	3.182	3.409
Chi-square	2792.91	2845.664
NFI	0.735	0.73

Source: PLS Processed, 2024

The PLS-Predict test evaluates the predictive strength of the PLS model, extending the R-Square measurement⁴². The analysis confirms that most endogenous variable indicators exhibit Root Mean Square Error (RMSE) and Mean Absolute Error (MAE) values lower than those of the LM model, demonstrating strong predictive accuracy.

The Goodness of Fit (GoF) index, introduced by Tenenhaus et al. (2004) and refined by Henseler et al. (2014), assesses the overall performance of the structural and measurement models⁴³. The GoF value of 0.54, exceeding the high threshold of 0.36, indicates that the model effectively explains relationships among latent variables.

⁴¹ T. Ramayah et al., "Testing a Confirmatory model of Facebook Usage in SmartPLS using Consistent PLS," *International Journal of Business and Innovation* 3 (2017): 1-14, <http://www.theijbi.net/>.

⁴² Hair et al., "When to use and how to report the results of PLS-SEM."

⁴³ Henseler et al., "Common Beliefs and Reality About PLS: Comments on Rönkkö and Evermann (2013)";

The PLS model quality assessment includes a linearity test and endogeneity evaluation using Fimix PLS⁴⁴. The linearity test analyzes path coefficients, confirming that p-values for quadratic effects ($p > 0.5$) indicate a linear relationship among Service Quality, Co-Creation, Co-Production, and Customer Loyalty, reinforcing the model's robustness.

The endogeneity assessment, conducted using the Gaussian Copula approach, evaluates three models (GC Co-Creation, $p = 0.24 > 0.05$; GC Co-Production, $p = 0.34 > 0.05$; and GC Co-Creation and GC Co-Production, $p = 1.42$ and 0.62 , both > 0.05). The results confirm the absence of endogeneity issues, validating the reliability of the model estimations.

Table 13. Quadratic Effect.

QE	p values
QE (Service Quality) -> Co-Creation	0.932
QE (Service Quality) -> Co-Production	0.675
QE (Co-Creation) -> Customer Loyalty	0.213
QE (Co-Production) -> Customer Loyalty	0.526

Source: PLS Processed, 2024

DISCUSSION

This study confirms that service quality in classification societies significantly enhances co-creation in ship design, fostering stakeholder trust and engagement⁴⁵. High-quality service, defined by accessibility, personnel availability, responsiveness, and engineering expertise, promotes a collaborative and trust-driven environment, facilitating co-creation. These findings align with Kholick & Kaihatu (2021), who emphasize the positive impact of service quality on corporate reputation and service adoption⁴⁶.

M. Tenenhaus, S. Amato, dan V Esposito Vinzi, "A global goodness-of-fit index for PLS structural equation modelling," *Proceedings of the XLII SIS Scientific Meeting*, 2004, 739-742.

⁴⁴ Hair et al., "When to use and how to report the results of PLS-SEM."

⁴⁵ Albuquerque dan Ferreira, "Service quality, loyalty, and co-creation behaviour: a customer perspective."

⁴⁶ Kholick dan Kaihatu, "Analysis of the Effect of Service Quality on Corporate Image and Service Usage Decisions at PT. Biro Klasifikasi Indonesia (Persero)."

The results further demonstrate that co-creation plays a vital role in customer loyalty, as active collaboration among classification societies, shipyards, and shipowners strengthens engagement⁴⁷. Customers exhibit greater loyalty when classification societies involve them in the design and planning process, ensuring compliance with classification standards. The BKI design verification process, which integrates an IT system for feedback and technical information exchange, exemplifies this engagement, reinforcing customer ownership and loyalty.

Additionally, the study confirms that co-production significantly influences customer loyalty by ensuring ships meet customer specifications, enhancing satisfaction and long-term commitment. BKI plays a critical role in co-production, overseeing ship component inspections, including hulls, machinery, and electrical systems, at various construction stages. Approval is granted exclusively following thorough evaluations conducted by production teams, quality control (QC) personnel, and owner surveyors (OS). Serving as the ultimate authority in the inspection process, classification societies assume a decisive role in addressing and resolving construction-related challenges⁴⁸.

The findings support the hypothesis that service quality impacts customer loyalty through co-creation. High-quality service strengthens co-creation, which subsequently enhances customer loyalty⁴⁹. Similarly, the study establishes that service quality affects customer loyalty through co-production, as improved service quality reinforces co-production, leading to higher customer retention⁵⁰. These findings align with Urban (2015) and Visman et al. (2022), who highlight the role of co-production in enhancing relevance and sustainability through stakeholder collaboration⁵¹.

The study provides empirical support for the role of service quality, co-creation, and co-production in customer relationship management. The results confirm that co-creation and co-production mediate the relationship between service quality and

⁴⁷ Wijaya dan Putra, "Sinar Dharmayana Putra / Relationships between Service Quality, Brand Image, Customer Satisfaction, and Customer Loyalty of UC Makassar from Student's Perspective."

⁴⁸ Nguyen, "The impact of value co-creation behavior on customer loyalty in the service domain."

⁴⁹ Diderich, "An axiomatic model towards understanding value creation and appropriation in demand-driven markets."

⁵⁰ Charni, Brun, dan Ricard, "Impact of employee job satisfaction and commitment on customer perceived value: An original perspective."

⁵¹ E. Visman et al., "Defining metrics for monitoring and evaluating the impact of co-production in climate services," *Climate Services* 26, no. 100297 (2022), <https://doi.org/https://doi.org/10.1016/j.cliser.2022.100297>; W Urban, "Service Design for Coproduced Service Excellence," *Social Sciences* 86, no. 4 (2015), <https://doi.org/https://doi.org/10.5755/j01.ss.86.4.7880>.

customer loyalty, supporting Service-Dominant Logic (SDL) theory Lusch & Vargo (2006), which emphasizes the active role of customers in value creation⁵². The findings reinforce that co-creation and co-production are critical mediators in enhancing customer loyalty, consistent with Hanifawati & Yudin (2022)⁵³. Additionally, this research advances the development of co-creation and co-production models in the shipping sector, aligning with Maduka (2016) and Van De Scheur (2017), who emphasize their relevance in predicting customer loyalty determinants⁵⁴.

From a practical perspective, the study recommends that classification societies prioritize service quality improvements and implement co-creation and co-production strategies⁵⁵. Basarudin, Asfahani, & Wijaya (2024) highlight that high service quality significantly improves customer satisfaction and loyalty⁵⁶.

To maintain a customer-centric approach, BKI should enhance customer engagement by addressing complaints and improving customer service responsiveness⁵⁷. Additionally, BKI should strengthen its IT infrastructure to facilitate collaborative ship design and improve the expertise of personnel responsible for design approvals. In ship production, BKI must enhance workforce competency, particularly in field inspections and technical assessments.

Moreover, this study contributes to academic literature by offering a comprehensive analysis of the interrelationships among classification societies, shipping companies, shipyards, and other stakeholders in shipbuilding. The findings enhance the understanding of how service quality, co-creation, and co-production collectively influence customer loyalty in the maritime industry.

⁵² R. F. Lusch dan S. L Vargo, "Service-dominant logic: reactions, reflections and refinements," *Marketing Theory* 6, no. 3 (2006): 281-288, <https://doi.org/https://doi.org/10.1177/1470593106066781>.

⁵³ T. Hanifawati dan C Yudin, "Dampak Co-Creation pada Pemasaran Produk Pangan Online Terhadap Loyalitas dengan Mediasi Kepuasan pada Pelanggan Sayurbox," *Media Agribisnis* 6, no. 1 (2022): 38-49, <https://doi.org/https://doi.org/10.35326/agribisnis.v6i1.2307>.

⁵⁴ L Van De Scheur, "Customer satisfaction, trust and its influence on co-production and customer loyalty A study that demonstrates the effects per online and offline channel type in a service context," 2017; O. B Maduka, "Effects of Customer Value Co-Creation on Customer Loyalty in the Nigerian Service Industry," *International Journal of Business and Management* 11, no. 2 (2016): 77, <https://doi.org/https://doi.org/10.5539/ijbm.v11n12p77>.

⁵⁵ Albuquerque dan Ferreira, "Service quality, loyalty, and co-creation behaviour: a customer perspective."

⁵⁶ C Basarudin Asfahani, M., Wijaya, "Enhancing Customer Loyalty at the Indonesian Classification Bureau through Satisfaction Creation with Service Innovation and Service Quality," *International Journal of Science and Society* 6, no. 2 (2024), <http://ijsoc.goacademica.com>.

⁵⁷ Goh dan Leung YIP, "A Way Forward for Ship Classification and Technical Services."

D. CONCLUSION

This study underscores the pivotal role of service quality, co-creation, and co-production in enhancing customer loyalty within classification societies. The findings indicate that service quality is the primary driver of co-creation and co-production, with improvements in service quality increasing the active participation of classification societies in ship design and production, thereby strengthening customer relationships and adding value for stakeholders. While both co-creation and co-production positively affect customer loyalty, co-production has a stronger impact, highlighting the significance of direct involvement in the production process.

The PLS-SEM model developed in this study aligns well with empirical data, demonstrating high goodness-of-fit and strong predictive accuracy, reinforcing existing research on the importance of collaborative engagement between companies and customers in fostering customer loyalty.

Future research should investigate moderating variables affecting these relationships and conduct comparative analyses across industries for benchmarking. Additionally, the influence of government regulations granting PT BKI exclusive statutory authority on customer loyalty warrants further exploration, as such regulations may provide a competitive advantage. Given the varying institutional frameworks under IACS and non-IACS membership, along with diverse customer profiles across countries, the generalizability of these findings is limited. Finally, as this study examines a restricted set of variables, future research should explore additional factors that may further influence customer loyalty in classification societies.

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