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Evaluating the Role of Two-Axle Trucks in Rice Distribution Efficiency: Evidence from South Sulawesi, Indonesia

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Authors' contributions

This work was carried out in collaboration among all authors. All authors read and approved the final manuscript.

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Abstract

South Sulawesi Province, Indonesia, is one of the major rice-producing regions where transportation plays an important role in maintaining the stability of agricultural supply chains. This study analyzes the performance of two-axle truck transportation in rice distribution within Sidenreng Rappang Regency using an integrated logistics evaluation approach. A quantitative descriptive method was employed using survey data collected from 120 respondents consisting of rice entrepreneurs and transport operators. The Customer Satisfaction Index (CSI) and Importance Performance Analysis (IPA) were applied to evaluate service performance and user satisfaction, while a gravity-based distribution model was used to analyze rice distribution flows toward Parepare and Makassar cities. The results indicate that two-axle trucks are predominantly used because of

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their operational efficiency, accessibility, and compatibility with regional road conditions. The CSI value of 81.5% indicates that users are generally very satisfied with the transportation services. However, the IPA results reveal that several service attributes still require improvement, particularly driver insurance and safety assurance. The gravity-based distribution model also shows that Parepare has a stronger distribution intensity than Makassar due to lower transportation resistance and shorter distribution distance. This study contributes to agricultural logistics and transportation planning by integrating customer satisfaction analysis with spatial freight distribution modeling to evaluate rural rice transportation systems in developing regions.

Keywords: Rice distribution; two-axle trucks; freight transport; CSI; IPA; gravity-based distribution model.

1. Introduction

Freight transportation is a critical element in the production and distribution process, as its costs and operational characteristics directly influence supply chain efficiency and competitiveness (Meitzen et al., 2012) and depend on the distance and weight of the cargo being transported (Shihnazarov et al., 2023). As economic activity intensifies, the volume and pattern of freight transport also shift accordingly, impacting infrastructure demand and transport intensity (Filip & Popa, 2014; Wang et al., 2021). The national importance of freight transport lies in its fundamental role in facilitating trade, supporting industrial development, and significantly contributing to National Gross Domestic Product (GDP) (MacCarthy et al., 2016).

Distribution serves as a pivotal component in the logistics system, connecting producers, intermediaries, and end-users (Czinkota et al., 2021). Trucking, in particular, remains a dominant transport mode due to its high flexibility, capacity to reach remote areas, and adaptability to various operational environments (Vashisht, 2019). Previous studies emphasize the effectiveness of structured distribution models and the application of gravity-based mathematical frameworks in optimizing commodity flows across regional and urban networks (Boukebbab & Boulahlib, 2015; Gonzalez-Feliu, 2019; Lasić et al., 2023; Saengsathien & Namchimplee, 2022). Factors such as vehicle capacity, distribution routes, market demand, and transportation infrastructure are critical elements to consider when developing a distribution strategy (Meisen, 2015).

In Indonesia, particularly in South Sulawesi Province, rice remains a strategic commodity that plays an essential role in regional food security and economic stability. The distribution of rice largely depends on road freight transportation, especially two-axle trucks, due to their operational flexibility, accessibility, and suitability for regional road conditions (Vashisht, 2019). Efficient transportation systems are therefore required to maintain distribution continuity, reduce logistics costs, and ensure timely delivery of agricultural commodities. Previous research on freight transportation in South Sulawesi also shows that operational cost characteristics are an important factor influencing freight transport performance and logistics efficiency (Hakzah et al., 2020). However, transportation inefficiencies, infrastructure limitations, and service quality issues may negatively affect the effectiveness of rice distribution systems in developing regions (Tavasszy et al., 2012; Wang et al., 2021).

Previous studies have emphasized that logistics service quality, transportation mode selection, transportation cost, vehicle capacity, and distribution performance are important factors in improving logistics efficiency and customer satisfaction (Meng et al., 2015; Muangpan, 2022; Solanki et al., 2023; Tavasszy et al., 2012; Tuğdemir Kök & Deveci, 2019). In addition, gravity-based distribution models have been widely applied to evaluate commodity movement patterns and transportation network efficiency (Boukebbab & Boulahlib, 2015; Gonzalez-Feliu, 2019; Lasić et al., 2023; Saengsathien & Namchimplee, 2022). Nevertheless, studies that specifically integrate customer satisfaction analysis with quantitative freight distribution modeling for two-axle truck services remain limited, particularly in the context of agricultural logistics systems in developing regions.

This manuscript is important for the scientific community because it provides an integrated evaluation of rice transportation services by combining the Customer Satisfaction Index (CSI), Importance Performance Analysis (IPA), and a gravity-based distribution model within the context of agricultural logistics. The CSI and IPA methods are employed to assess user satisfaction, measure service performance, and identify priority service attributes that require improvement. Meanwhile, the gravity-based distribution model is applied to analyze rice distribution flows toward Parepare and Makassar as major regional distribution centers in South Sulawesi Province. Previous studies have demonstrated the relevance of gravity-based approaches and structured

distribution models in evaluating commodity flows and transportation network efficiency (Boukebbab & Boulahlib, 2015; Gonzalez-Feliu, 2019; Lasić et al., 2023; Saengsathien & Namchimplee, 2022). Therefore, this integrated analytical framework contributes to a more comprehensive understanding of service quality, freight distribution patterns, and transportation planning for rural agricultural logistics systems in developing regions.

The findings of this study are expected to contribute to agricultural logistics research and transportation planning by highlighting the operational importance of two-axle trucks and identifying key service aspects that require improvement, particularly driver insurance and safety assurance. Therefore, this study aims to: (1) evaluate the service quality of two-axle trucks in rice logistics using the Customer Satisfaction Index (CSI); (2) identify service performance gaps and priority improvement attributes through Importance Performance Analysis (IPA); and (3) analyze rice distribution flow patterns toward Parepare and Makassar using a gravity-based distribution model. The results of this study are expected to provide strategic recommendations for improving the efficiency and effectiveness of rice distribution services in South Sulawesi Province, Indonesia.

1.1 Relevant Theories

Literature related to agricultural logistics emphasizes that transportation performance plays an important role in maintaining the efficiency, reliability, and sustainability of commodity distribution systems. In freight transportation systems, service quality, transportation costs, vehicle capacity, accessibility, and distribution routes are considered key determinants influencing logistics performance and customer satisfaction (Meng et al., 2015; Solanki et al., 2023; Tavasszy et al., 2012; Tuğdemir Kök & Deveci, 2019). In the context of rice distribution, road freight transportation is particularly important because it connects production areas, rice mills, traders, and consumption centers within regional supply chains. Previous studies have also demonstrated that gravity-based distribution models are useful for evaluating commodity movement patterns and transportation network efficiency, especially in regional and urban logistics systems (Boukebbab & Boulahlib, 2015; Gonzalez-Feliu, 2019; Lasić et al., 2023; Saengsathien & Namchimplee, 2022). Furthermore, customer satisfaction evaluation methods such as the Customer Satisfaction Index (CSI) and Importance Performance Analysis (IPA) are widely applied to identify service quality gaps and determine service attributes that require improvement in transportation services (Esmailpour et al., 2020; Martilla & James, 1977; Raoniar et al., 2015). Therefore, integrating freight distribution modeling with CSI and IPA provides a more comprehensive analytical framework for evaluating rice logistics services and identifying strategic improvements in two-axle truck transportation systems.

In transportation and logistics studies, service quality assessment is commonly used to evaluate operational effectiveness and customer satisfaction. Importance Performance Analysis (IPA) plays a crucial role in identifying service factors that significantly affect customer satisfaction and loyalty, as well as service elements that consumers perceive as requiring improvement (Wahyuni et al., 2020). By employing IPA, organizations can map out areas that need improvement, maintenance, or reduction in order to enhance overall customer satisfaction (Tjitrohartoko & Saraswati, 2020). Satisfaction is defined as the feeling of contentment that arises from comparing the enjoyment of a product or service with one's expectations (Prabowo et al., 2019). Customer satisfaction represents the customer's perception that their expectations have been met or exceeded (Kotler & Keller, 2015), and it is the response to the perceived alignment between their expectations and the actual service performance (Zeithaml et al., 2010).

Evaluating service quality and customer satisfaction is a key strategy to address various challenges in transportation, such as reducing traffic congestion, minimizing air and noise pollution, and decreasing energy consumption. There is substantial insight into how customers perceive transportation services, considering factors such as reliability, frequency, travel time, and fare levels (Hensher et al., 2003), along with service coverage, network efficiency, and distance traveled (Eriksson et al., 2008; Tyrinopoulos, 2004), and safety concerns (Smith & Clarke, 2000). Identifying gaps in the performance of public transport service attributes relative to their importance is vital for service enhancement (Esmailpour et al., 2020). These factors play a crucial role in customer assessments of transportation service quality (Brady & Cronin, 2001; Oliver, 2010).

In an IPA survey, respondents are specifically asked to rate the relevance of various characteristics, helping identify both strengths and areas for improvement. This method is commonly employed due to its simplicity in identifying quality indicators that can lead to better service quality (Raoniar et al., 2015). This approach, often referred to as quadrant analysis, attempts to quantify the relationship between customer perceptions and the

objectives for improving service or product quality. By comparing the perceived importance with actual performance, it is possible to assess the level of customer satisfaction. Dissatisfaction arises when customers' expectations exceed their perceptions, or vice versa.

The results of this analysis are typically displayed using a Cartesian diagram (Martilla & James, 1977), a tool that effectively presents the findings of IPA and visually categorizes service attributes into four quadrants. These quadrants help determine which attributes should be prioritized for improvement, maintenance, or reduction in order to maximize customer satisfaction and service quality.

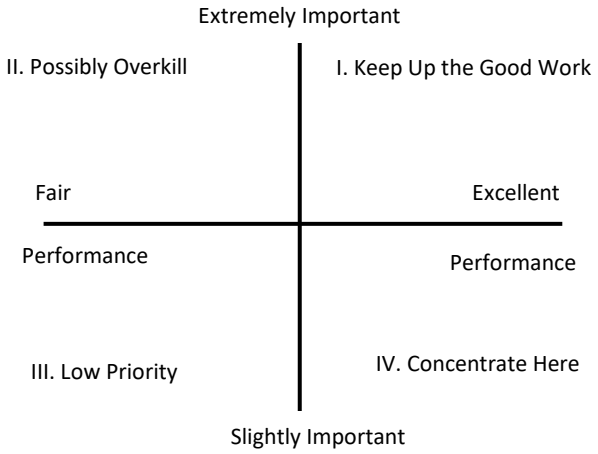


Fig. 1. Importance Performance Analysis (IPA) cartesian diagram

2. Methods

2.1 Research Object and Location

This study was conducted in Sidenreng Rappang Regency, located in South Sulawesi, Indonesia, which is a prominent rice-producing area. Geographically, the region is situated between 3°43'–4°09' South Latitude and 119°41'–120°10' East Longitude, covering a total area of 1,883.25 km². It has an estimated agricultural area of 44,958 hectares. In 2020, the rice production in the region reached 253,356 tons (Badan Pusat Statistik, 2025). Primary data for this study were collected through surveys administered to 120 respondents, including rice traders and transporters who utilize two-axle trucks for distribution.

2.2 Research Design and Approach

This study adopted a quantitative descriptive approach to evaluate the performance of two-axle truck transportation services in rice distribution systems. The analytical framework consisted of three main components: (1) a gravity-based distribution model used to analyze rice distribution flows between Sidenreng Rappang Regency and destination cities; (2) the Customer Satisfaction Index (CSI) method to measure overall user satisfaction; and (3) Importance Performance Analysis (IPA) to identify service attributes requiring improvement based on the gap between user expectations and perceived performance. The integration of these methods provides a comprehensive evaluation of both transportation service quality and regional freight distribution patterns. The respondents were selected purposively based on their direct involvement in rice transportation and distribution activities using two-axle trucks in the study area.

2.3 Gravity-Based Distribution Model

This study employs a gravity-based distribution model to evaluate rice transportation flows between Sidenreng Rappang Regency and the destination cities of Parepare and Makassar. The model operates under the fundamental assumptions that transportation flow is directly proportional to the production at the origin and the

demand at the destination, while being inversely proportional to the distance between locations. The general formula used for analyzing rice distribution movement is:

$$Ti = Ai \cdot Oi \cdot Bi \cdot Di \cdot exp\ (-\beta Ci) \quad (1)$$

Where:
Ai = Destimation attractiveness factor
Oi = Demand level or travel volume
Bi = Correction factor based on location characteristic
Di = Dependence level on a particular destination
$exp\ (-\beta Ci)$ = Travel resistance function based on cost or distance

The formula $Ti = Ai \cdot Oi \cdot Bi \cdot Di \cdot exp\ (-\beta Ci)$ is used in the analysis of movement distribution, especially in the context of transport and logistics (Vashisht, 2019). This is a general form of the gravity-based distribution model, which takes into account the attractiveness of the destination (Ai), the level of demand or travel volume (Oi), the location correction factor (Bi), the degree of dependence on a particular destination (Di), and the travel constraint function based on cost or distance $exp\ (-\beta Ci)$.

2.4 Customer Satisfaction Index Method

The Customer Satisfaction Index (CSI) quantifies overall satisfaction across 18 service attributes by combining the weight factor (WF) and the mean satisfaction score (MSS). The CSI is calculated through the following steps: (a) Determine the Mean Importance Score (MIS), which represents the average importance score assigned by each respondent.

$$\bar{X}_I = \frac{\sum_{i=1}^{n} X_i}{n} \quad (2)$$

$$\bar{Y}_I = \frac{\sum_{i=1}^{n} Y_i}{n} \quad (3)$$

Where:
n = Number of consumers
Xi = i-th Attribute satisfaction value X
Yi = i-th Attribute importance value Y
(b) Making Weight Factors (WF) this weight is the percentage of the MIS value per attribute to the total MIS of all attributes.

$$WF = \frac{MISi}{\sum_{i=1}^{P} MISi} \quad (4)$$

Where:
p = pth importance attribute made a weight score (WS)

This weight is the product of the WF with the average, which is the mean satisfaction score (MSS).

$$WS = WF \times MSS \quad (5)$$

Determining customer satisfaction index (CSI) by the ratio of the weight average (WA) divided by the highest scale (HS or the maximum scale used on a scale of 5 times 100%)

$$CSi = \frac{\sum_{i=1}^{p} WS_i}{HS} \times 100\% \quad (6)$$

Description:
CSi = weight score i (expectation)
Hs = Highest Score

2.5 Importance Performance Analysis Method

Importance Performance Analysis (IPA) assists in strategic decision-making by mapping service attributes into four quadrants based on the relationship between user expectations and perceived service performance. IPA aids in strategic decision-making by mapping service attributes onto a Cartesian diagram divided into four quadrants:

Quadrant I: High importance, high performance ("Keep Up the Good Work")
Quadrant II: Low importance, high performance ("Possible Overkill")
Quadrant III: Low importance, low performance ("Low Priority")
Quadrant IV: High importance, low performance ("Concentrate Here").

The level of conformity between the importance and quality performance of the attributes is determined by comparing the performance score with the importance score, using the following formula:

$$Tki = \frac{\bar{X}_i}{\bar{Y}_i} \times 100\% \quad (7)$$

Description: Tki = Respondent suitability level. Xi = Performance assessment scores. Yi = Expectancy assessment score. Then calculate the average value for each attribute using the following formula:

$$\overline{X} = \frac{\sum_{i=1}^{N} X_i}{n} \quad (8)$$

$$\overline{Y} = \frac{\sum_{i=1}^{N} Y_i}{n} \quad (9)$$

The average performance score and average importance score for each service attribute were calculated using the following equations, where X_i represents the performance score, Y_i represents the importance score, and n is the number of respondents.

The calculated average scores were then used as the coordinates in the Cartesian diagram for Importance Performance Analysis (IPA). The overall mean values of performance and importance served as the crosshair lines to divide the diagram into four quadrants.

All respondents participated voluntarily in this study and were informed about the objectives and procedures of the research before completing the questionnaire. The respondents provided their consent to participate, and no personal or sensitive information was collected during the survey process. The data obtained were used solely for academic and research purposes. Respondent confidentiality and anonymity were maintained throughout the study to ensure ethical compliance in data collection and analysis.

3. Results

3.1 Characteristics of Rice Production and Selection of Rice Transport Vehicles

The results of a survey conducted with rice mills and rice entrepreneurs across Sidenreng Rappang Regency reveal the following characteristics:

Table 1. Characteristics of rice production and selection of rice transportation vehicles

Parameter		Number	Frequency (%)
Rice production	< 50 tons/day	5 factories	50.0%
	> 50 tons/day	5 factories	50.0%
	< 1.250 tons/month	2 factories	20.0%
	> 1.250 tons/month	8 factories	80.0%
Vehicles used	Two-axle	94	81.0%
	Three-axle	26	19.0%
Vehicle ownership status	Owned	12	10.0%
	Owned by company	108	90.0%
Reasons for choosing a vehicle	Speed	47	39.2%
	Cost	48	40.0%
	Load weight	17	14.2%
	Volume	8	6.7%

The survey findings from rice mills in Sidenreng Rappang Regency indicate that 80% of the factories produce more than 1,250 tons of rice monthly, reflecting a high-volume, continuous distribution demand. Two-axle trucks are the dominant mode of transportation, utilized by 81% of respondents, primarily due to their speed (39.2%) and cost-efficiency (40.0%). Only 10% of users own their trucks, while 90% rely on company-owned fleets, suggesting a centralized logistics structure that may enhance coordination within the supply chain.

This preference aligns with operational priorities, where faster delivery and cost control take precedence over load volume or truck size. The widespread use of two-axle trucks underscores their strategic suitability in relation to the infrastructure conditions and delivery range typical of rural South Sulawesi.

3.2 Gravity-Based Distribution Model Analysis

The analysis of rice distribution to the cities of Parepare and Makassar is based on the gravity-based distribution model utilizing two-axle trucks. The model operates under the assumption that transportation flow is directly proportional to the production at the origin and the demand at the destination, while being inversely proportional to the distance between the two locations. The following formulas represent the calculated distribution flow for each city:

Parepare (T29)

$T29 = 1.0 \times 37.34 \times 0.01 \times 0.40 \times 0.06600 = 0.009857$

Makassar (T39)

$T39=1.0\times57.79\times0.005\times0.21\times0.005793=0.003515$

The higher score for Parepare suggests stronger distribution flows, likely due to factors such as shorter distance, fewer cost barriers, or more favorable road accessibility. In contrast, despite Makassar's larger market potential, indicated by a higher population and base demand, the relative distribution intensity is lower, which may be attributed to logistical inefficiencies or greater travel impediments.

The gravity-based distribution model, analogous to Newton’s Law of Gravitation, estimates the flow of goods between locations based on the "masses" of the origin (supply) and destination (demand), as well as the distance separating them. The model assumes several key principles, which are as follows: First, the flow of goods is directly proportional to the supply capacity of the origin and the demand level of the destination, making larger locations more attractive for transportation. Second, transportation flow exhibits an inverse relationship with distance, with distance acting as the primary impedance factor. Third, the model assumes constant distance elasticity, which is represented through an exponential decay function, ($\exp(-\beta Ci)$), where β is a constant value across all routes. Fourth, the model treats transportation characteristics, including vehicle performance, infrastructure quality, and operational efficiency, as homogeneous. Fifth, distance and cost parameters are considered exogenous variables, remaining constant throughout the analysis. Finally, the model excludes confounding factors such as regulatory policies, market competition, and seasonal variations. While this simplification facilitates the modeling process, it also limits the model's real-world applicability, particularly in more complex transportation systems. These findings indicate that transportation accessibility and distribution resistance significantly influence rice distribution intensity, supporting the applicability of gravity-based distribution models in regional agricultural logistics analysis.

3.3 Calculation of Conformity Level

The conformity level between satisfaction and expectations was calculated based on the provided table. The highest level of conformity recorded was 114.6%, which falls under the "very good" category. In contrast, the lowest conformity level was 101.5%, indicating a relatively modest alignment between expectations and satisfaction.

Table 2. Conformity level of service attributes

No	Question	Xi	Yi	Tki	MIS	MSS	WF	Wfi
X1	The condition of the two-axle truck is good for distributing rice.	163	185	114.3%	4.625	4.075	0.059	0.240
X2	The two-axle truck is efficient for distributing rice.	172	182	107.7%	4.550	4.300	0.058	0.249
X3	The two-axle truck is easy to obtain for distributing rice.	174	184	111.5%	4.600	4.350	0.058	0.255
X4	The two-axle truck is cheaper for distributing rice than other trucks.	164	188	114.6%	4.700	4.100	0.060	0.245
X5	The two-axle truck has the flexibility to distribute rice.	167	181	108.4%	4.525	4.175	0.057	0.240
X6	The two-axle truck driver drives the vehicle well.	161	173	107.5%	4.325	4.025	0,055	0.221
X7	The two-axle truck driver has a backup driver to distribute rice.	163	167	102.7%	4.175	4.075	0.053	0.216
X8	The two-axle truck driver carries vehicle equipment.	155	171	110.3%	4.275	3.875	0.054	0.211
X9	The two-axle truck driver plays an important role in supporting the smooth distribution of rice.	158	172	108.9%	4.300	3.950	0.055	0.216
X10	The two-axle truck driver serves the needs of rice distribution well	161	174	108.1%	4.350	4.025	0.055	0.223
X11	The two-axle truck driver pays attention to the needs of service users.	160	171	106.5%	4.125	3.875	0.052	0.203
X12	The two-axle truck has insurance when distributing rice.	164	169	103.0%	4.225	4.100	0.054	0.220
X13	Two-axle truck drivers ensure that goods arrive safely at their destination.	165	169	103.4%	4.225	4.125	0.054	0.222
X14	Two-axle truck drivers have their own insurance to distribute rice.	160	165	101.5%	4.150	4.000	0.057	0.226
X15	Two-axle truck drivers use time efficiently when distributing rice.	161	178	111.3%	4.425	4.025	0.052	0.211
X16	Two-axle truck drivers meet the transportation needs of the rice community.	161	170	105.6%	4.250	4.025	0.054	0.218
X17	Two-axle trucks meet the eligibility requirements of service users.	163	182	111.7%	4.550	4.075	0.058	0.236
X18	Two-axle truck drivers care and respond to the needs of service users.	165	168	102.8%	4.200	4.125	0.053	0.220
	Total				78.575			4.075

Table 2 presents the conformity analysis results for 18 service attributes (X1–X18), including the Mean Importance Score (MIS), Mean Satisfaction Score (MSS), Weight Factor (WF), and Weighted Factor Index (WFi). The highest conformity level was recorded for attribute X4 (114.6%), indicating that users perceived the transportation cost aspect very positively. In contrast, the lowest conformity level was identified for attribute X14 (101.5%), related to driver insurance, suggesting that this aspect still requires improvement. Overall, the results indicate that most service attributes achieved relatively high satisfaction and performance levels.

3.4 Service Satisfaction Evaluation: CSI and IPA

$$CSi = \frac{\sum_{i=1}^{p} WS_i}{HS} \times 100\%$$

Description:

CSi = weight score i (expectation)
Hs = Highest Score = 5

$$CSi = \frac{4.075}{5} \times 100\% = (81.5)$$

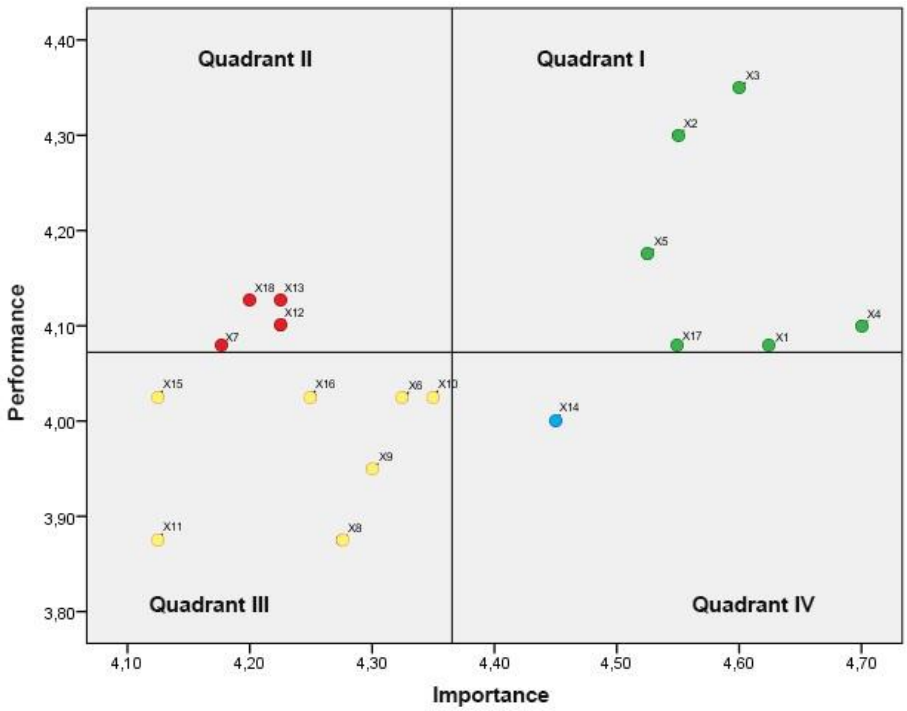


Fig. 2. Importance Performance Analysis (IPA) cartesian diagram results

Fig. 2 illustrates the distribution of service attributes across the four IPA quadrants, indicating the relative importance and performance of each transportation service attribute evaluated in this study. The Customer Satisfaction Index (CSI) result of 81.5% places the service performance within the "very satisfied" category, indicating that the overall service has met or exceeded user expectations. Key service attributes contributing to this high CSI include truck reliability (X1), accessibility (X3), affordability (X4), and service eligibility (X17). These attributes were mapped into Quadrant I of the Importance-Performance Analysis (IPA) matrix, highlighting their dual roles as high-importance and high-performance indicators. These attributes represent strategic strengths that should be maintained and leveraged. Attributes falling into Quadrants II and III, such as redundancy of backup drivers (X7, X18) and the presence of equipment (X8, X9), although not immediately critical, require continuous monitoring to adapt to shifting user priorities. In contrast, Quadrant IV contains attribute X14 (driver personal insurance coverage), which presents a significant gap: although it is of high importance, its performance is low. This indicates latent dissatisfaction regarding driver personal insurance coverage, despite its recognized necessity. However, it suggests that managerial attention is not immediately required to address this gap in terms of improving accountability and trust.

These results demonstrate that two-axle truck transportation services generally satisfy user expectations and play a significant role in supporting rice distribution activities in South Sulawesi Province.

4. Discussion

This study provides important insights into the optimization of rice distribution logistics in South Sulawesi Province, particularly regarding the operational role of two-axle trucks in supporting agricultural supply chains.

The findings from the Customer Satisfaction Index (CSI) and Importance Performance Analysis (IPA) demonstrate that transportation service quality significantly influences user satisfaction and logistics efficiency. These findings are consistent with previous studies emphasizing that transportation reliability, accessibility, service quality, and operational efficiency are critical determinants of freight transportation performance and customer satisfaction (Meng et al., 2015; Muangpan, 2022; Tavasszy et al., 2012).

The CSI value of 81.5% indicates that users are generally very satisfied with the performance of two-axle truck transportation services. This finding is consistent with (Muangpan, 2022), who emphasized that transportation reliability and service quality significantly influence customer satisfaction in distribution systems. This result suggests that operational flexibility, transportation accessibility, and cost efficiency are perceived positively by service users. Similar findings were reported by (Solanki et al., 2023) and (Tuğdemir Kök & Deveci, 2019), who emphasized that transportation mode selection and logistics performance are strongly influenced by service reliability and operational effectiveness. The IPA results further reveal that several service attributes still require improvement, particularly those related to driver insurance and safety assurance. These findings indicate that although the transportation services generally perform well, users still consider safety protection and accountability as important service components. This result is in line with previous transportation studies highlighting safety and service assurance as important indicators affecting customer perceptions of transportation quality (Esmailpour et al., 2020; Smith & Clarke, 2000). The gravity-based distribution analysis also demonstrates that Parepare exhibits stronger rice distribution intensity than Makassar despite Makassar having a larger market potential. This finding suggests that transportation resistance, accessibility, and travel distance significantly influence freight distribution patterns. Similar observations were reported by (Gonzalez-Feliu, 2019) and (Lasić et al., 2023), who found that transportation flow efficiency is strongly associated with network accessibility and regional connectivity.

Key implications for improving logistics service delivery include: enhancing driver insurance and safety assurance systems to address the performance gaps identified in Quadrant IV; optimizing distribution networks to resolve the observed inefficiencies in flow patterns, where Parepare experiences higher distribution intensity compared to Makassar despite its lower market potential; adopting technology-driven transportation systems to enable real-time tracking and route optimization; promoting collaborative fleet management models that leverage economies of scale for smaller operators; and developing performance-based incentive programs for drivers to improve service delivery.

These insights provide a foundation for stakeholders ranging from logistics providers to policymakers to refine their strategies, focusing on enhancing key service attributes that contribute to customer satisfaction. Addressing these practical recommendations will ultimately lead to more efficient and effective transportation systems that are better aligned with user expectations and market demands.

From a scientific perspective, this study contributes to agricultural logistics research by integrating customer satisfaction analysis with spatial freight distribution modeling. This integrated framework provides a more comprehensive understanding of transportation service quality and regional commodity distribution systems in developing regions.

5. Conclusions and Recommendations

This study evaluated the role of two-axle trucks in supporting rice distribution systems in South Sulawesi Province, Indonesia, by integrating the Customer Satisfaction Index (CSI), Importance Performance Analysis (IPA), and a gravity-based distribution model. The results demonstrate that two-axle trucks play an important role in maintaining rice distribution efficiency due to their operational flexibility, accessibility, and suitability for regional transportation conditions.

The Customer Satisfaction Index (CSI) value of 81.5% indicates that users are generally very satisfied with the transportation services. However, the IPA results reveal that several service attributes still require improvement, particularly those related to driver insurance and safety assurance. In addition, the gravity-based distribution analysis shows that Parepare has stronger distribution intensity than Makassar, suggesting that transportation accessibility and distribution resistance significantly influence rice distribution patterns.

These findings provide practical implications for policymakers and logistics providers in improving agricultural transportation systems, particularly in rural areas. Enhancing transportation safety, insurance protection, and logistics service quality may improve user trust and support more sustainable rice distribution systems. From a scientific perspective, this study contributes to agricultural logistics research by integrating customer satisfaction analysis with spatial freight distribution modeling in the context of developing regions.

From a scientific perspective, the integration of performance diagnostics (CSI–IPA) with spatial modeling (gravity-based approach) contributes to the methodological advancement in rural transport studies. Future research should consider incorporating dynamic variables such as seasonality, price fluctuations, and the integration of digital tracking systems to improve real-time responsiveness and adaptability in agricultural logistics.

Future studies are recommended to incorporate additional variables such as seasonal distribution patterns, transportation costs, digital logistics systems, and real-time freight monitoring to provide a more comprehensive understanding of agricultural logistics performance. Future research is also recommended to examine the economic impact of rice transportation efficiency on farmer income, logistics costs, market access, and regional food supply stability. Further studies may also explore the integration of digital logistics systems, route optimization, and sustainable transportation strategies to improve agricultural distribution performance and strengthen the economic welfare of rural communities.

6. Study Limitations

This study has several limitations that should be considered. First, the analysis was limited to rice distribution activities in Sidenreng Rappang Regency, South Sulawesi Province, so the findings may not fully represent rice logistics conditions in other regions. Second, the study focused only on two-axle trucks, while other transportation modes and vehicle types were not analyzed in detail. Third, the gravity based distribution model used in this study considered selected distribution variables and did not fully incorporate dynamic factors such as seasonal changes, fuel price fluctuations, road congestion, and regulatory policies. Therefore, future studies are recommended to include broader study areas, comparative vehicle analysis, and dynamic logistics variables to obtain a more comprehensive understanding of agricultural freight transportation systems.

Consent

As per international standards or university standards, Participants' written consent has been collected and preserved by the author(s).

Disclaimer (Artificial Intelligence)

Author(s) hereby declare that NO generative AI technologies such as Large Language Models (ChatGPT, COPILOT, etc.) and text-to-image generators have been used during the writing or editing of this manuscript.

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Competing Interests

The authors declare that they have no known competing financial or non-financial interests, or personal relationships that could be construed as influencing the reported work.

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