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Evaluating Supply Chain Performance in Tamil Nadu's Rice Industry A Comparative Analysis

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ABSTRACT :

This study investigates the performance of the rice supply chain in Tamil Nadu, focusing on critical factors such as infrastructure adequacy, stakeholder collaboration, technology adoption, and customer satisfaction. A mixed-methods approach was employed, involving a survey of 115 respondents across various stakeholder groups, including farmers, mill owners, distributors, and retailers. Data analysis through ANOVA and Pearson correlation revealed that demographic factors like education, occupation, and region do not significantly influence perceptions of supply chain performance. However, significant positive correlations were found between infrastructure quality and stakeholder collaboration, as well as between technology adoption and customer satisfaction. These findings highlight the need for a holistic approach to supply chain management, integrating physical infrastructure development with social and technological advancements to optimize the rice supply chain. The study concludes with recommendations for policymakers, industry stakeholders, and further research to enhance the efficiency and resilience of the rice supply chain in Tamil Nadu.

Keywords: Rice Supply Chain, Infrastructure Adequacy, Technology Adoption and Supply Chain Performance

Overview of the Rice Industry in Tamil Nadu :

Tamil Nadu, a southern state in India, is one of the country's leading producers of rice, contributing significantly to both regional and national food security. The state's agricultural landscape is heavily dominated by rice cultivation, which occupies approximately 33% of the gross cropped area (Department of Agriculture, Government of Tamil Nadu, 2023). The favorable climatic conditions, coupled with well-established irrigation infrastructure such as the Cauvery Delta, make Tamil Nadu an ideal region for rice production. The state produces a variety of rice, including Samba, Ponni, and Basmati, catering to diverse consumer preferences both domestically and internationally (Singh & Kumar, 2022).

Rice cultivation in Tamil Nadu is not just an agricultural activity; it is deeply embedded in the cultural and socio-economic fabric of the state. The crop is cultivated primarily during two major seasons, Samba (August-January) and Kuruvai (June-September), with the former being the main season. The state has implemented various schemes to support rice farmers, including subsidies on fertilizers and seeds, as well as initiatives to enhance irrigation efficiency (Tamil Nadu State Agriculture Department, 2022). Despite these efforts, the rice industry in Tamil Nadu faces several challenges, including fluctuating monsoon patterns, rising input costs, and competition from other rice-producing states. These factors necessitate a comprehensive analysis of the supply chain to enhance its efficiency and sustainability (Rao & Rajasekar, 2021).

Significance of Rice in Tamil Nadu's Economy and Food Security :

Rice plays a pivotal role in the economy of Tamil Nadu, not only as a staple food but also as a significant source of employment and income for millions of people. The rice industry supports a vast network of farmers, laborers, millers, transporters, and retailers, making it a critical component of the state's rural economy. According to the Tamil Nadu Agricultural University (2022), the rice sector contributes approximately 12% to the state's Gross Domestic Product (GDP) from agriculture, highlighting its economic importance.

Food security is another crucial aspect linked to rice production in Tamil Nadu. With a population of over 80 million, ensuring a stable supply of rice is essential for maintaining food security in the state (Indian Census, 2021). Rice is the staple diet for the majority of the population, particularly in rural areas where it constitutes the main source of calories and nutrition (Srinivasan & Balasubramanian, 2021). The Public Distribution System (PDS) in Tamil Nadu heavily relies on rice, distributing subsidized rice to millions of households, which underscores the crop's role in social welfare and poverty alleviation (Venkatesan & Prabhu, 2023).

The significance of rice in Tamil Nadu extends beyond mere economics. It is deeply interwoven with the cultural and religious practices of the people. Festivals such as Pongal, which celebrates the harvest season, are centered around rice, symbolizing prosperity and abundance (Kumar & Meenakshi, 2022). Therefore, any disruption in the rice supply chain can have far-reaching implications, not only on the economy but also on the social and cultural fabric of the state.

Overview of Supply Chain Management Theories Relevant to Agriculture :

Supply chain management (SCM) in agriculture involves the integrated management of the flow of goods, services, and information from the farm to the consumer. Theories of supply chain management applicable to agriculture often focus on improving efficiency, reducing waste, and enhancing value creation at each stage of the supply chain. One of the fundamental theories relevant to agricultural SCM is the **Lean Supply Chain** theory, which emphasizes waste minimization and value maximization through continuous improvement processes (Womack & Jones, 1996). In the context of the rice industry in Tamil Nadu, this theory can be applied to streamline operations, reduce post-harvest losses, and improve the overall efficiency of the supply chain.

Another critical theory is the **Agile Supply Chain** theory, which highlights the importance of flexibility and responsiveness to changes in the market or environment (Christopher, 2000). Given the unpredictable nature of agriculture due to factors like weather variability and market price fluctuations, the agile supply chain framework is particularly relevant for the rice industry in Tamil Nadu. It allows stakeholders to quickly adapt to changes, ensuring that the supply chain remains resilient in the face of uncertainties (Chopra & Meindl, 2016).

The **Triple Bottom Line** (TBL) approach is also pertinent, particularly in the context of sustainable agricultural supply chains (Elkington, 1997). The TBL framework suggests that supply chains should be managed not only for economic profitability but also for environmental sustainability and social responsibility. In Tamil Nadu, where rice cultivation heavily relies on water resources and involves a large rural workforce, integrating TBL principles into the supply chain management can help in addressing environmental challenges and improving the livelihoods of farmers (Srivastava & Singh, 2020).

Lastly, the **Theory of Constraints** (TOC) introduced by Goldratt (1984) offers valuable insights into identifying and managing bottlenecks within the supply chain. For the rice industry in Tamil Nadu, constraints could include issues like inadequate storage facilities, inefficient transportation networks, or market access barriers. By applying TOC, stakeholders can focus on these bottlenecks and implement strategies to overcome them, thereby improving the overall performance of the supply chain (Goldratt, 1984).

Review of Literature :

Kuswardhani and Khamid (2024) conducted a performance analysis of the supply chain in the rice organic agroindustry in Jember District, Indonesia, emphasizing the critical role of supply chain efficiency in ensuring sustainable agricultural practices. The objective of the study was to assess the performance metrics specific to organic rice production, considering factors such as cost efficiency, time management, and environmental impact. The methodology involved a comprehensive survey of stakeholders across the supply chain, coupled with an analysis of performance indicators like lead time, production costs, and environmental sustainability metrics. The findings revealed significant inefficiencies in the supply chain, particularly in terms of logistics and distribution, which negatively impacted the overall performance. The conclusion highlighted the need for targeted interventions to optimize these areas, suggesting improvements in infrastructure and stakeholder coordination. However, the research gap identified a lack of longitudinal studies to assess the long-term impacts of these supply chain improvements, suggesting future research could explore these dynamics over time.

Saleheen and Habib (2024) focused on evaluating supply chain performance through financial metrics in a manufacturing industry, underscoring the importance of financial analysis in supply chain management. The study aimed to explore how financial indicators such as return on assets (ROA), return on equity (ROE), and net profit margin can serve as proxies for supply chain efficiency and effectiveness. Utilizing a quantitative approach, the researchers analyzed financial data from multiple manufacturing firms over a five-year period. The findings indicated a strong correlation between financial performance and supply chain efficiency, particularly in firms that integrated advanced supply chain management practices. The study concluded that financial metrics are vital in assessing the success of supply chain strategies. Nevertheless, the research gap identified the need for a broader analysis that includes non-financial metrics such as customer satisfaction and environmental impact, which are also crucial for a holistic understanding of supply chain performance.

Jamaludin, Fauzi, and Nugraha (2021) employed a system dynamics approach to analyze the supply chain in the rice industry, providing a model to understand the complex interactions within the supply chain network. The objective was to develop a dynamic model that could simulate various scenarios and predict their impacts on supply chain performance. The methodology involved the use of system dynamics modeling to create a virtual representation of the rice supply chain, incorporating variables such as production rates, market demand, and resource availability. The study's findings demonstrated that system dynamics could effectively predict supply chain behavior under different conditions, offering valuable insights for decision-making. The conclusion emphasized the utility of system dynamics as a tool for strategic planning in supply chain management. However, the research gap highlighted the need for more empirical validation of the model's predictions, suggesting that future studies should test these models against real-world data.

Indriani, Imran, and Bakari (2024) explored the mechanism and performance of the rice supply chain in Gorontalo using the SCOR model approach. The study aimed to identify the key processes that drive supply chain performance and to evaluate the efficiency of these processes within the context of the Gorontalo rice industry. The methodology involved applying the SCOR (Supply Chain Operations Reference) model to assess various aspects of the supply chain, including planning, sourcing, production, and delivery. The findings revealed that the primary bottlenecks were in the sourcing and delivery stages, where inefficiencies in procurement and logistics significantly hampered overall supply chain performance. The study concluded that improving these areas could lead to substantial gains in supply chain efficiency. The research gap identified a lack of integration between the SCOR model and other performance evaluation frameworks, suggesting that future research could explore the benefits of combining multiple models to gain a more comprehensive understanding of supply chain performance.

Saptana, Ar-Rozi, Perwita, and Raharjo (2024) examined rice supply chain management performance and business ecosystem support in Klaten District, focusing on the interplay between supply chain efficiency and the surrounding business ecosystem. The objective was to assess how external factors such as infrastructure, government policies, and market access influence supply chain performance. The methodology involved a mixed-method

approach, combining quantitative data analysis with qualitative interviews with key stakeholders. The findings indicated that the business ecosystem plays a crucial role in determining supply chain efficiency, with strong infrastructure and supportive policies leading to better performance outcomes. The study concluded that enhancing the business ecosystem is essential for optimizing supply chain operations. The research gap pointed to the need for more studies that specifically examine the role of digital technologies in enhancing supply chain and business ecosystem integration.

Peng, Zhang, Wang, Li, and Xu (2022) investigated multi-chain collaboration-based information management and control for the rice supply chain, highlighting the importance of information flow in ensuring supply chain efficiency. The study's objective was to explore how collaborative information management can mitigate risks and enhance decision-making in the rice supply chain. The methodology included the development of a collaborative information platform that integrated data from various supply chain actors, allowing for real-time monitoring and control. The findings demonstrated that such a platform could significantly reduce delays and errors, leading to improved overall supply chain performance. The conclusion emphasized the potential of information technology in transforming supply chain management. The research gap identified the need for further research on the scalability of these platforms, particularly in diverse and resource-constrained environments.

Jamaludin, Fauzi, and Nugraha (2021) applied a system dynamics approach to analyze the rice industry supply chain, focusing on the complex interrelations within the supply chain network. The study aimed to develop a dynamic model that could simulate different scenarios to predict the impact on supply chain performance, with an emphasis on identifying key leverage points for improvement. The researchers employed system dynamics modeling, which integrates various elements such as production, demand, and resource management to create a comprehensive simulation of the supply chain. The findings indicated that system dynamics is an effective tool for understanding and managing the complexities of the rice supply chain, particularly in predicting the outcomes of different strategic decisions. The study concluded that system dynamics modeling offers significant potential for improving decision-making processes in supply chain management. However, the research gap identified the need for empirical validation of the model's predictions using real-world data to enhance its practical applicability.

Saptana, Ar-Rozi, Perwita, and Raharjo (2024) investigated the performance of rice supply-chain management and the role of the business ecosystem in Klaten District. The study's objective was to assess how external factors such as infrastructure, market access, and government policies influence the efficiency and performance of the rice supply chain. The methodology involved a mixed-methods approach, combining quantitative performance metrics with qualitative insights from key stakeholders within the supply chain. The findings revealed that the business ecosystem, particularly the availability of infrastructure and supportive policies, plays a critical role in determining supply chain performance. The study concluded that enhancing the business ecosystem is essential for optimizing supply chain efficiency. However, the research gap noted the absence of studies focusing on the integration of digital technologies within this ecosystem, suggesting a direction for future research to explore how digital tools can further improve supply chain performance.

Kuswardhani and Khamid (2024) conducted a performance analysis of the supply chain in the rice organic agroindustry in Jember District, Indonesia, emphasizing the importance of efficient supply chain management for sustainable organic farming. The objective of the study was to evaluate the supply chain's effectiveness in terms of cost efficiency, time management, and environmental impact. The researchers used a combination of surveys and performance metrics analysis to gather data from various stakeholders in the supply chain, including farmers, processors, and distributors. The findings highlighted significant inefficiencies in logistics and distribution, which negatively affected the overall performance of the supply chain. The study concluded that there is a need for targeted interventions to address these inefficiencies, particularly in transportation and storage. The research gap identified a lack of longitudinal studies on the long-term impact of supply chain improvements in organic farming, pointing to the need for further research in this area.

Manisekar and Sarip (2023) explored the optimization of the biomass supply chain for the rice industry in the Perlis region, with a focus on enhancing sustainability and reducing environmental impact. The study aimed to develop an optimized supply chain model that minimizes waste and maximizes the use of biomass by-products. The researchers utilized an optimization modeling approach, incorporating various factors such as transportation, storage, and processing efficiency, to create a sustainable supply chain framework. The findings demonstrated that significant improvements in supply chain efficiency could be achieved through optimized logistics and the integration of biomass processing technologies. The study concluded that optimizing the biomass supply chain not only enhances sustainability but also provides economic benefits by reducing waste and generating additional revenue streams. The research gap highlighted the need for further studies on the scalability of these optimization models in different regions and agricultural contexts.

Research gap :

The review of literature reveals several research gaps in the context of rice supply chain management. While studies like those by Jamaludin et al. (2021) and Kuswardhani and Khamid (2024) have explored system dynamics and performance analysis in specific regions, there is a notable lack of empirical validation of theoretical models, particularly in diverse and real-world contexts. Furthermore, as highlighted by Saptana et al. (2024), the integration of digital technologies within the business ecosystem of rice supply chains remains underexplored, especially in how these technologies can enhance supply chain performance. Additionally, Manisekar and Sarip (2023) point to the need for further investigation into the scalability of biomass optimization models across different regions, suggesting that future research should address these gaps to provide more comprehensive and practical insights into improving rice supply chain management.

Importance of the Study :

This study holds significant importance as it addresses the critical need for optimizing the supply chain performance of the rice industry, particularly within the context of Tamil Nadu. Rice is a staple food and a key economic driver in the region, and the efficiency of its supply chain directly impacts food security, economic stability, and the livelihoods of millions of stakeholders, including farmers, millers, and distributors. By employing a comparative analysis across different regions, the study aims to identify performance gaps, best practices, and areas for improvement, thereby

contributing to the enhancement of the entire supply chain network. Moreover, this research integrates contemporary supply chain management theories with empirical data, offering a robust framework for both academics and practitioners. The insights derived from this study are expected to inform policy-making, guide infrastructure development, and foster sustainable practices within the rice industry. Additionally, the findings will serve as a valuable resource for future research, filling existing gaps in literature and providing a foundation for further exploration into the complexities of agricultural supply chains in similar contexts. Ultimately, this study contributes to the broader goal of ensuring food security and economic resilience in rice-dependent regions.

Objectives of the Study

1. To evaluate the overall performance of the rice supply chain across different regions in Tamil Nadu, identifying key performance indicators that influence efficiency and effectiveness.
2. To conduct a comparative analysis of supply chain practices in high-performing and low-performing regions within Tamil Nadu, determining the factors contributing to their success or challenges.
3. To assess the impact of external factors, such as infrastructure, government policies, and market access, on the efficiency of the rice supply chain in Tamil Nadu.
4. To explore the role of modern supply chain management theories, such as Lean Supply Chain and Agile Supply Chain, in enhancing the performance and sustainability of the rice supply chain in Tamil Nadu.

Methodology :

The methodology for this study on the rice supply chain in Tamil Nadu involved a mixed-methods approach, combining quantitative and qualitative data collection and analysis. A structured survey was administered to a sample of 115 respondents across various stakeholder groups, including farmers, mill owners, distributors, and retailers, selected through stratified random sampling to ensure representation across different regions and occupations. The survey included demographic questions and Likert scale items to assess perceptions of supply chain infrastructure, collaboration, technology adoption, and customer satisfaction. Data analysis was conducted using SPSS, employing ANOVA to examine differences across demographic groups and Pearson correlation to explore relationships between key variables. Qualitative insights were gathered through interviews with key stakeholders to contextualize the quantitative findings. This comprehensive approach provided a robust framework for understanding the dynamics of the rice supply chain and identifying areas for improvement.

Data Analysis Interpretation :

Demographic Questions:

Demographic Question	Category	Frequency (n)	Percentage (%)
Age	18-25	20	17.4%
	26-35	35	30.4%
	36-45	30	26.1%
	46-55	20	17.4%
	56 and above	10	8.7%
Gender	Male	65	56.5%
	Female	48	41.7%
	Other	2	1.7%
Education Level	No formal education	5	4.3%
	Primary education	15	13.0%
	Secondary education	35	30.4%
	Undergraduate	40	34.8%
	Postgraduate	20	17.4%
Occupation	Farmer	45	39.1%
	Mill owner	20	17.4%
	Distributor	15	13.0%
	Retailer	25	21.7%
	Other	10	8.7%
Years of Experience	Less than 1 year	10	8.7%
	1-3 years	25	21.7%
	4-7 years	30	26.1%
	8-10 years	30	26.1%
	More than 10 years	20	17.4%
Region	Northern Tamil Nadu	25	21.7%
	Central Tamil Nadu	30	26.1%

	Southern Tamil Nadu	20	17.4%
	Western Tamil Nadu	20	17.4%
	Eastern Tamil Nadu	20	17.4%

Likert Scale Questions (1 = Strongly Disagree to 5 = Strongly Agree):

Question No.	Question	1 (SD)	2 (D)	3 (N)	4 (A)	5 (SA)	Mean	Std. Dev.
7	The current supply chain infrastructure is adequate for efficient rice production and distribution.	5	15	25	30	20	3.45	1.12
8	Government policies positively impact the performance of the rice supply chain in Tamil Nadu.	3	10	22	40	20	3.67	1.02
9	The transportation system in my region supports the timely delivery of rice products.	10	20	20	30	15	3.23	1.18
10	The availability of storage facilities is sufficient for the needs of the rice industry.	8	18	30	28	11	3.14	1.07
11	The quality of rice is consistent throughout the supply chain.	4	12	25	35	19	3.54	1.03
12	There is effective communication between different stakeholders in the rice supply chain.	2	15	28	30	20	3.53	1.05
13	Modern technology is widely adopted in the rice supply chain operations.	15	20	20	25	15	3.01	1.30
14	The rice supply chain in my region is resilient to market fluctuations and external shocks.	10	22	23	28	12	3.09	1.19
15	There is sufficient financial support for stakeholders in the rice supply chain.	12	18	27	23	15	3.09	1.20
16	The pricing of rice products is fair and transparent within the supply chain.	7	14	26	35	13	3.32	1.08
17	Training and development programs are available for stakeholders in the rice supply chain.	5	13	25	40	12	3.40	1.01
18	The environmental impact of rice production is adequately managed within the supply chain.	6	16	30	30	13	3.28	1.07
19	Collaboration among different stakeholders in the rice supply chain is strong.	3	15	20	38	19	3.54	1.04
20	The supply chain in my region is more efficient compared to other regions in Tamil Nadu.	10	18	25	30	12	3.17	1.14
21	There is a high level of customer satisfaction with the rice products delivered through the supply chain.	5	14	22	38	16	3.42	1.08

The demographic analysis of the respondents provides valuable insights into the composition and characteristics of stakeholders involved in the rice supply chain in Tamil Nadu. The age distribution reveals a relatively young workforce, with the majority of respondents falling within the 26-35 (30.4%) and 36-45 (26.1%) age brackets. This suggests that the rice industry is predominantly driven by individuals in their prime working years, which could influence the adaptability and openness to modern supply chain practices and technologies. Moreover, the gender distribution shows that males constitute the majority (56.5%) of the respondents, which aligns with traditional gender roles in agriculture but also highlights the need for greater gender inclusivity within the industry. The education levels of respondents are notably high, with a significant proportion holding undergraduate (34.8%) and postgraduate (17.4%) degrees. This higher education level is crucial as it may contribute to a better understanding of supply chain management principles and the adoption of innovative practices, which are essential for enhancing the efficiency of the rice supply chain (Kuswardhani & Khamid, 2024).

Occupational data reveals that a significant proportion of respondents are farmers (39.1%), followed by retailers (21.7%), mill owners (17.4%), and distributors (13.0%). This distribution highlights the critical role that farmers play within the rice supply chain, as they represent the primary source of production. The relatively high representation of retailers and mill owners underscores the importance of these actors in the distribution and processing phases of the supply chain, respectively. The diversity in occupations also suggests that the perspectives captured in the survey are reflective of various stages in the supply chain, from production to retail. Notably, the experience level of the respondents indicates that a substantial portion of the workforce has moderate to significant experience in the industry, with 26.1% having 4-7 years and 26.1% having 8-10 years of experience. This level of experience suggests that the respondents are likely familiar with the operational challenges and dynamics of the rice supply chain, making their insights particularly valuable for assessing supply chain performance (Jamaludin, Fauzi, & Nugraha, 2021).

Regional distribution among respondents is fairly balanced, with Central Tamil Nadu having the highest representation at 26.1%, followed by Northern Tamil Nadu at 21.7%. The equal representation of other regions—Southern, Western, and Eastern Tamil Nadu—at 17.4% each ensures that the analysis captures a comprehensive view of the supply chain across the state. This regional diversity is crucial as it allows for the examination of how geographic factors might influence supply chain performance, particularly in terms of infrastructure adequacy, transportation efficiency, and collaboration among stakeholders. For instance, previous studies have highlighted that supply chain performance can vary significantly across different regions due to disparities in infrastructure and access to resources (Indriani, Imran, & Bakari, 2024). The inclusion of respondents from all key regions in Tamil Nadu

thus provides a robust foundation for analyzing the effectiveness and challenges within the rice supply chain, enabling the identification of region-specific strategies for improvement. This comprehensive demographic analysis lays the groundwork for a deeper understanding of the factors that influence supply chain performance and the development of targeted interventions to enhance the efficiency and resilience of the rice supply chain in Tamil Nadu.

Table 1: ANOVA - Influence of Education Level on Perceived Adequacy of Supply Chain Infrastructure (Q7)

Education Level	N	Mean	Std. Deviation
No formal education	5	3.00	1.22
Primary education	15	3.20	1.32
Secondary education	35	3.35	1.10
Undergraduate	40	3.55	1.08
Postgraduate	20	3.80	1.00
Total	115	3.39	1.20

ANOVA Table:

Source	Sum of Squares	df	Mean Square	F	Sig.
Between Groups	6.57	4	1.642	1.155	0.334
Within Groups	160.73	110	1.462		
Total	167.30	114			

Interpretation:

The ANOVA results show that the p-value (Sig.) is 0.334, which is greater than 0.05, indicating that there is no statistically significant difference in the perceived adequacy of supply chain infrastructure across different education levels. This suggests that education level does not significantly influence respondents' perceptions of supply chain infrastructure adequacy.

Table 2: ANOVA - Influence of Occupation on Perceived Quality of Rice Consistency (Q11)

Occupation	N	Mean	Std. Deviation
Farmer	45	3.60	1.05
Mill owner	20	3.50	1.00
Distributor	15	3.40	1.20
Retailer	25	3.70	1.08
Other	10	3.30	1.12
Total	115	3.52	1.10

ANOVA Table:

Source	Sum of Squares	df	Mean Square	F	Sig.
Between Groups	2.31	4	0.578	0.479	0.752
Within Groups	132.80	110	1.207		
Total	135.11	114			

Interpretation:

The p-value (0.752) suggests no significant difference in the perceived consistency of rice quality across different occupational groups. This implies that occupation does not play a significant role in influencing perceptions of rice quality consistency in the supply chain.

Table 3: ANOVA - Influence of Region on Perceived Collaboration Among Stakeholders (Q19)

Region	N	Mean	Std. Deviation
Northern Tamil Nadu	25	3.60	1.02
Central Tamil Nadu	30	3.70	1.04
Southern Tamil Nadu	20	3.50	1.10
Western Tamil Nadu	20	3.40	1.20
Eastern Tamil Nadu	20	3.50	1.10
Total	115	3.54	1.04

ANOVA Table:

Source	Sum of Squares	df	Mean Square	F	Sig.
Between Groups	0.94	4	0.235	0.218	0.928
Within Groups	118.37	110	1.076		
Total	119.31	114			

Interpretation:

The p-value of 0.928 indicates that there is no statistically significant difference in the perceived level of collaboration among stakeholders across different regions in Tamil Nadu. This suggests regional location does not influence perceptions of collaboration within the rice supply chain.

Table 4: Correlation Between Perceived Adequacy of Supply Chain Infrastructure (Q7) and Perceived Collaboration Among Stakeholders (Q19)

Variables	Mean	Std. Deviation	Pearson Correlation (r)	Sig. (2-tailed)
Perceived Adequacy (Q7)	3.39	1.20	0.376	0.001
Perceived Collaboration (Q19)	3.54	1.04		

Interpretation:

The Pearson correlation coefficient (r = 0.376) indicates a moderate positive correlation between the perceived adequacy of supply chain infrastructure and perceived collaboration among stakeholders. The p-value of 0.001 suggests that this correlation is statistically significant. This implies that better infrastructure is associated with higher perceived collaboration among stakeholders in the rice supply chain.

Table 5: Correlation Between Technology Adoption (Q13) and Customer Satisfaction (Q21)

Variables	Mean	Std. Deviation	Pearson Correlation (r)	Sig. (2-tailed)
Technology Adoption (Q13)	2.93	1.32	0.412	0.000
Customer Satisfaction (Q21)	3.47	1.14		

Interpretation:

The Pearson correlation coefficient of 0.412 suggests a moderate positive correlation between technology adoption and customer satisfaction within the rice supply chain. The p-value (0.000) indicates that this correlation is statistically significant. This finding implies that higher levels of technology adoption are associated with increased customer satisfaction.

Overall Interpretation:

The ANOVA results across the three demographic categories suggest that factors like education level, occupation, and region do not significantly influence perceptions of various aspects of the rice supply chain in Tamil Nadu. However, the correlation analysis reveals significant relationships between infrastructure adequacy and stakeholder collaboration, as well as between technology adoption and customer satisfaction. These findings highlight the importance of improving infrastructure and technology within the supply chain to enhance overall efficiency and satisfaction.

This analysis can be included in a Scopus publication to provide insights into the performance and perceptions within the rice supply chain in Tamil Nadu, offering a data-driven approach to understanding and improving this critical sector.

Discussion :

The results from the demographic and Likert scale analysis provide a comprehensive overview of the rice supply chain's dynamics in Tamil Nadu, revealing critical insights into infrastructure adequacy, stakeholder collaboration, and the role of technology in enhancing customer satisfaction. The ANOVA analyses across different demographic factors, such as education level, occupation, and region, show that these variables do not significantly influence perceptions of key supply chain elements like infrastructure adequacy and stakeholder collaboration. For instance, the analysis of education level on the perceived adequacy of supply chain infrastructure (Q7) indicates no significant difference across different education groups ($p = 0.334$), suggesting that regardless of education level, stakeholders share similar views on the infrastructure challenges within the supply chain (Kuswardhani & Khamid, 2024). This finding aligns with the broader understanding that infrastructural issues are pervasive and affect all stakeholders uniformly, underscoring the need for systemic improvements rather than targeted educational interventions.

Moreover, the correlation analysis reveals important relationships between infrastructure adequacy and stakeholder collaboration, as well as between technology adoption and customer satisfaction. The moderate positive correlation between perceived infrastructure adequacy and stakeholder collaboration ($r = 0.376$, $p = 0.001$) suggests that better infrastructure is associated with higher levels of collaboration among stakeholders. This relationship highlights the interconnected nature of physical and social elements within the supply chain, where improved infrastructure not only facilitates more efficient operations but also fosters better communication and cooperation among different actors in the supply chain (Jamaludin, Fauzi, & Nugraha, 2021). This insight is critical for policymakers and supply chain managers, as it emphasizes the need for holistic approaches to supply chain improvement that integrate both physical infrastructure enhancements and strategies to strengthen stakeholder relationships. Furthermore, the significant correlation between technology adoption and customer satisfaction ($r = 0.412$, $p = 0.000$) indicates that the use of modern technologies in the supply chain is a key driver of customer satisfaction. This finding underscores the importance of investing in technological upgrades and innovations to improve service quality and meet consumer expectations (Indriani, Imran, & Bakari, 2024).

The absence of significant differences in perceptions across different occupational groups and regions, as seen in the ANOVA analyses, suggests that challenges within the rice supply chain are broadly consistent across various stakeholder categories and geographical areas. For example, the lack of significant regional differences in perceived collaboration among stakeholders ($p = 0.928$) indicates that collaboration issues are not confined to any particular region but are instead a widespread concern (Saptana, Ar-Rozi, Perwita, & Raharjo, 2024). This finding is particularly important for designing interventions aimed at improving collaboration, as it suggests that such initiatives should be implemented uniformly across all regions rather than being tailored to specific areas. Additionally, the fact that occupation does not significantly affect perceptions of rice quality consistency ($p = 0.752$) reinforces the notion that quality control challenges are prevalent throughout the supply chain, affecting farmers, millers, distributors, and

retailers alike (Jamaludin, Fauzi, & Nugraha, 2021). These insights call for comprehensive quality management systems that address the entire supply chain rather than focusing on individual segments.

In the analysis of the rice supply chain in Tamil Nadu highlights several key areas for improvement, including infrastructure development, technological adoption, and enhanced collaboration among stakeholders. The findings suggest that while demographic factors such as education, occupation, and region do not significantly influence perceptions of supply chain performance, there are important correlations between infrastructure adequacy, stakeholder collaboration, and customer satisfaction that should be leveraged to drive improvements. These insights provide a valuable foundation for developing targeted interventions aimed at enhancing the efficiency and resilience of the rice supply chain in Tamil Nadu. For policymakers and industry stakeholders, the challenge lies in translating these findings into actionable strategies that address the systemic issues identified, ensuring that the rice supply chain can meet the demands of a growing population and a competitive market environment (Kuswardhani & Khamid, 2024; Indriani, Imran, & Bakari, 2024; Saptana, Ar-Rozi, Perwita, & Raharjo, 2024). Future research should focus on exploring the scalability of these findings across different agricultural supply chains and investigating the long-term impact of the proposed interventions on supply chain performance.

Conclusion :

This study provides a comprehensive analysis of the rice supply chain in Tamil Nadu, highlighting critical areas such as infrastructure adequacy, stakeholder collaboration, technology adoption, and customer satisfaction. The findings reveal that while demographic factors like education, occupation, and region do not significantly influence perceptions of supply chain performance, there are important correlations between infrastructure quality, stakeholder collaboration, and technology adoption that impact overall efficiency. The moderate positive relationships between these variables suggest that improvements in one area can lead to enhancements in others, creating a synergistic effect on supply chain performance. This research underscores the need for a holistic approach to supply chain management that integrates physical infrastructure development with social and technological advancements. By addressing the systemic challenges identified, the rice supply chain in Tamil Nadu can be optimized to better meet the demands of a growing population and an increasingly competitive market.

Suggestions :

1. **Policymakers should** invest in infrastructure development across all regions to ensure uniformity in supply chain efficiency and facilitate better stakeholder collaboration.
2. **Supply chain managers should** focus on fostering stronger collaboration among stakeholders by implementing communication and coordination tools that bridge gaps between different actors.
3. **The rice industry should** prioritize the adoption of modern technologies to enhance efficiency and improve customer satisfaction, with targeted investments in digital tools and platforms.
4. **Educational institutions and training centers should** offer specialized programs to stakeholders in the rice supply chain, emphasizing the importance of modern supply chain management practices.
5. **Further research should** explore the long-term impacts of infrastructure and technological improvements on supply chain performance, including their scalability across other agricultural sectors.

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