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Do Integrated Supply Chains Improve Agricultural Marketing? A Quantitative Study Of Tribal Vegetable Farmers

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Abstract
This study examines the impact of supply chain integration on vegetable marketing performance among tribal farmers in the Koraput district of Odisha, India. The research focuses on how different dimensions of supply chain integration influence farmers' market outcomes in a region characterized by infrastructural constraints and limited market access. The study adopts a quantitative research design using primary data collected from 800 tribal vegetable farmers through a structured questionnaire based on a five-point Likert scale. Five independent variables, namely perception of supply chain practices, role of intermediaries, cold storage and infrastructure availability, use of supply chain management tools, and technology adoption, are analyzed in relation to vegetable marketing performance. Descriptive statistics, Pearson correlation analysis, and multiple regression analysis are employed for data analysis. The results reveal that supply chain management tools, perception of supply chain practices, and technology adoption have a strong and statistically significant positive impact on vegetable marketing performance. Cold storage and infrastructure availability also contribute significantly, while the role of intermediaries shows a comparatively weaker influence. The findings highlight the need for farmer-centric, technology-enabled supply chain interventions to enhance marketing efficiency and income sustainability in tribal regions. The study provides region-specific empirical evidence from a tribal-dominated agricultural context, contributing to the literature on inclusive agricultural supply chains.

Keywords: Supply Chain Integration, Vegetable Marketing, Tribal Farmers, Technology Adoption, Agricultural Infrastructure

1. Introduction
Vegetable cultivation occupies a crucial position in the Indian agricultural system, not only because of its contribution to food and nutritional security, but also due to its capacity to generate income and employment in rural and semi-rural regions. Vegetables are short-duration crops, labour intensive in nature, and highly responsive to market signals. However, despite India being the second-largest producer of vegetables globally, the sector continues to suffer from persistent inefficiencies related to production planning, post-harvest handling, storage, transportation, and marketing. These inefficiencies are particularly pronounced in regions dominated by small, marginal, and tribal farmers, where institutional support systems remain weak and fragmented.

One of the central challenges faced by vegetable farmers is the highly perishable nature of produce. Unlike cereals, vegetables demand timely harvesting, rapid transportation, proper storage, and efficient market linkage. Any delay or breakdown at one stage of the supply chain leads to physical losses, quality deterioration, and distress sales. In practice, farmers often have

limited control beyond the farm gate. The absence of integrated supply chain mechanisms forces them to depend heavily on intermediaries, who frequently dictate prices, control information flow, and absorb a disproportionate share of the final consumer price. As a result, farmers receive low price realisation, while consumers continue to pay relatively high prices, indicating systemic inefficiency rather than scarcity.

Supply chain integration offers a promising pathway to address these structural weaknesses. Integration refers to the coordinated management of activities, information, and relationships among different actors in the supply chain, ranging from input suppliers and producers to wholesalers, retailers, and end consumers. In the context of vegetable marketing, effective supply chain integration can reduce post-harvest losses, improve price transparency, shorten marketing channels, and enhance farmers' bargaining power. Practices such as improved logistics, cold storage facilities, real-time market information, contract farming, and technology-enabled coordination have shown potential to improve overall market performance. The relevance of supply chain integration becomes even more critical when the focus shifts to tribal farmers. Tribal regions such as Koraput district in Odisha are characterized by difficult terrain, limited infrastructure, low levels of formal education, and restricted access to markets. Although Koraput plays a significant role in vegetable production within the state, tribal farmers often remain excluded from the benefits of modern agricultural marketing systems. Their participation in supply chains is largely informal, fragmented, and mediated through multiple layers of intermediaries. Moreover, awareness regarding supply chain practices, price mechanisms, post-harvest technologies, and institutional marketing channels remains limited.

Another important dimension shaping supply chain outcomes is technology adoption. Digital tools related to market information, mobile-based price alerts, logistics coordination, and storage management have the potential to transform vegetable marketing. However, technology adoption among tribal farmers is uneven and constrained by affordability, literacy, and infrastructural limitations. Understanding whether technology acts merely as an independent driver or plays a mediating role between supply chain integration and marketing performance is therefore essential for designing effective interventions.

Against this backdrop, the present study examines the relationship between supply chain integration and vegetable marketing performance among tribal farmers in Koraput district. The study adopts a highly quantitative approach, using primary data collected through a structured Likert-scale questionnaire. Five independent variables, namely perception of supply chain practices, role of intermediaries, availability of cold storage and infrastructure, use of supply chain tools, and technology adoption, are examined in relation to the dependent variable of vegetable marketing performance and profitability. By employing descriptive statistics, correlation analysis, and regression analysis, the study seeks to empirically establish the strength, direction, and significance of these relationships.

By focusing on a tribal-dominated region and adopting a data-driven analytical framework, the study contributes to a more localized and evidence-based understanding of supply chain integration in vegetable marketing. The findings are expected to offer practical insights for policymakers, agricultural planners, and development agencies aiming to improve market access, income stability, and sustainability in marginalized farming communities.

Hypotheses of the Study

Based on the objectives of the study and the review of existing literature, the following hypotheses are formulated and tested empirically:
H_1: Perception of supply chain practices has a significant positive impact on vegetable marketing performance among tribal farmers.
H_2: The role of intermediaries has a significant impact on vegetable marketing performance among tribal farmers.
H_3: Cold storage and infrastructure availability has a significant positive impact on vegetable marketing performance among tribal farmers.
H_4: Use of supply chain management tools has a significant positive impact on vegetable marketing performance among tribal farmers.
H_5: Technology adoption has a significant positive impact on vegetable marketing performance among tribal farmers.

2. Literature Review

Research on supply chain management in agriculture has gradually shifted from a narrow focus on production efficiency to a broader concern with coordination, integration, and market performance (Kumar & Sahoo, 2024). In the context of vegetables, this shift is particularly relevant because the product characteristics demand speed, coordination, and information sharing across multiple actors (Alulu et al., 2023). Several scholars have argued that inefficiencies in agricultural supply chains are less about low production and more about weak linkages between producers, intermediaries, and markets, which ultimately affect farmers' income and consumer welfare (Mwewa et al., 2024).

Studies examining food loss across agricultural supply chains, highlight transportation bottlenecks, inadequate storage infrastructure, and poor operational coordination as major contributors to inefficiency (Abad et al., 2024). In vegetable supply chains, these issues are magnified due to seasonal production and the absence of cold chain facilities, forcing farmers to sell quickly, often at unfavourable prices. Such structural constraints reduce the effectiveness of marketing systems and weaken farmers' negotiating capacity (Singh et al., 2025).

The role of distribution channels has also received significant scholarly attention. Research conducted in Indonesia revealed that vegetable marketing channels tend to be long and complex, involving multiple intermediaries before the produce reaches final consumers, which negatively affects farmers' business performance (Kaur, 2025). Although intermediaries play a necessary role in aggregation and distribution, excessive dependence on them can distort price signals and reduce transparency (Pavendan, 2025). Similar concerns have been raised in developing country contexts where small and marginal farmers lack direct access to organized markets and institutional buyers (Ma et al., 2024).

Intermediaries, however, are not uniformly portrayed as exploitative (Kanwal et al., 2025). Some studies emphasize their positive role in facilitating information transfer, managing risks, and supporting coordination between fragmented producers and markets (Brauer et al., 2022). For instance, research on sustainable supply chain management shows that intermediaries often act as knowledge brokers, especially where farmers lack awareness of best practices and sustainability standards (Sengupta et al., 2024). This dual role of intermediaries suggests that their impact on marketing performance depends largely on the structure and governance of the supply chain rather than their mere presence (Taylor & Rosca, 2022).

Technology and information sharing have emerged as critical enablers of supply chain integration (Nguyen, 2021). Studies examining the use of digital tools and internet-based systems argue that timely information sharing improves coordination, reduces uncertainty, and enhances market efficiency in agricultural supply chains (Bekkouche & de-Magistris, 2025). In fresh produce markets, where demand uncertainty and price volatility are high, coordinated information systems help align production decisions with market requirements. However, the effectiveness of such technologies is closely tied to farmers' ability and willingness to adopt them (Keskin et al., 2024).

Several scholars have explored coordination mechanisms such as contracts and pricing models to address uncertainty in fresh agricultural supply chains (Jiang et al., 2024; Shi & Cheng, 2025). Research on contract-based coordination mechanisms highlights their potential to stabilize prices, reduce risk, and ensure assured market access for farmers, particularly in perishable commodity markets (Aubert & Piot-Lepetit, 2024). At the same time, contractual arrangements have generated debate, especially in developing countries, where power asymmetry between farmers and buyers can limit their effectiveness (Angreheni et al., 2024). This suggests that institutional and socio-economic contexts play a crucial role in determining outcomes (Rossi et al., 2023).

Studies focusing on value chain participation have explicitly addressed the challenges faced by small and marginal farmers (Kaur, 2025; Ma et al., 2024). For instance, research among potato farmers in Pakistan showed that marginalization by intermediaries significantly undermines their profitability and long-term sustainability, while greater value chain integration enables them to achieve more competitive cost structures (Horst & Watkins, 2022). These insights strongly resonate with tribal farming contexts, where farmers typically operate with limited assets, low bargaining power, and weak institutional support.

Cold storage and infrastructure availability remain persistent concerns in the literature. Studies focusing on Indian fruit and vegetable supply chains consistently identify inadequate cold chain facilities, fragmented logistics, and poor transportation as key constraints affecting farmers' income and market access (Sajankar et al., 2025). Even where infrastructure exists, limited awareness and poor accessibility reduce its effective utilization, particularly among farmers in remote and tribal regions (Utama et al., 2025).

From a methodological perspective, earlier studies have employed a mix of qualitative approaches, descriptive analysis, and advanced modeling techniques such as structural equation modelling (Anand et al., 2022; Jena et al., 2024; Lee et al., 2023; Raj, 2024; Sahu et al., 2024). While these approaches provide valuable insights, many studies rely either on macro-level data or mixed samples that do not adequately capture region-specific realities, especially those of tribal farmers (Dhivya et al., 2025; Tasnim et al., 2025). Moreover, the integration of perceptual variables with measurable marketing outcomes remains limited (Rao & Sharma, 2025).

Research Gap

A critical review of existing literature reveals several important gaps. First, most studies address supply chain challenges in a generalized agricultural context, with limited emphasis on tribal farmers and region-specific conditions. Second, while individual factors such as intermediaries, infrastructure, or technology adoption have been examined independently, there

is a lack of integrated empirical models that simultaneously assess their combined effect on vegetable marketing performance. Third, very few studies quantitatively examine farmers' perceptions using Likert-scale instruments and link these perceptions to measurable market outcomes through regression-based analysis. Finally, the mediating role of technology in strengthening the relationship between supply chain integration and marketing performance remains underexplored, particularly in tribal-dominated regions like Koraput district of Odisha. This study seeks to address these gaps by adopting a highly quantitative, perception-based approach to examine how multiple dimensions of supply chain integration influence vegetable marketing performance among tribal farmers.

3. Research Methodology

The present study adopts a structured and quantitative research methodology to empirically examine the impact of supply chain integration on vegetable marketing performance among tribal farmers in the Koraput district of Odisha. The methodological design is aligned with the objectives of the study and is suitable for testing relationships among multiple variables using statistical techniques. The approach emphasizes measurement, reliability, and analytical rigor, which are essential for producing evidence-based conclusions in applied agricultural and supply chain research.

Research Design

The study follows a descriptive and explanatory research design. The descriptive component helps in understanding the socio-economic profile of tribal farmers and their general perception regarding supply chain practices. The explanatory component is employed to establish cause-and-effect relationships between supply chain integration variables and vegetable marketing performance. This combination allows the study to move beyond surface-level observations and quantitatively assess how different dimensions of supply chain integration influence marketing outcomes.

Nature and Source of Data

The study relies primarily on primary data collected through a structured questionnaire. The questionnaire is designed using a five-point Likert-type scale ranging from 1 (Strongly Disagree) to 5 (Strongly Agree), which enables the measurement of farmers' perceptions in a standardized and quantifiable manner. Secondary data are used to support the conceptual framework and are sourced from academic journals, government reports, and published studies related to agricultural supply chains and vegetable marketing.

Study Area and Sampling

The geographical scope of the study is confined to the Koraput district of Odisha, a region characterized by a high concentration of tribal farmers and significant vegetable cultivation activity. A probability-based sampling technique, specifically stratified random sampling, is employed to ensure adequate representation across different blocks and farming communities within the district. This method helps reduce sampling bias and improves the generalizability of the findings within the study area. Based on population estimates of registered tribal vegetable farmers and using Slovin's formula at a 95 percent confidence level with a 5 percent margin of error, a minimum sample size was calculated. To enhance statistical power and allow for subgroup analysis, the final sample size was extended to 800 respondents.

Variables of the Study

The study is structured around one dependent variable and five independent variables, all measured using multiple Likert-scale statements.
The dependent variable of the study is:

- Vegetable Marketing Performance, which captures farmers' perceptions regarding price realization, market access, sales stability, reduction in distress sales, and overall profitability from vegetable cultivation.

The five independent variables are:

1. Perception of Supply Chain Practices, which reflects farmers' awareness and understanding of supply chain activities such as coordination, information flow, and market linkage.
2. Role of Intermediaries, which measures farmers' perceptions of the influence of middlemen on pricing, market access, and bargaining power.
3. Cold Storage and Infrastructure Availability, which assesses access to storage facilities, transportation, and post-harvest infrastructure.
4. Use of Supply Chain Management Tools, which includes practices related to logistics planning, collective marketing, and organized distribution mechanisms.
5. Technology Adoption, which captures the use of digital tools, mobile-based market information, and technology-enabled coordination in marketing activities.

Each construct is operationalized through multiple statements to ensure adequate coverage of the underlying concept.

Data Collection and Reliability

Data are collected through field surveys conducted among tribal farmers with the assistance of trained investigators, ensuring clarity and cultural appropriateness of questions. Prior to final analysis, the internal consistency of the questionnaire is assessed using Cronbach's Alpha. A reliability coefficient of 0.70 or above is considered acceptable, indicating satisfactory internal consistency of the measurement scale.

Statistical Tools and Techniques

The collected data are coded and analyzed using statistical software such as SPSS. Descriptive statistics, including mean and standard deviation, are used to summarize respondent characteristics and variable trends. Pearson correlation analysis is applied to examine the strength and direction of relationships among the variables. Multiple regression analysis is employed to assess the impact of the five independent variables on vegetable marketing performance and to test the proposed hypotheses. The level of significance is set at 5 percent for all inferential analyses.

4. Data Analysis and Interpretation

This section presents the empirical analysis of primary data collected from tribal vegetable farmers in the Koraput district to examine the influence of supply chain integration on vegetable marketing performance. The analysis is structured in a progressive manner, beginning with descriptive statistics to understand the central tendency and dispersion of the study variables, followed by correlation analysis to explore the strength and direction of relationships among them. Finally, multiple regression analysis is employed to assess the relative impact of the five independent variables on the dependent variable. The use of these statistical tools allows for a rigorous examination of farmers' perceptions and practices, while also ensuring that the findings are statistically reliable and interpretable within a quantitative research framework.

Table 1: Descriptive Statistics

Variables	Mean	Standard Deviation
Perception of Supply Chain Practices	3.62	0.71
Role of Intermediaries	3.18	0.83
Cold Storage and Infrastructure Availability	2.89	0.76
Use of Supply Chain Management Tools	3.41	0.69
Technology Adoption	3.27	0.74
Vegetable Marketing Performance	3.54	0.68

Source: Author's Compilation

The descriptive statistics indicate a moderate level of awareness and engagement with supply chain integration among tribal vegetable farmers in the Koraput district. The mean value for perception of supply chain practices is relatively high, suggesting that farmers possess a reasonable understanding of coordination, market linkage, and distribution-related activities. Vegetable marketing performance also records a favorable mean, implying that farmers perceive moderate improvement in price realization and market access. However, the comparatively lower mean score for cold storage and infrastructure availability reflects a clear structural constraint, indicating limited access to post-harvest facilities. The standard deviation values across variables remain within an acceptable range, showing consistency in responses and indicating that perceptions are uniform among respondents rather than highly polarized. This pattern highlights that while knowledge and basic practices are emerging, infrastructural gaps continue to restrict marketing efficiency.

Table 2: Correlation Analysis

Variables	SCP	ROI	CSI	SCMT	TA	VMP
Supply Chain Practices (SCP)	1					
Role of Intermediaries (ROI)	0.42**	1				
Cold Storage & Infrastructure (CSI)	0.38**	0.46**	1			
Supply Chain Management Tools (SCMT)	0.55**	0.41**	0.49**	1		
Technology Adoption (TA)	0.51**	0.36**	0.44**	0.58**	1	
Vegetable Marketing Performance (VMP)	0.63**	0.47**	0.52**	0.66**	0.61**	1

Source: Author's Compilation
Note: Correlation is significant at the 0.01 level (2-tailed).

The correlation matrix in the Table-2, reveals several meaningful relationships between supply chain integration variables and vegetable marketing performance. Vegetable marketing performance shows a strong and positive correlation with the use of supply chain management tools, indicating that farmers who actively engage in organized logistics, collective marketing, and structured distribution tend to experience better market outcomes. A similarly strong relationship is observed between marketing performance and perception of supply chain practices, suggesting that awareness and understanding of supply chain mechanisms translate into improved price realization and market participation.

Technology adoption also exhibits a high positive correlation with vegetable marketing performance. This implies that access to digital tools, mobile-based market information, and technology-enabled coordination supports better marketing decisions and reduces uncertainty. The positive association between cold storage and infrastructure availability and marketing performance further highlights the importance of post-harvest facilities in minimizing distress sales and improving sales timing.

The role of intermediaries shows a moderate positive correlation with marketing performance. This indicates that intermediaries are not inherently detrimental; rather, their influence depends on how effectively they facilitate market access and information flow. However, the relatively lower strength of this relationship compared to other variables suggests potential inefficiencies or power imbalances.

Inter-correlations among independent variables are positive and statistically significant but remain below critical multicollinearity thresholds. This suggests that while the variables are conceptually related, each captures a distinct dimension of supply chain integration. Overall, the correlation results justify the use of regression analysis to further examine the individual and combined impact of these variables on vegetable marketing performance.

Table 3: Multiple Regression Analysis

Independent Variables	Beta Coefficient (β)	t-value	Sig. (p-value)
Perception of Supply Chain Practices	0.241	6.12	0.000
Role of Intermediaries	0.118	3.04	0.002
Cold Storage & Infrastructure Availability	0.173	4.58	0.000
Use of Supply Chain Management Tools	0.286	7.21	0.000
Technology Adoption	0.227	5.89	0.000
R^2	0.62		
Adjusted R^2	0.61		
F-value	258.34		0.000

Source: Author's Compilation

The multiple regression analysis in the Table-3, explains a substantial proportion of variation in vegetable marketing performance among tribal farmers. The coefficient of determination (R^2 = 0.62) indicates that 62 percent of the changes in marketing performance are jointly explained by the five independent variables included in the model. After adjusting for the number of predictors, the adjusted R^2 remains high at 0.61, suggesting that the model does not suffer from overfitting and retains strong explanatory power. The overall model is statistically significant, as reflected by the F-statistic of 258.34 with a p-value of 0.000, confirming that the independent variables collectively exert a meaningful influence on the dependent variable.

Among the predictors, the **use of supply chain management tools** records the highest standardized beta coefficient (β = 0.286), making it the most influential variable in the model. This implies that a one-unit increase in the adoption of supply chain management tools leads to an average increase of 0.286 units in vegetable marketing performance, holding other variables constant. The corresponding t-value of 7.21 exceeds conventional critical thresholds,

and the p-value of 0.000 confirms strong statistical significance. This numerical dominance highlights the central role of organized logistics, collective marketing, and structured distribution mechanisms in improving farmers' market outcomes.

The **perception of supply chain practices** emerges as the second most influential variable, with a beta coefficient of 0.241. This indicates that improved awareness and understanding of supply chain coordination contribute to a 0.241 unit increase in marketing performance. The t-value of 6.12 and p-value of 0.000 demonstrate a highly significant relationship. In practical terms, farmers who better understand how supply chain's function are more capable of negotiating prices, choosing appropriate market channels, and timing their sales more effectively.

Technology adoption also shows a strong positive and statistically significant effect on marketing performance, with a beta value of 0.227. This means that for every unit increase in technology adoption, marketing performance improves by approximately 0.227 units. The t-value of 5.89 and p-value of 0.000 provide clear evidence that digital tools, market information systems, and communication technologies play a critical role in reducing information asymmetry and improving decision-making in vegetable marketing.

The coefficient for **cold storage and infrastructure availability** is positive and significant, with a beta value of 0.173. Although smaller in magnitude compared to awareness and technology, the effect remains economically meaningful. The t-value of 4.58 and p-value of 0.000 indicate that access to storage and transport infrastructure significantly enhances marketing performance by enabling farmers to avoid immediate post-harvest sales and reduce physical losses.

The **role of intermediaries** has the lowest beta coefficient ($\beta = 0.118$), though it remains statistically significant at the 1 percent level, with a t-value of 3.04 and p-value of 0.002. Numerically, this suggests that intermediaries contribute positively to marketing performance, but their influence is comparatively weaker. This result reflects the mixed role of intermediaries in tribal vegetable markets, where they facilitate market access but also limit farmers' price control.

Overall, the evidence from the analysis confirms that operational tools, awareness, and technology exert stronger effects on marketing performance than intermediary dependence alone. The regression results clearly support the argument that improving supply chain integration through farmer-centric mechanisms yields measurable and statistically significant gains in vegetable marketing performance.

5. Findings

The empirical analysis yields several clear and policy-relevant findings regarding supply chain integration and vegetable marketing among tribal farmers in the Koraput district. First, the study finds that the overall level of supply chain integration is moderate, with farmers showing reasonable awareness of supply chain practices but facing serious constraints in infrastructure and post-harvest facilities. Second, descriptive and correlational results indicate that vegetable marketing performance improves when farmers have better access to organized supply chain

mechanisms rather than relying solely on traditional channels. Third, the regression analysis confirms that the use of supply chain management tools is the most influential factor affecting marketing performance, followed closely by farmers' perception of supply chain practices and technology adoption. Fourth, cold storage and infrastructure availability significantly reduce distress sales and post-harvest losses, thereby enhancing price realization. Finally, intermediaries continue to play a role in facilitating market access, but their impact is relatively weaker compared to direct integration mechanisms. Overall, the findings suggest that farmer-centric, technology-enabled supply chain integration leads to measurable improvements in marketing efficiency and profitability for tribal vegetable farmers.

6. Suggestions

Based on the empirical findings, several practical suggestions emerge. First, government agencies and local institutions should prioritize the development of cold storage and basic post-harvest infrastructure in tribal regions to reduce distress sales. Second, targeted training programs are required to improve farmers' understanding of supply chain practices and market mechanisms, with a focus on practical application rather than theory. Third, promoting collective marketing and farmer producer organizations can strengthen the use of supply chain management tools and reduce excessive dependence on intermediaries. Fourth, technology adoption should be encouraged through affordable digital platforms, local language interfaces, and extension support. Finally, policy interventions must be region-specific, recognizing the socio-economic constraints faced by tribal farmers rather than applying uniform agricultural marketing models.

7. Conclusion

The present study provides empirical evidence on the role of supply chain integration in improving vegetable marketing performance among tribal farmers in the Koraput district of Odisha. Using a highly quantitative approach based on primary data and multivariate statistical analysis, the study demonstrates that marketing inefficiencies in tribal vegetable farming are not solely production-related but are deeply rooted in weak coordination, limited infrastructure, and inadequate access to modern supply chain mechanisms. The findings clearly indicate that farmers who engage with structured supply chain management tools, possess better awareness of supply chain practices, and adopt basic technologies achieve superior marketing outcomes in terms of price realization and market stability.

The study also highlights that while intermediaries continue to play a functional role in facilitating market access, their influence on marketing performance is relatively limited compared to direct integration mechanisms. This suggests a gradual shift from intermediary-driven marketing toward more farmer-centric and organized supply chain systems. Moreover, the significant role of cold storage and infrastructure underscores the importance of post-harvest investments in reducing losses and improving farmers' bargaining positions.

Overall, the study contributes to the existing literature by offering region-specific, data-driven insights from a tribal-dominated agricultural context. The conclusions emphasize that inclusive supply chain integration, supported by infrastructure development and technology adoption, can enhance marketing efficiency and income sustainability for marginalized farming communities. These insights hold important implications for policymakers and development practitioners aiming to design effective agricultural marketing interventions in tribal and rural regions.

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