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Exploring the impact of supply chain integration and agility on commodity supply chain performance

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Abstract

The aim of this research was to explore the influence of supply chain integration (SCI) on commodity supply chain performance (SCP) with the mediating role of supply chain agility (SCA). The research methodology employed a correlational approach using structural equation modeling. 131 employees from active companies in the agricultural commodity supply chain (SC) sector in Iran participated in the study. Analysis of the data was carried out utilizing Partial Least Squares Structural Equation Modeling (PLS-SEM) employing SMARTPLS software. The results indicate that customer integration (CI), supplier integration (SI), and internal integration have a positive and significant impact on SCA and commodity SCP. Additionally, the influence of SCA on commodity SCP is positive and significant. SCA plays a positive and significant mediating role in the impact of CI, SI, and internal integration on commodity SCP. Therefore, it can be concluded that companies that possess CI, SI, and internal integration in their commodity SC process demonstrate more satisfactory performance in the commodity SC.

Keywords: Supply Chain Integration; Supply Chain Agility; Commodity Supply Chain Performance; Customer Integration; Supplier Integration; Internal Integration

1. Introduction

Supply Chain (SC) can be conceptualized as a network of suppliers, producers, distributors, and warehouses that operate to deliver a product or service to end customers. These activities may involve sourcing raw materials, transforming raw materials into final products, transporting products to end customers, or any other relevant activity in this regard (Lambert & Cooper, 2000; Snyder and Shen, 2019). Therefore, the SC refers to a network encompassing entities, personnel, technologies, processes, data, and assets involved in the transfer of goods or services from suppliers to customers (Min et al., 2019). A commodity SC encompasses supply chain management (SCM) strategies overseeing the efficient and effective flow of goods, information, and financial transactions. This includes activities like procurement, storage, transportation, distribution, and delivery services, ensuring optimal handling of product types, quality, quantity, timing, and location. Given that a significant portion of developing and underdeveloped countries heavily rely on agricultural imports, rural commodity SCs in these countries are exposed to unusual risks (Jakfar & Halim, 2022; Dehghani and Larijani, 2023; Solaimanian et al., 2022).

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The proper functioning of the SC is a highly critical subject with various aspects and influenced by different factors. Supply chain performance (SCP) relates to the overall activities in fulfilling the end customers' needs, including aspects such as product accessibility, timely delivery, and all inventories and capacities within the chain that are responsive to customer demands (Zandi & Luhan, 2023; Zandi & Luhan, 2024). SCP extends beyond the boundaries of an organization or a company as it encompasses raw materials, components, intermediate products, and finished goods (Ka et al., 2019). Furthermore, this performance goes beyond traditional organizational functions such as procurement, manufacturing, distribution, sales and marketing, and research and development (Khorsandi and Khorsandi, 2022; Hashemian et al., 2024; Sanaei and Abbassi, 2022). Companies have recognized that they cannot enhance efficiency within their organization without focusing on improving SCP. Therefore, enhancing SCP enhances companies' competitive capabilities in the market (Tayur et al., 2012; Markus & Buijs, 2022). As a result of the importance of SCP for companies and organizations, especially in agricultural commodity supply chains (Wari et al., 2023; Risal et al., 2023), identifying the influential factors on the performance of agricultural commodity SCs is of great significance. Consequently, the present study examines the impact of supply chain integration (SCI) on the performance of commodity SCs with the mediating role of supply chain agility (SCA).

2. Literature Review

A crucial element contributing to a product's market success is the presence of a streamlined and productive SC. An essential measure of SC effectiveness is its integration, characterized by the efficient, systematic, and effective flow of goods and information (Peng et al., 2016; Hugos, 2011; Hanachi, 2017). If information reaches SC members slowly, with delays, or distorted, it leads to inconsistencies, increased inventory, reduced customer service levels, and other problems that ultimately result in dissatisfaction among the final customers of that SC (Sanaei, 2024; Kirchoff et al., 2016; Khanuja & Jain, 2020). SCM entails the integration of SC activities and the associated information exchanges to enhance relationships within the SC. This is aimed at gaining a competitive advantage that is both secure and enduring. Hence, SCM refers to the process of integrating SC activities and associated information flows by enhancing and coordinating operations within the SC for the manufacturing and delivery of products (Saragih et al., 2020). Consequently, companies emphasize the consolidation and integration of internal and external activities, drawing attention to SCM, as highlighted in the following definition: "The SC refers to all activities related to the flow of products and services and their transformation from raw material sources to end consumers, which also includes employee information within the production flow, and management refers to the integration and integration of such activities both inside and outside the company" (Ayers, 1999).

The objective of process integration within the SC is to eliminate obstacles and ensure a seamless flow of materials, resources, and information. Sharing information during integration minimizes ambiguity, enhances predictive capabilities, and aids in cost reduction efforts for companies (Liker & Choi, 2004). SCI emphasizes extensive collaboration with customers and suppliers to lower product development costs by involving key suppliers (Shashi et al., 2018). Research findings indicate that SCI significantly and positively influences SCA (Shukor et al., 2021) and overall company performance (Sadeghi et al., 2022; Uwamahoro, 2018; Liu et al., 2021).

On the other hand, survival in dynamic and fluctuating markets requires tools that can overcome environmental challenges, e.g., safe and efficient methods for outsourcing disposing or recycling of hospital waste (Sabeti Karajvandani et al. 2024; Paksaz et al, 2021; AmirKhani & Borhani, 2016; Esmaili et al., 2024), and agility is such a tool. The key factors for success in agile SCs include the utilization of information technology, process integration, appropriate planning, development of employee skills, market sensitivity and responsiveness, introduction of new products, flexibility, delivery speed, cost reduction, product quality, and customer satisfaction (Zohoor and Eslami, 2021; Karabulut et al., 2022). Patel & Sambasivan, 2022). To gain a competitive advantage in a variable business environment, companies need to align their operations with suppliers and customers and collaborate with each other to achieve an acceptable level of agility (Mehregan et al., 2023; Aslam et al., 2020; Shoeibi & Baghbadorani, 2023). Additionally, companies should focus on knowledge transfer (Azimi Asmaroud, 2022) to ensure that new insights and expertise are shared effectively among partners and stakeholders to enhance overall agility and competitiveness. Consequently, agile SCs have been prominent competitive initiatives and aim to give importance to customers and employees. Therefore, an agile SC is capable of responding appropriately to changes in the work environment. SCA refers to the quick response to short-term changes in the SC; in fact, agility means that the SC can quickly adapt to changes and provide an appropriate response (Al Humdan et al., 2020). An agile SC demonstrates responsiveness to changes, uncertainties, and unpredictabilities in its business environment, adapting with suitable responses. Consequently, an agile SC necessitates a range of specific capabilities or competencies (Du et al., 2021). Sharp et al. (1999) and Christopher (1998) classified these capabilities into four groups: 1) Responsiveness, the ability to detect changes and quickly, responsively, and actively respond to them, using changes to improve and expand; 2) Competence, the ability to effectively achieve organizational goals; 3) Flexibility/Adaptability, the ability to employ processes and facilities to achieve similar goals; 4) Speed, the ability to complete an activity at maximum speed possible. Thus, an agile SC is able to respond appropriately to changes in its work environment. Research results have also shown that SCA has a significant positive impact on company performance (Nazempour et al., 2020; Manzoor et al., 2021; Zhu & Gao, 2021).

In general, as emphasized in the theoretical literature, the role of SCI and SCA on commodity SCP has been highlighted. However, empirical background reviews indicate that few studies have presented a model for the impact of SCI on commodity SCP with the mediating role of SCA. Therefore, the main issue of the present research is to provide a model for the impact of SCI on commodity SCP with the mediating role of SCA. Drawing upon theoretical literature and the research context, a conceptual research model is presented in Figure 1.

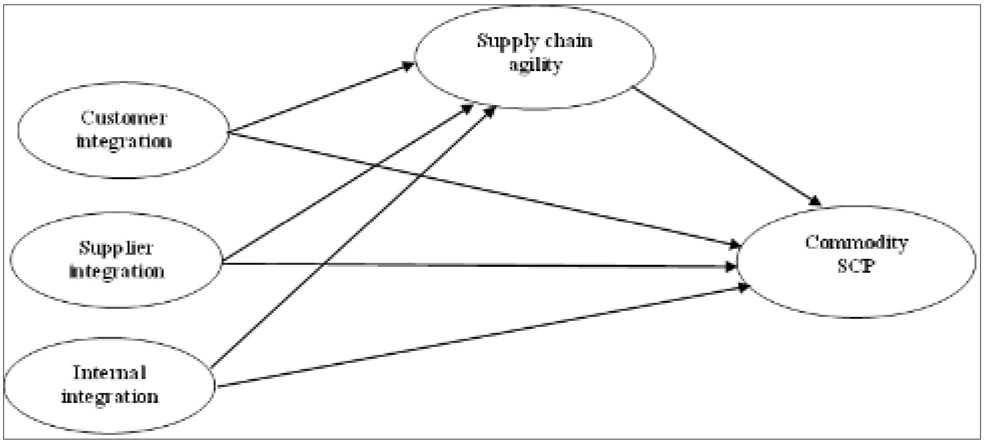

Figure 1 The conceptual model

3. Research Methodology

3.1. Sampling

The target population of the research consisted of employees of active companies in the agricultural Commodity SC sector in Iran. Questionnaires were sent to 164 employees of these companies after a telephone call and request for participation, of which 131 questionnaires (79.88%) were returned after completion.

3.2. Measures

To measure SCI, the questionnaire developed by Flynn et al. (2010) was utilized. This questionnaire comprises 15 items, measuring customer integration (CI), supplier integration (SI), and internal integration with 5 items each. SCA was measured using the questionnaire developed by Shukor et al. (2021), which was based on the questionnaires developed by Swafford et al. (2006) and Betts and Tadisina (2009) and consists of 8 items. For measuring SCP, the questionnaire developed by Qrunfleh & Tarafdar (2014) was employed, which includes 10 items. Items were measured on a five-point Likert scale ranging from strongly disagree (1) to strongly agree (5).

4. Results

4.1. Measurement Testing

To evaluate reliability, Cronbach's alpha coefficient and composite reliability were compared. For validity assessment, factor loadings, means, and variances were analyzed using the Fornell-Larcker criterion. Hair et al. (2006)'s composite reliability (CR) index surpasses Cronbach's alpha due to its factor-weighted computation, offering more accurate results. Factor loadings above 0.60 indicate a well-defined structure in confirmatory factor analysis. Average Variance Extracted (AVE) confirms convergent validity, with values recommended to be 0.50 or higher. Ensuring factor loadings above 0.60 is vital; otherwise, items should be revised or removed. This approach demonstrates the reliability and validity of the research constructs effectively (Table 1).

To assess convergent validity, the study used the Fornell-Larcker criterion, which requires a construct's AVE to surpass its correlations with other constructs. This ensures the construct's indicators have higher correlations within the construct than with other constructs. Table 2 displays the findings on correlations and AVE for validation purposes.

Table 1 Reliability of Constructs

Variable	Item	Factor Loading	Cronbach's alpha	Composite Reliability	AVE
CI	1	0.767	0.817	0.871	0.576
	2	0.764			
	3	0.806			
	4	0.705			
	5	0.749			
SI	1	0.904	0.866	0.904	0.656
	2	0.646			
	3	0.853			
	4	0.801			
	5	0.822			
Internal integration	1	0.687	0.762	0.839	0.512
	2	0.643			
	3	0.803			
	4	0.737			
	5	0.697			
SCA	1	0.718	0.872	0.899	0.526
	2	0.783			
	3	0.795			
	4	0.693			
	5	0.07			
	6	0.671			
	7	0.07			
	8	0.735			
Commodity SCP	1	0.904	0.922	0.935	0.593
	2	0.842			
	3	0.72			
	4	0.669			
	5	0.635			
	6	0.777			
	7	0.757			
	8	0.824			
	9	0.831			
	10	0.07			

Table 2 Correlations and AVE of Constructs

Variables	Commodity SCP	CI	Internal integration	SI	SCA
Commodity SCP	0.770				
CI	0.588	0.759			

Internal integration	0.663	0.691	0.715		
SI	0.635	0.653	0.671	0.809	
SCA	0.571	0.600	0.661	0.658	0.725

4.2. Structural Analysis

A conceptual model was used to predict commodity SCP through SEM with PLS estimation (Kamranfar et al., 2023; Toosi & Ahmadi, 2023). The PLS method estimated the model based on research hypotheses, while bootstrapping with 300 subsamples calculated t-statistic values for path coefficient significance. The tested model in Figure 2 revealed positive impacts of CI, SI, internal integration on SCA and performance. SCA positively influenced commodity SCP, as indicated by the explained variances within the circles.

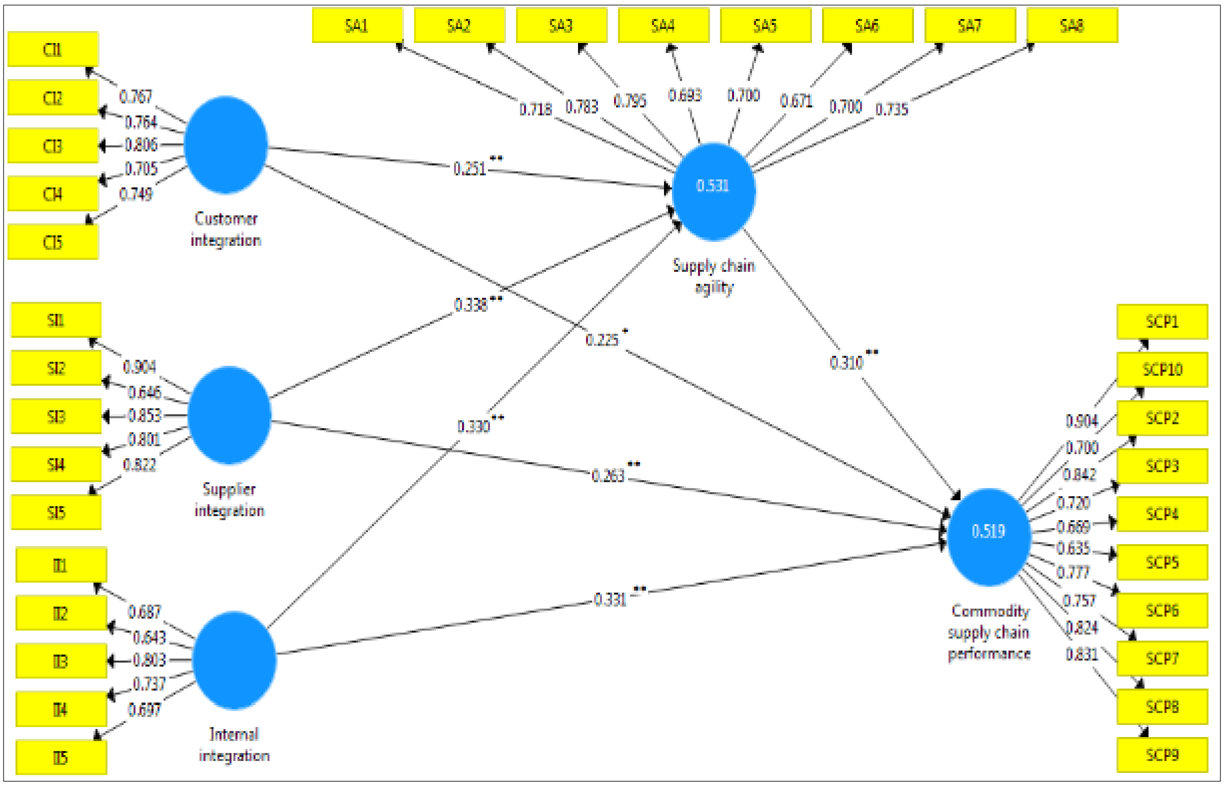

Figure 2 The tested Model

Table 3 presents path coefficients and variances for research variables. It shows that customer, supplier, and internal integration positively impact SCA and commodity SCP. SCA also positively affects commodity SCP. Moreover, 52% of the variance in commodity SCP and 53% in SCA are explained by the research variables. Indirect coefficients are shown in Table 4.

Table 3 Path coefficients

Variables	□□	t-value	P value	Variance explained
On commodity SCP via:				
SCA	0.310**	3.218	0.01	
CI	0.225*	2.547	0.05	0.519
SI	0.263**	2.794	0.01	

Internal integration	0.331**	3.613	0.01	
On SCA via: CI SI Internal integration	 0.251** 0.338** 0.330**	 2.986 4.698 3.897	 0.01 0.01 0.01	0.531

Table 4 indicates that SCA significantly mediates the positive impact of CI, SI, and internal integration on commodity SCP. The Goodness of Fit (GOF) index for the tested model was 0.55, suggesting an appropriate fit. Values exceeding 0.36 signify acceptable model quality.

Table 4 Indirect Paths

Paths	Indirect Effects	T Statistics	P Values
CI -> SCA -> Commodity SCP	0.078	2.189	0.05
Internal integration -> SCA -> Commodity SCP	0.105	2.481	0.05
SI -> SCA -> Commodity SCP	0.102	2.654	0.01

5. Conclusion

The research aimed to propose a model assessing the impact of SCI on commodity SCP, mediated by SCA, via structural equation modeling. Findings reveal that the model fits the data well, explaining 52% of the variance in commodity SCP and 53% in SCA. Results show that CI significantly boosts both SCA and commodity SCP. This suggests that effective engagement with key customers through technology, innovative order processing, market information sharing, and efficient communication leads to improved SCA and enhances commodity SCP.

Another important finding is that internal integration positively influences both SCA and commodity SCP. Thus, enhancing internal integration leads to improved SCA and subsequently enhances commodity SCP. This indicates that when a company effectively coordinates teams, synchronizes functions across departments, and timely shares information within the organization, it enhances SCA and improves commodity SCP.

Another discovery from the study is that SI positively affects both SCA and commodity SCP. Effective SI enhances SCA and thereby improves commodity SCP. This underscores the importance of satisfactory information exchange, quick ordering processes, strategic collaboration, sustainable procurement, and involving suppliers in procurement and production to enhance SCA and commodity SCP.

Another significant finding is that SCA significantly affects commodity SCP. Thus, improving SCA leads to enhanced commodity SCP. This implies that reducing manufacturing and product development times, increasing new product introductions, enhancing customization, adjusting global delivery capabilities, improving customer service, delivery reliability, and responsiveness to market needs can all contribute to better commodity SCP.

Overall, the study reveals that both SCI and agility positively impact commodity SCP. SCA acts as a mediator in the relationship between SCI and commodity SCP, indicating that enhancing agility enhances the effects of integration. Companies with integrated customer, supplier, and internal processes tend to perform better. However, findings are limited to self-reported data from Iranian agricultural commodity SC companies, suggesting caution in generalization. Future research could benefit from qualitative analysis (Borhani et al., 2022; Ghorashi et al., 2015; Ghorashi et al., 2018) and mixed-method approaches (Song et al., 2022), data mining, different types of machine learning techniques (Aghamohammadghasem et al., 2023; Dehghani and Larijani, 2023; Dutta et al., 2022; Momeni et al,, 2023; Vahdatpour & Zhang, 2024; Nematirad et al., 2023; Schwarz and Horestani, 2025; Horestani & Schwarz, 2024; Kiaghadi & Hoseinpour, 2023; Emami & Kabir, 2023), and deep learning (Talebzadeh et al., 2024) to further explore factors affecting commodity supply chain performance, surpassing the limitations of traditional linear techniques such as SEM and multiple regression.

Compliance with ethical standards

Disclosure of conflict of interest

No conflict of interest to be disclosed.

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