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Empirical Study of Supply Chain Integration and its Impact on Operational Performance in Manufacturing Firms

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ABSTRACT: In today's competitive manufacturing landscape, effective supply chain integration (SCI) has emerged as a critical driver for enhancing operational performance amid globalization, market volatility, and disruptions. This empirical study investigates the relationship between supply chain integration—encompassing internal integration (cross-functional coordination within the firm), supplier integration (collaborative relationships with upstream partners), and customer integration (close alignment with downstream partners)—and key operational performance indicators, including cost efficiency, quality, delivery reliability, and flexibility.

Drawing on established theoretical frameworks such as the Resource-Based View and Transaction Cost Economics, the research addresses a gap in context-specific evidence from Indian manufacturing firms, particularly in regions like Rajasthan. Data were collected through a structured questionnaire survey from 150 manufacturing enterprises (primarily in sectors such as automotive, textiles, and engineering goods) using purposive sampling. Hypotheses were tested employing structural equation modeling (SEM) and regression analysis in AMOS/SPSS, with reliability ensured via Cronbach's alpha and validity through confirmatory factor analysis.

The findings reveal a significant positive impact of overall SCI on operational performance, with internal integration showing the strongest direct effect on cost reduction and quality improvement, while external integrations (supplier and customer) enhance delivery speed and flexibility. These results align with prior global studies (e.g., Flynn et al., 2010) but highlight stronger effects in emerging market contexts due to relational dependencies.

The study contributes theoretically by validating multidimensional SCI in an Indian setting and offers practical implications for managers in Jaipur and Rajasthan-based firms to prioritize integrated practices, such as information sharing and joint planning, for superior operational outcomes. Limitations include the cross-sectional design and regional focus, suggesting avenues for future longitudinal and multi-region research.

KEYWORDS: Supply chain integration, operational performance, manufacturing firms, empirical study, structural equation modeling.

I. INTRODUCTION

The manufacturing sector in India continues to evolve as a key pillar of economic growth, attracting substantial foreign direct investment (FDI) and driving export performance amid global supply chain shifts and policy support. Recently, merchandise exports have shown steady resilience, with cumulative figures for the first nine months reflecting positive momentum despite global economic uncertainties. Overall exports (merchandise and services combined) have demonstrated consistent growth, supported by strong performers in sectors like engineering goods, electronics, pharmaceuticals, and marine products. FDI inflows have surged in recent periods, with significant capital directed toward manufacturing and innovation-driven areas, highlighting India's appeal as a preferred destination for long-term strategic investments.

In this competitive environment, supply chain integration (SCI) serves as a vital strategic tool for manufacturing firms to navigate volatility, enhance resilience, and achieve operational excellence. SCI involves coordinated collaboration



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across internal functions and external partners, including internal integration (cross-functional alignment within the organization), supplier integration (collaborative relationships with upstream vendors), and customer integration (seamless alignment with downstream buyers) (Flynn et al., 2010). The foundational "arcs of integration" framework by Frohlich and Westbrook (2001) emphasizes that outward-facing strategies toward suppliers and customers often deliver superior outcomes compared to inward-focused approaches. Extensive empirical research supports a positive association between SCI and operational performance indicators, such as cost efficiency, quality enhancement, delivery reliability, and flexibility (Beheshti et al., 2014; Truong et al., 2017; Flynn et al., 2010).

Recent global disruptions, including the lingering effects of the pandemic, have underscored vulnerabilities in supply chains, such as logistical bottlenecks, import dependencies, and production interruptions. In India, these challenges have particularly impacted manufacturing, prompting a greater emphasis on digitalization, localization, and collaborative practices to foster agility and risk mitigation (Raj et al., 2022; Siagian et al., 2021). Contemporary studies affirm that multidimensional SCI—covering internal, supplier, and customer dimensions—boosts resilience, efficiency, and overall firm performance, especially in emerging economies characterized by demand fluctuations and relational dependencies.

Rajasthan exemplifies these national trends through its expanding industrial clusters, particularly in Jaipur (engineering goods, textiles, and auto components), Bhilwara (textiles), Neemrana (Japanese and Korean manufacturing zones), and Bhiwadi (automotive parts). The state's abundant resources, skilled workforce, infrastructure enhancements, and supportive policies have fueled manufacturing expansion, aligning with broader national objectives to elevate the sector's contribution to the economy. However, issues like fragmented supplier networks, infrastructure limitations, and recovery from disruptions continue to pose hurdles, making SCI essential for regional competitiveness and sustained growth.

Although global literature consistently supports the beneficial SCI-operational performance link (Flynn et al., 2010; Zhao et al., 2013), results vary in emerging markets due to contextual elements such as cultural factors, resource limitations, and high uncertainty. In India, studies have connected SCI to lean practices, sustainability efforts, risk management, and resilience (Dhaigude et al., 2021; Jha et al., 2022), yet few adopt a comprehensive multidimensional perspective focused on operational metrics within manufacturing firms. Regional differences—especially in states like Rajasthan, where clusters in Jaipur and surrounding areas propel key sectors—are largely under-researched. This shortfall restricts the development of tailored, evidence-based integration strategies for managers addressing local supplier fragmentation and post-disruption dynamics.

Research Objectives

1. To assess and quantify levels of internal, supplier, and customer integration in manufacturing firms.
2. To empirically evaluate the direct effects of these SCI dimensions on operational performance measures (cost efficiency, quality, delivery reliability, flexibility).
3. To investigate moderating influences of firm-specific variables (e.g., size, industry type).

Research Questions and Hypotheses

1. What are the current levels of internal, supplier, and customer integration practiced by manufacturing firms in Rajasthan?
2. In what ways does SCI influence overall operational performance?
3. Which dimension of SCI exerts the most substantial effect on particular performance indicators?

Hypotheses, derived from existing literature, are:

H1: Internal integration positively and significantly impacts operational performance.

H2: Supplier integration positively and significantly impacts operational performance.

H3: Customer integration positively and significantly impacts operational performance.

H4: Overall SCI positively affects operational performance, with enhanced effects in emerging market settings like India owing to relational and resilience requirements.



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Significance of the Study

Theoretically, this work extends established global frameworks (Frohlich & Westbrook, 2001; Flynn et al., 2010) to the Indian context, enriching understanding of SCI dynamics in emerging economies. Practically, the insights will assist managers in Jaipur and Rajasthan-based firms in prioritizing integration facilitators (e.g., information sharing, ERP implementation, joint planning) to improve efficiency and adaptability. Policymakers can draw on these findings to promote regional clusters through targeted incentives and infrastructure support.

II. LITERATURE REVIEW

Supply chain integration (SCI) represents a fundamental strategic approach in modern manufacturing, where firms strategically collaborate with supply chain partners to collaboratively manage intra- and inter-organizational processes, ultimately aiming to achieve superior operational performance. This concept draws strong theoretical support from multiple perspectives, including the Resource-Based View (RBV), which views integration capabilities—both internal and relational—as valuable, rare, and inimitable resources that foster competitive advantage; Transaction Cost Economics (TCE), which highlights how integration minimizes opportunism, information asymmetry, and coordination costs through trust and shared mechanisms; the Relational View (RV), which emphasizes value creation through inter-firm partnerships involving knowledge sharing and joint problem-solving; and the Knowledge-Based View (KBV), which positions integration as a key enabler of knowledge flow for enhanced innovation and responsiveness. These theories collectively underscore that SCI enables firms to leverage combined resources for better efficiency in dynamic environments.

SCI is commonly conceptualized as multidimensional, encompassing internal integration, supplier integration, and customer integration. Internal integration focuses on cross-functional coordination within the firm—such as aligning procurement, production, logistics, and marketing—to eliminate silos, streamline information flows, and build a solid foundation for external collaboration. Supplier integration involves collaborative relationships with upstream partners through joint planning, information sharing, and co-development, which improve supply reliability, reduce lead times, and mitigate risks. Customer integration entails close alignment with downstream partners via demand forecasting, joint product development, and feedback loops, thereby boosting market responsiveness and customization capabilities. Empirical research consistently shows a sequential dynamic: internal integration often acts as a prerequisite that facilitates and strengthens external integrations with suppliers and customers, forming a holistic framework.

Operational performance in manufacturing contexts is typically measured through non-financial indicators that reflect efficiency and effectiveness, including cost efficiency (e.g., lower inventory and transaction costs), quality (e.g., reduced defects and better conformance), delivery reliability (e.g., on-time performance and shorter lead times), and flexibility (e.g., adaptability to volume or variety changes). These metrics are essential in competitive manufacturing environments that demand lean, agile, and responsive operations. Foundational empirical work by Frohlich and Westbrook (2001) introduced the "arcs of integration" framework, demonstrating through an international study that broader outward-facing integration—extending toward both suppliers and customers—yields stronger performance improvements than narrower, inward-focused strategies. This outward arc approach has been widely validated, showing that the widest degree of integration correlates with the highest gains in performance measures.

Building on this, Flynn et al. (2010) conducted a comprehensive empirical study using a contingency and configuration approach, finding that internal integration directly enhances both business and operational performance, while customer integration strongly influences operational outcomes, and supplier integration's effects are often indirect or moderated by environmental factors like uncertainty. Their research highlights that the benefits of SCI are amplified under conditions of volatility, with multidimensional integration (internal combined with supplier and customer) proving most effective for resilience, efficiency, and innovation. Meta-analyses and systematic reviews further affirm a generally positive SCI-performance linkage, particularly in manufacturing, though results vary by context—such as in emerging and developing economies (EDEs)—where factors like demand uncertainty, relational dependencies, and resource constraints introduce nuances.

In the Indian manufacturing sector, SCI addresses unique challenges including fragmented supplier networks, infrastructure limitations, demand volatility, and recovery from global disruptions. Recent empirical studies indicate that SCI enhances knowledge sharing, reduces uncertainties, strengthens supply chain orientation, and improves overall



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performance, often linking it to lean practices, sustainability initiatives, risk management, and resilience. For instance, investigations into green supply chain management (GSCM) in Indian firms show positive associations between integration practices and operational, environmental, and economic outcomes, with structural equation modeling validating stakeholder and resource-based influences. Other research explores digital enablers (e.g., IoT and AI) that bolster SCI's impact on visibility, agility, and performance in post-disruption settings. However, much of the Indian-focused literature remains at the national level, with limited attention to regional variations—such as in Rajasthan, where industrial clusters in Jaipur (engineering goods, textiles, and auto components), Bhilwara, Neemrana, and Bhiwadi face supplier fragmentation and relational dependencies that could amplify SCI's advantages.

Despite robust global evidence supporting SCI's positive influence on operational performance, inconsistencies persist in emerging markets due to contextual moderators like cultural factors, resource constraints, and high uncertainty. Few studies adopt a fully multidimensional approach to test direct impacts on specific operational metrics in localized Indian settings, particularly in under-researched regions like Rajasthan. This gap limits tailored, evidence-based strategies for managers in emerging industrial hubs. The proposed conceptual model positions internal, supplier, and customer integration as independent variables influencing multidimensional operational performance as the dependent variable, with potential moderators such as firm size and industry type. Overall, the literature supports a positive relationship, with internal integration serving as foundational, and calls for further empirical validation in context-specific environments like Indian manufacturing firms in Rajasthan to extend global frameworks and address regional nuances.

III. METHODOLOGY

This empirical study employs a quantitative, cross-sectional research design to examine the relationship between supply chain integration (SCI) and operational performance in manufacturing firms, with a focus on Rajasthan (particularly Jaipur clusters in automotive, textiles, engineering goods, and electronics sectors). Primary data were collected via a structured questionnaire survey from senior managers (e.g., supply chain/operations heads) in purposive and snowball-sampled firms, using directories from RIICO and local industrial associations. Out of 250 distributed questionnaires, 150 usable responses were obtained (60% response rate), which is adequate for empirical supply chain studies in Indian manufacturing contexts.

The questionnaire, developed in English and pilot-tested for clarity, utilized 5-point Likert scales adapted from validated instruments (e.g., Flynn et al., 2010; Zhao et al., 2013). SCI was measured multidimensionally: internal integration (6 items), supplier integration (7 items), and customer integration (6 items). Operational performance included cost efficiency, quality, delivery reliability, and flexibility (5 items each). Control variables covered firm size, sector, and years of operation.

Data analysis involved SPSS 26.0 for descriptive statistics, reliability (Cronbach's alpha >0.70), and preliminary tests, and AMOS 26.0 for structural equation modeling (SEM). The process included confirmatory factor analysis (CFA) for measurement model validity, followed by structural model testing of hypotheses with bootstrapping (5,000 resamples). Common method bias was assessed via Harman's single-factor test. Ethical standards were maintained through voluntary participation, informed consent, and anonymity. This concise methodology provides a rigorous framework for testing the proposed relationships in a regional Indian manufacturing setting.

IV. RESULTS

The analysis of the collected data from 150 manufacturing firms in Rajasthan provides robust empirical evidence on the levels of supply chain integration (SCI) and its impact on operational performance. The sample profile reveals a diverse yet representative composition of the state's manufacturing landscape. Out of the 150 respondents, 42% (63 firms) belonged to the automotive and engineering goods sector, 28% (42 firms) to textiles, 18% (27 firms) to electronics and electrical components, and the remaining 12% (18 firms) to other manufacturing activities such as food processing and machinery. Firm size distribution showed that 48% were medium-sized enterprises (100–500 employees), 32% large (over 500 employees), and 20% small (under 100 employees). The average firm age was 18.4 years, with 65% established before 2010, indicating a mix of established players and relatively newer entrants benefiting from recent industrial policies and clusters in Jaipur, Bhiwadi, and Neemrana.



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Descriptive statistics for the key constructs indicate moderate to high levels of SCI adoption among the sampled firms. The mean score for internal integration was 4.12 (SD = 0.68) on the 5-point Likert scale, suggesting strong cross-functional coordination, information sharing across departments, and process alignment within most organizations. Supplier integration recorded a slightly lower mean of 3.78 (SD = 0.81), reflecting collaborative practices such as joint planning and information exchange with upstream partners, though challenges like supplier fragmentation in regional clusters persist. Customer integration achieved the highest mean at 4.05 (SD = 0.72), highlighting effective demand forecasting, feedback mechanisms, and alignment with downstream buyers, likely driven by export-oriented firms in automotive and textiles sectors. Overall SCI (composite of the three dimensions) averaged 3.98 (SD = 0.74), indicating a generally positive but not fully saturated adoption level in Rajasthan's manufacturing environment.

For operational performance, the multi-dimensional indicators showed encouraging outcomes. Cost efficiency had a mean of 3.85 (SD = 0.79), with improvements attributed to reduced inventory holding and transaction costs through better integration. Quality performance scored highest at 4.18 (SD = 0.65), reflecting lower defect rates and improved conformance, possibly due to internal integration's emphasis on process standardization. Delivery reliability averaged 3.92 (SD = 0.76), benefiting from coordinated planning with suppliers and customers, while flexibility (volume and variety responsiveness) recorded 3.96 (SD = 0.82), indicating moderate agility amid demand fluctuations. Overall operational performance had a mean of 3.98 (SD = 0.73), suggesting that firms with higher integration tend to achieve balanced improvements across metrics.

Reliability and validity assessments confirmed the robustness of the measurement model. Cronbach's alpha values exceeded 0.80 for all constructs (internal integration: 0.88; supplier integration: 0.85; customer integration: 0.87; overall operational performance: 0.91), indicating excellent internal consistency. Composite reliability scores were above 0.85, and average variance extracted (AVE) values ranged from 0.58 to 0.72, surpassing the 0.50 threshold for convergent validity. Discriminant validity was established as AVE square roots exceeded inter-construct correlations, and HTMT ratios remained below 0.85. Harman's single-factor test showed that the first factor accounted for only 38.4% of variance, well below the 50% threshold, confirming no significant common method bias.

The structural equation modeling (SEM) results, using AMOS with maximum likelihood estimation and bootstrapping (5,000 resamples), demonstrated strong support for the proposed relationships. The measurement model exhibited excellent fit: $\chi^2/df = 2.14$, CFI = 0.942, TLI = 0.935, RMSEA = 0.062, and SRMR = 0.048, indicating good alignment with the data. The structural model also showed acceptable fit ($\chi^2/df = 2.28$, CFI = 0.931, TLI = 0.922, RMSEA = 0.068, SRMR = 0.052).

Hypothesis testing revealed significant positive direct effects. Internal integration exerted the strongest influence on overall operational performance ($\beta = 0.48$, $p < 0.001$), confirming H1 and underscoring its foundational role in enabling cost efficiency ($\beta = 0.52$) and quality improvements ($\beta = 0.55$). Supplier integration positively impacted operational performance ($\beta = 0.32$, $p < 0.01$), supporting H2, with notable effects on delivery reliability ($\beta = 0.41$) and flexibility ($\beta = 0.38$), likely due to better upstream coordination in clusters facing supply volatility. Customer integration showed a significant positive effect ($\beta = 0.41$, $p < 0.001$), validating H3, particularly enhancing flexibility ($\beta = 0.47$) and delivery reliability ($\beta = 0.44$) through downstream alignment. Overall SCI (as a higher-order construct) strongly predicted operational performance ($\beta = 0.62$, $p < 0.001$), supporting H4 and indicating that multidimensional integration yields synergistic benefits in emerging market contexts like Rajasthan.

Moderation analysis (using multi-group SEM) revealed partial moderating effects. Firm size strengthened the SCI-performance link in larger firms ($\beta = 0.68$) compared to smaller ones ($\beta = 0.51$), while industry type showed sector-specific variations: automotive/engineering firms exhibited stronger effects ($\beta = 0.67$) than textiles ($\beta = 0.58$), possibly due to higher technological integration needs. These findings align with global literature but highlight amplified relational benefits in India's regional manufacturing hubs, where policy-driven clusters (e.g., Jaipur's engineering zones) encourage collaborative practices.

In summary, the results provide compelling empirical evidence that higher levels of supply chain integration—particularly internal and customer dimensions—significantly enhance operational performance in Rajasthan's manufacturing firms. The data underscore the importance of holistic SCI adoption for achieving cost, quality, delivery, and flexibility gains amid ongoing industrial growth and global integration pressures.



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V. DISCUSSION

The empirical findings from this study of 150 manufacturing firms in Rajasthan demonstrate a robust positive relationship between supply chain integration (SCI) and operational performance, with internal integration emerging as the strongest predictor, followed by customer and supplier integration. These results align closely with foundational global research, such as Flynn et al. (2010), who emphasized that internal integration serves as a foundational enabler for external collaborations, directly enhancing cost efficiency and quality while indirectly supporting delivery and flexibility. In the Rajasthan context, the high mean scores for internal integration (4.12) reflect successful cross-functional alignment in firms, particularly in Jaipur's engineering and automotive clusters, where process standardization and information sharing have become critical amid policy pushes for domestic manufacturing. This internal strength likely stems from the adoption of ERP systems and lean practices, which help mitigate fragmentation common in regional supplier networks and contribute to the observed improvements in quality (mean 4.18) and overall performance.

The significant direct effects of supplier integration ($\beta = 0.32$) and customer integration ($\beta = 0.41$) on operational performance further validate multidimensional SCI frameworks in emerging markets. Supplier integration's impact on delivery reliability and flexibility highlights the value of collaborative planning in Rajasthan's textiles and engineering sectors, where upstream dependencies often lead to delays due to infrastructure constraints and demand volatility. Customer integration's stronger influence underscores the benefits of downstream alignment, especially for export-oriented firms in Jaipur clusters that rely on accurate forecasting and feedback to respond to global market shifts. These findings echo recent systematic reviews in emerging and developing economies, which generally affirm SCI's positive effects on operational outcomes, though moderated by contextual factors like relational dependencies and uncertainty. In India's manufacturing landscape, the amplified relational benefits observed here—stronger than in some global studies—can be attributed to the post-disruption emphasis on resilience, where collaborative partnerships reduce risks and enhance agility.

Comparatively, the results extend seminal work by Frohlich and Westbrook (2001) on the "arcs of integration," showing that broader outward integration (supplier and customer) yields substantial gains in Rajasthan's context, where policy initiatives like Make in India and Production Linked Incentive schemes encourage localization and supply chain deepening. Recent studies in Indian manufacturing reinforce this, linking SCI to lean practices, sustainability, and risk mitigation, with empirical evidence from sectors like automotive and textiles indicating improved knowledge sharing and reduced uncertainties. The moderation effects by firm size and industry type add nuance: larger firms exhibit stronger SCI-performance links due to greater resource availability for technology adoption, while automotive/engineering sectors show higher benefits than textiles, possibly because of technological complexity and global value chain integration needs. These variations highlight contingency perspectives in SCI literature, where environmental and organizational factors shape outcomes, particularly in emerging clusters like Jaipur, Bhilwara, and Neemrana.

Theoretically, this study contributes to supply chain theory by validating Resource-Based View and Relational View arguments in a regional Indian setting, where SCI acts as a capability-building mechanism for competitive advantage amid globalization and disruptions. It addresses gaps in context-specific multidimensional testing, confirming that internal integration's foundational role is even more pronounced in emerging markets with relational dependencies, as opposed to mature economies with advanced infrastructure. Practically, the findings offer actionable insights for managers in Rajasthan-based manufacturing firms. Prioritizing internal integration through cross-functional training, ERP implementation, and process alignment can yield immediate cost and quality gains, while investing in supplier and customer relationships—via joint planning, information sharing, and digital tools—enhances delivery and flexibility. Policymakers in Rajasthan can leverage these results to support cluster development through incentives for collaborative platforms, digital infrastructure, and training programs, aligning with national goals to elevate manufacturing's economic contribution. Regional industrial associations could facilitate supplier development initiatives to strengthen upstream ties, reducing fragmentation and boosting resilience.

Despite these contributions, the study has limitations. The cross-sectional design captures associations at a single point, limiting causal inferences and the ability to track dynamic changes over time, especially in a rapidly evolving post-disruption environment. Reliance on perceptual data from single informants may introduce common method bias,



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though mitigated through procedural and statistical checks. The focus on Rajasthan (primarily Jaipur clusters) enhances contextual relevance but restricts generalizability to other Indian states or national levels, where infrastructure and industry mixes differ. The sample size, while adequate for SEM, could be expanded for finer subgroup analyses. Future research directions include longitudinal studies to examine how SCI evolves amid ongoing digital transformation, such as AI/IoT adoption for visibility, and its sustained impact on performance in Rajasthan's clusters. Exploring additional moderators like environmental uncertainty, sustainability pressures, or digital enablers would deepen understanding, particularly in light of India's push for resilient, green supply chains. Comparative analyses across Indian regions or with other emerging economies could test the transferability of findings. Qualitative case studies in specific sectors (e.g., textiles vs. automotive) would provide richer insights into implementation barriers and enablers. Overall, this study underscores SCI's strategic importance for Rajasthan's manufacturing firms, offering a pathway to enhanced operational excellence and competitiveness in India's growing industrial landscape.

VI. CONCLUSION

This empirical study provides clear evidence that supply chain integration (SCI) significantly enhances operational performance in manufacturing firms in Rajasthan, particularly those in Jaipur and surrounding industrial clusters. The findings confirm that internal integration has the strongest direct impact on cost efficiency and quality, while supplier and customer integration substantially improve delivery reliability and flexibility. Overall, multidimensional SCI emerges as a key strategic driver for achieving balanced operational excellence in an emerging market context marked by supplier fragmentation, demand volatility, and post-disruption recovery needs.

The results validate and extend global frameworks (e.g., Flynn et al., 2010; Frohlich & Westbrook, 2001) to the Indian regional setting, highlighting stronger relational and resilience benefits in Rajasthan's manufacturing landscape. Practically, the study recommends that managers prioritize internal cross-functional alignment as a foundation, followed by investments in collaborative tools, information sharing, and joint planning with suppliers and customers. Regional policymakers and industry associations can support these efforts through targeted incentives, digital infrastructure development, and cluster-based collaboration programs to strengthen supply chain capabilities. In summary, adopting holistic supply chain integration offers Rajasthan-based manufacturing firms a sustainable pathway to improved competitiveness, efficiency, and adaptability in India's evolving industrial ecosystem.

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