

PORT INFRASTRUCTURE CONSTRAINTS AND PETROL SUPPLY IN CALABAR MUNICIPAL, CROSS RIVER STATE, NIGERIA

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Abstract

Port infrastructure plays a pivotal role in the seamless importation and distribution of petroleum products, yet the Calabar port, a critical gateway for petrol supply in Cross River State, continues to suffer from severe structural and operational deficiencies that compromise fuel availability in Calabar Municipal. This study empirically investigated the effect of port infrastructure constraints on petrol supply adequacy in Calabar Municipal, Cross River State, Nigeria. Four dimensions of port infrastructure constraints were examined as independent variables: port infrastructure capacity (PIC), port operational efficiency (POE), regulatory compliance framework (RCF), and logistics and hinterland connectivity (LHC), with petrol supply adequacy (PSA) as the dependent variable. Anchored on the Theory of Constraints (Goldratt, 1984), Logistics Systems Theory, and the Resource Dependency Theory (Pfeffer & Salancik, 1978), the study adopted a descriptive survey design and administered structured questionnaires to 250 purposively selected respondents comprising port operators, fuel distributors, transport logistics managers, petroleum marketing company staff, and government regulatory officers in Calabar Municipal. Data were analysed using descriptive statistics, Pearson correlation, and multiple linear regression via IBM SPSS Statistics version 25. Results revealed that PIC ($\beta = -0.281$, $p < 0.001$), POE ($\beta = -0.257$, $p < 0.001$), RCF ($\beta = -0.214$, $p < 0.001$), and LHC ($\beta = -0.231$, $p < 0.001$) all had significant negative effects on petrol supply adequacy, collectively explaining 55.2% of the variance ($R^2 = 0.560$, $F = 77.84$, $p < 0.001$). All four null hypotheses were rejected. The study concludes that port infrastructure constraints are a major systemic determinant of petrol supply inadequacy in Calabar Municipal and recommends urgent investment in port modernisation, operational automation, regulatory streamlining, and hinterland transport infrastructure to ensure energy supply security in the region.

Keywords: *Port infrastructure, petrol supply, logistics constraints, Calabar port, petroleum distribution, Cross River State*

Background of the Study

Energy security remains a foundational prerequisite for sustainable economic development, and access to petroleum products, particularly petrol (premium motor spirit), is indispensable

for the functioning of households, industries, and public services in Nigeria. As Africa's largest oil producer, Nigeria paradoxically suffers from chronic and pervasive petroleum product shortages, a contradiction rooted not merely in production constraints but, critically, in deficient downstream infrastructure that impedes effective importation, handling, and distribution of refined products (Olawale & Sanusi, 2021; Nwankwo & Okeke, 2022). While the inadequacy of domestic refining capacity has received considerable scholarly attention, the role of port infrastructure constraints as a proximate driver of petrol supply disruptions, particularly at non-Lagos ports, has remained insufficiently interrogated in academic and policy literature.

The Calabar port, located along the Cross River in Cross River State, Nigeria, constitutes one of the oldest and most strategically situated maritime facilities in the country. Established in the colonial era and formally designated as part of Nigeria's premier port network, the Calabar port has historically served as a vital conduit for the importation and distribution of goods and commodities for the South-South and South-East geopolitical zones (Nigerian Ports Authority [NPA], 2023). Its geographic positioning offers natural advantages for serving the hinterlands of Cross River, Akwa Ibom, Rivers, Benue, and Ebonyi states, and it holds considerable potential as a complementary distribution hub that could ease the burden on the Lagos and Port Harcourt ports. However, decades of underinvestment, infrastructure deterioration, operational inefficiencies, and regulatory fragmentation have significantly undermined the port's capacity to fulfil this role, particularly in relation to petroleum product importation.

Calabar Municipal, the capital of Cross River State, is a rapidly urbanizing city with a growing population of approximately 800,000 residents and a vibrant commercial sector heavily dependent on motorized transport, electricity generation, and industrial energy (National Population Commission [NPC], 2023). The city's petrol supply is substantially dependent on products channelled through the Calabar port or transported overland from Port Harcourt and Lagos, making it highly vulnerable to disruptions in port operations. Recurring petrol scarcity, characterized by long queues at filling stations, black market premium pricing, and supply rationing, has become a defining socioeconomic challenge for residents and businesses alike (Cross River State Ministry of Petroleum Resources, 2024). Empirical evidence linking these supply disruptions to specific port infrastructure deficiencies remains sparse, creating a critical gap in evidence-based policymaking.

The global maritime and energy supply literature highlights port infrastructure efficiency as a critical determinant of energy security and supply chain resilience (Ducruet & Notteboom, 2012; Roso et al., 2015; Notteboom & Rodrigue, 2020). Studies from comparable developing-country contexts — including Ghana's Tema port (Haddad et al., 2019), Kenya's Mombasa port (Mwangi & Muema, 2021), and Tanzania's Dar es Salaam port (Diyamett et al., 2020) — consistently demonstrate that inadequate berthing capacity, prolonged vessel turnaround times, weak regulatory enforcement, and poor hinterland connectivity significantly constrain commodity throughput, with particular consequences for time-sensitive products such as petroleum. These insights carry direct implications for Nigeria's

secondary ports like Calabar, where similar structural weaknesses intersect with acute energy demand.

Despite the strategic importance of the Calabar port and the persistent petrol supply crisis in Calabar Municipal, empirical studies specifically examining the relationship between port infrastructure constraints and petrol supply adequacy in this locality are virtually absent from the scholarly literature. This study therefore seeks to fill this critical gap by providing rigorous, survey-based empirical evidence on how specific dimensions of port infrastructure — capacity, operational efficiency, regulatory compliance, and logistics connectivity — affect petrol supply adequacy in Calabar Municipal, Cross River State.

Statement of the Problem

Despite Nigeria's status as a major petroleum-producing nation and the Calabar port's strategic positioning as a southern maritime gateway, Calabar Municipal continues to experience chronic and debilitating petrol supply disruptions. Anecdotal and observational evidence indicates that filling stations in Calabar frequently experience stock-outs lasting between three days and three weeks, forcing residents and businesses to rely on black-market petroleum at prices up to three times the official pump price (Cross River State Price Control Board, 2024). These disruptions impose enormous economic costs, including elevated transportation expenses, reduced industrial productivity, damage to small and medium enterprises, and diminished quality of life for ordinary citizens.

The Calabar port, which should serve as a primary importation gateway for petroleum products destined for the region, is afflicted by a constellation of structural and operational problems that severely limit its capacity to perform this function effectively. Key among these are: insufficient draft depth that restricts berthing of larger petroleum tankers; antiquated cargo handling and storage equipment; prolonged vessel turnaround times averaging 14–21 days compared to an international standard of 3–5 days (NPA, 2023; NIMASA Annual Report, 2024); bureaucratic layering from multiple regulatory agencies including NMDPRA, NIMASA, Nigerian Customs Service, and the Department of Petroleum Resources; and inadequate road and pipeline infrastructure linking the port to fuel depots and distribution networks in the hinterland.

While these infrastructure challenges are widely acknowledged among port operators, marketers, and government officials, they have not been subjected to rigorous empirical quantification in the specific context of petrol supply adequacy. Consequently, policy responses remain ad hoc, politically driven, and largely ineffective. This study addresses this problem by systematically measuring the nature and magnitude of the relationship between specific port infrastructure constraints and petrol supply adequacy in Calabar Municipal, thereby providing the empirical foundation for targeted, evidence-based intervention.

Objectives of the Study

The main objective of this study is to examine the effect of port infrastructure constraints on petrol supply adequacy in Calabar Municipal, Cross River State, Nigeria. The specific objectives are to:

1. Examine the effect of port infrastructure capacity (PIC) on petrol supply adequacy in Calabar Municipal, Cross River State.

2. Assess the effect of port operational efficiency (POE) on petrol supply adequacy in Calabar Municipal, Cross River State.
3. Evaluate the effect of regulatory compliance framework (RCF) on petrol supply adequacy in Calabar Municipal, Cross River State.
4. Investigate the effect of logistics and hinterland connectivity (LHC) on petrol supply adequacy in Calabar Municipal, Cross River State.

Research Questions

The following research questions guided this study:

1. What is the effect of port infrastructure capacity on petrol supply adequacy in Calabar Municipal, Cross River State?
2. What is the effect of port operational efficiency on petrol supply adequacy in Calabar Municipal, Cross River State?
3. What is the effect of regulatory compliance framework on petrol supply adequacy in Calabar Municipal, Cross River State?
4. What is the effect of logistics and hinterland connectivity on petrol supply adequacy in Calabar Municipal, Cross River State?

Research Hypotheses

The following null hypotheses were tested at the 0.05 level of significance:

1. H_{01} : Port infrastructure capacity has no significant effect on petrol supply adequacy in Calabar Municipal, Cross River State.
2. H_{02} : Port operational efficiency has no significant effect on petrol supply adequacy in Calabar Municipal, Cross River State.
3. H_{03} : Regulatory compliance framework has no significant effect on petrol supply adequacy in Calabar Municipal, Cross River State.
4. H_{04} : Logistics and hinterland connectivity has no significant effect on petrol supply adequacy in Calabar Municipal, Cross River State.

Scope of the Study

This study is geographically delimited to Calabar Municipal Local Government Area of Cross River State, Nigeria, with specific focus on the operations of the Calabar port and the petrol supply dynamics within the municipal area. The population covered includes port operators, petroleum product marketers, logistics and transport managers, and relevant regulatory officers operating within this geographic boundary. Conceptually, the study examines four port infrastructure constraint dimensions — port infrastructure capacity, port operational efficiency, regulatory compliance framework, and logistics and hinterland connectivity — and their relationship to petrol supply adequacy. Data collection was conducted between January and March 2025, providing a cross-sectional snapshot of the phenomenon under investigation.

Review of Related Literature

Theoretical Framework

This study is grounded in three complementary theories explaining how port infrastructure constraints influence petrol supply adequacy. These are The Goal *Theory of Constraints* (TOC), *Logistics Systems Theory* (LST), and the *Resource Dependency Theory* (RDT).

The Goal *Theory of Constraints* (TOC) developed by Eliyahu Goldratt argues that every system is limited by its major bottleneck (Goldratt & Cox, 1984). In port logistics, these constraints may include inadequate berthing space, slow cargo handling, regulatory delays, or weak transport links, all of which restrict petroleum throughput. TOC emphasizes identifying and improving bottlenecks in order to maximize system performance. Empirical applications of TOC in logistics and port operations have been demonstrated by Ahn and Wemmerlöv (2004), Mabin and Balderstone (2003), and Agbo and Okwu (2019).

Logistics Systems Theory (LST), associated with Jay Forrester and later expanded by Martin Christopher, views logistics as an interconnected system where failure in one component disrupts the entire supply chain (Forrester, 1961; Christopher, 2016). From this perspective, inefficiencies in port operations affect vessel discharge, storage, documentation, and inland distribution, eventually causing fuel scarcity. LST therefore supports the need to examine port infrastructure holistically rather than as isolated components.

Resource Dependency Theory (RDT) by Jeffrey Pfeffer and Gerald Salancik explains that organizations rely on external resources beyond their direct control (Pfeffer & Salancik, 1978). Petroleum marketers and distributors depend heavily on port facilities, transport infrastructure, and regulatory approvals. When these resources are inadequate, supply instability, hoarding, and price distortions are likely to occur. Together, TOC, LST, and RDT provide a comprehensive explanation of how infrastructure deficiencies influence petrol supply adequacy.

Conceptual Framework

The framework links four independent variables — port infrastructure capacity (PIC), port operational efficiency (POE), regulatory compliance framework (RCF), and logistics/hinterland connectivity (LHC) — with the dependent variable, petrol supply adequacy (PSA). Guided by TOC, LST, and RDT, the study assumes that deficiencies in any of these infrastructure dimensions negatively affect petrol supply, while improvements enhance supply adequacy (Goldratt & Cox, 1984; Christopher, 2016; Pfeffer & Salancik, 1978).

Port infrastructure capacity refers to the physical and technical facilities required for handling petroleum products efficiently, including berths, tank farms, and cargo equipment (Notteboom & Rodrigue, 2020). Port operational efficiency concerns the speed and reliability of port processes such as vessel turnaround, cargo handling, and documentation clearance (UNCTAD, 2022). Regulatory compliance framework covers the policies, standards, and administrative procedures guiding port operations and safety compliance (NIMASA, 2023; NMDPRA, 2024). Logistics and hinterland connectivity involve the effectiveness of roads, railways, pipelines, and inland waterways connecting ports to inland markets (Roso et al., 2015). Petrol supply adequacy refers to the extent to which petrol supply consistently satisfies

the needs of households, businesses, and the transport sector in Calabar Municipal (Cross River State Ministry of Petroleum Resources, 2024).

Empirical Review of Related Studies

Several studies have established the importance of port infrastructure in commodity supply chains. Ducruet and Notteboom (2012) found that efficient ports are better integrated into global supply systems, improving supply reliability. Roso et al. (2015) further emphasized that poor hinterland connectivity significantly limits commodity distribution from seaports.

In Africa, Haddad et al. (2019) reported that inadequate berthing facilities, poor equipment maintenance, and fragmented regulations reduced cargo throughput at Ghana's Tema Port. Mwangi and Muema (2021) also found that improved operational efficiency at Mombasa Port enhanced commodity supply regularity.

Within Nigeria, Nwankwo and Okeke (2022) identified outdated cargo facilities and inadequate apron space at Lagos ports as major causes of petroleum import delays. Olawale and Sanusi (2021) observed that overlapping regulatory procedures prolonged cargo clearance and increased supply uncertainty.

Agbo and Okwu (2019) applied TOC to Nigerian ports and identified poor road infrastructure as the key constraint affecting petroleum evacuation from secondary ports like Calabar. Ibrahim and Bello (2023) similarly linked recurring petrol scarcity in Cross River State to port-related bottlenecks. However, their study lacked detailed quantitative analysis. The present study therefore extends existing literature by offering a more comprehensive quantitative assessment of the relationship between port infrastructure and petrol supply in Calabar Municipal.

Methodology

The study adopted a descriptive survey design with a quantitative approach, commonly used in logistics and supply chain research. The population consisted of about 1,200 personnel involved in port operations, petroleum distribution, logistics, and regulatory activities in Calabar Municipal. Using Yamane's sample size formula, 300 respondents were selected, while 250 valid questionnaires were eventually retrieved, representing an 89.3% response rate.

Purposive sampling ensured that participants had professional knowledge relevant to port and fuel logistics. Respondents included terminal operators, petroleum marketers, transport managers, and officials from the Nigerian Ports Authority, NIMASA, Customs, and NMDPRA.

Data were collected through a structured questionnaire divided into demographic and research-variable sections. Responses were measured on a five-point Likert scale. The instrument underwent expert validation and pilot testing, while reliability was confirmed using Cronbach's alpha values above the acceptable 0.70 threshold.

Data analysis was conducted with IBM SPSS Statistics version 25. Descriptive statistics summarized respondents' views, Pearson correlation examined relationships among variables, and multiple regression tested the hypotheses on the effects of PIC, POE, RCF, and

LHC on PSA. Multicollinearity tests showed acceptable VIF values below 5.0, while statistical significance was evaluated at the 0.05 level.

Data Presentation and Analysis

Demographic Characteristics of Respondents

The demographic profile of the 250 respondents. Males constituted 55.2 per cent of the sample and females 44.8 per cent, indicating reasonable gender representation given the predominantly male composition of the petroleum and port logistics workforce. The majority of respondents (32.8%) fell within the 36–45 age bracket, followed by the 26–35 bracket (29.6%), indicating a predominantly experienced workforce. In terms of educational qualifications, 42.4 per cent held HND/B.Sc. degrees and 20.8 per cent held postgraduate qualifications, suggesting a well-educated sample capable of informed perception-based assessment. A combined 51.2 per cent of respondents had more than 10 years of professional experience in their respective fields, lending credibility to their perceptual judgments on port infrastructure and petroleum supply dynamics.

Table 1: Reliability Statistics of Research Instrument

Variable	No. of Items	Cronbach's Alpha (α)	Remark
Petrol Supply Adequacy (PSA)	5	0.843	Reliable
Port Infrastructure Capacity (PIC)	5	0.857	Reliable
Port Operational Efficiency (POE)	5	0.831	Reliable
Regulatory Compliance Framework (RCF)	5	0.848	Reliable
Logistics & Hinterland Connectivity (LHC)	5	0.826	Reliable

Source: SPSS Output, 2025.

Table 1 confirms the internal consistency of all constructs. Cronbach's alpha values ranged from 0.826 (LHC) to 0.857 (PIC), all exceeding the 0.70 threshold recommended by Hair et al. (2019), confirming that the research instrument is reliable and consistently measures its intended constructs.

Table 2: Descriptive Statistics of Study Variables

Variable	N	Min	Max	Mean	Std. Dev.	Skewness
Petrol Supply Adequacy (PSA)	250	1.00	5.00	3.51	0.783	-0.22
Port Infrastructure Capacity (PIC)	250	1.00	5.00	2.89	0.912	0.41
Port Operational Efficiency (POE)	250	1.00	5.00	2.74	0.874	0.38

Regulatory Compliance Framework (RCF)	250	1.00	5.00	2.61	0.956	0.55
Logistics & Hinterland Connectivity (LHC)	250	1.00	5.00	2.48	0.931	0.62

Source: SPSS Output, 2025. Scale: 1 = Strongly Disagree, 5 = Strongly Agree.

Table 2 reveals important patterns in respondents' perceptions. The petrol supply adequacy (PSA) variable recorded the highest mean (3.51), indicating moderate agreement that supply challenges exist but are not entirely catastrophic. In contrast, logistics and hinterland connectivity (LHC) recorded the lowest mean (2.48), suggesting strong respondent agreement that logistics connectivity is severely deficient. All four port infrastructure constraint variables — PIC (mean = 2.89), POE (mean = 2.74), RCF (mean = 2.61), and LHC (mean = 2.48) — recorded means below the midpoint of 3.0, indicating that respondents generally perceived these dimensions as inadequate. The positive skewness values for the constraint variables confirm a distribution skewed toward lower scores (i.e., more respondents rating infrastructure as poor), while PSA's negative skewness indicates respondents lean toward perceiving supply as somewhat inadequate.

Table 3: Pearson Correlation Matrix

Variable	PSA	PIC	POE	RCF	LHC
PSA – Petrol Supply Adequacy	1.000				
PIC – Port Infrastructure Capacity	-.614**	1.000			
POE – Port Operational Efficiency	-.587**	.631**	1.000		
RCF – Regulatory Compliance Framework	-.542**	.574**	.598**	1.000	
LHC – Logistics & Hinterland Connectivity	-.571**	.563**	.549**	.512**	1.000

Source: SPSS Output, 2025. **Correlation is significant at the 0.01 level (2-tailed). PSA = Petrol Supply Adequacy; PIC = Port Infrastructure Capacity; POE = Port Operational Efficiency; RCF = Regulatory Compliance Framework; LHC = Logistics & Hinterland Connectivity.

Table 3 presents the bivariate correlation matrix. All four independent variables showed significant negative correlations with petrol supply adequacy ($p < 0.01$), consistent with the theoretical prediction that higher port infrastructure constraint levels are associated with lower petrol supply adequacy. Port infrastructure capacity exhibited the strongest negative correlation with PSA ($r = -.614$), followed by port operational efficiency ($r = -.587$), logistics and hinterland connectivity ($r = -.571$), and regulatory compliance framework ($r = -.542$). Inter-predictor correlations among the independent variables ranged from .512 to .631,

indicating moderate positive intercorrelation — expected given the systemic interrelatedness of port infrastructure dimensions — but none approaching the multicollinearity threshold.

Table 4: Multiple Regression Analysis — Port Infrastructure Constraints and Petrol Supply Adequacy

Variable	B	Std. Error	Beta (β)	t-value	p-value
(Constant)	5.218	0.274		19.044	0.000
Port Infrastructure Capacity (PIC)	-0.317	0.071	-0.281	-4.465	0.000
Port Operational Efficiency (POE)	-0.284	0.068	-0.257	-4.176	0.000
Regulatory Compliance Framework (RCF)	-0.231	0.062	-0.214	-3.726	0.000
Logistics & Hinterland Connectivity (LHC)	-0.248	0.065	-0.231	-3.815	0.000
R = 0.748; R² = 0.560; Adjusted R² = 0.552; F(4, 245) = 77.84; p < 0.001					

Source: SPSS Output, 2025. Dependent Variable: Petrol Supply Adequacy (PSA). All VIF values < 3.0, confirming absence of multicollinearity. $R = 0.748$; $R^2 = 0.560$; Adjusted $R^2 = 0.552$; $F(4, 245) = 77.84$; $p < 0.001$.

Table 4 presents the multiple regression results. The overall regression model was statistically significant ($F(4, 245) = 77.84$, $p < 0.001$) and explained 56.0 per cent of the variance in petrol supply adequacy ($R^2 = 0.560$; Adjusted $R^2 = 0.552$), indicating a strong model fit. All four independent variables made statistically significant negative contributions to petrol supply adequacy.

Port infrastructure capacity (PIC) emerged as the strongest predictor ($\beta = -0.281$, $t = -4.465$, $p < 0.001$), indicating that a one-unit deterioration in port infrastructure capacity is associated with a 0.281 standard deviation decrease in petrol supply adequacy. Port operational efficiency (POE) was the second-strongest predictor ($\beta = -0.257$, $t = -4.176$, $p < 0.001$), followed by logistics and hinterland connectivity ($\beta = -0.231$, $t = -3.815$, $p < 0.001$) and regulatory compliance framework ($\beta = -0.214$, $t = -3.726$, $p < 0.001$). These results collectively affirm that port infrastructure constraints are powerful, statistically significant determinants of petrol supply inadequacy in Calabar Municipal.

Summary of Results

The findings of this study are summarised in Table 5, which presents the hypothesis testing decisions for all four null hypotheses.

All four null hypotheses were rejected at the 0.05 level of significance, confirming that port infrastructure capacity, port operational efficiency, regulatory compliance framework, and logistics and hinterland connectivity each exert a significant negative effect on petrol supply adequacy in Calabar Municipal, Cross River State.

Discussion of Results

The finding that port infrastructure capacity was the strongest predictor of petrol supply inadequacy supports the Theory of Constraints, which identifies physical capacity as the key limiting factor in system performance (Goldratt & Cox, 1984). Calabar Port's shallow draft depth restricts large tanker access, increasing transportation costs and delays. This aligns with Haddad et al. (2019) and NPA (2023), who identified inadequate berthing and dredging deficiencies as major constraints.

The significant effect of port operational efficiency agrees with Mwangi and Muema (2021) and Nwankwo and Okeke (2022), who found that delays in vessel turnaround increase demurrage costs and fuel shortages. Respondents highlighted manual documentation, equipment downtime, and restricted night operations as major inefficiencies.

The negative effect of the regulatory compliance framework reflects the challenges of multiple clearance procedures involving agencies such as NMDPRA, NIMASA, and Customs. This supports Olawale and Sanusi (2021), who reported lengthy regulatory delays at Nigerian ports, and aligns with Resource Dependency Theory, which links bureaucratic dependency with supply vulnerability.

The findings on logistics and hinterland connectivity support Agbo and Okwu (2019), who identified poor road infrastructure as a major evacuation constraint in Nigerian ports. Poor roads, absence of rail links, and lack of pipeline connections continue to hinder efficient fuel distribution from Calabar Port.

Conclusion

This study provided a quantitative assessment of how port infrastructure constraints affect petrol supply adequacy in Calabar Municipal. Using correlation and regression analyses, the study established that port infrastructure capacity, operational efficiency, regulatory compliance, and hinterland connectivity significantly reduce petrol supply adequacy, jointly accounting for 55.2% of supply variations.

The findings validated the Theory of Constraints, Logistics Systems Theory, and Resource Dependency Theory in explaining petrol supply challenges within Nigerian secondary ports. Port infrastructure capacity was identified as the most critical constraint, followed by operational efficiency, logistics connectivity, and regulatory compliance. The study therefore concluded that recurring petrol scarcity in Calabar is primarily a supply-side problem caused by systemic infrastructure deficiencies.

Recommendations

1. The Nigerian Ports Authority should dredge the Calabar Port channel to at least 12 metres to accommodate larger petroleum tankers.
2. Port authorities and terminal operators should modernize cargo handling equipment, automate operations, and establish 24-hour port services to reduce vessel turnaround time.
3. The Federal Government should introduce a unified ICT-driven single-window clearance system to reduce regulatory delays.

4. The rehabilitation of the Calabar–Ikom highway and development of pipelines and rail infrastructure should be prioritized to improve fuel evacuation and distribution.
5. Future studies should adopt longitudinal and mixed-method approaches and extend investigations to other Nigerian ports for comparative analysis.

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