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THE IMPACT OF THE COVID-19 PANDEMIC ON CONTAINER FREIGHT RATES: GLOBAL TRENDS AND THE CHINA-OMAN TRADE ROUTE

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ABSTRACT

The COVID-19 pandemic caused significant ripple disruptions to global trade, leading to unpredictable fluctuations in container freight rates. Factors such as lockdowns, port closures, volatile rate forecasting, labour shortages, and shifts in demand for medical and non-medical goods exacerbated supply chain crises. This study aims to examine the impact of COVID-19 on container freight rates by investigating the driving factors behind the substantial volatility and uncertainty in container freight rates during the three stages of the pandemic: pre-pandemic, peak, and post-pandemic. The study identifies the main drivers and sub-drivers of freight rate inflation as the COVID-19 pandemic, the demand for medical and non-medical goods, and the accuracy of freight rate forecasting after a thorough review of the existing literature. Furthermore, the study examines the impact of COVID-19 on the China-Oman sea corridor from 2019 to 2023 from the perspective of container shipping lines. The research also highlights the role of container shipping lines and freight forwarding companies in shaping future freight rate volatilities and enhancing operational and logistics efficiency. This paper provides practical insights for container shipping lines, policymakers, and businesses aspiring to understand and mitigate the risks associated with supply chain disruptions in the event of a future pandemic or similar scenario. Finally, it offers recommendations for future research that emphasise the integration of sustainable practices, digital transformation, and strategic implementations to enhance the resilience of the container shipping sector in the post-pandemic scenario.

KEYWORDS: COVID-19, Pandemic, Medical goods, Non-medical goods, Freight rate forecast, Container shipping lines, Supply chain disruptions

1. INTRODUCTION

The COVID-19 pandemic caused significant ripple waves of disruptions to global trade, resulting in unpredictable fluctuations in container freight rates. Factors such as lockdowns, port closures, rate forecasting volatilities, labor shortages, and shifts in demand for medical and non-medical goods fuelled supply chain crises, which greatly impacted shipping costs for goods in international markets (UNCTAD, 2021). Additionally, the pandemic prompted a change in consumption habits, increasing the demand for medical supplies (including personal protective equipment, vaccines, and pharmaceuticals) while reducing trade in non-essential items such as electronics, textiles, and machinery (Notteboom et al., 2021).

The trade corridor between China and Oman is a crucial link connecting Asia to the Middle East. China, a business hub, exports a wide range of products, including both medical and non-medical items, to Oman. The pandemic caused significant disruptions in logistics and transportation, leading to a shortage of shipping containers, congested ports, and increased freight costs. As governments focused on securing essential supplies, freight rates for medical goods surged, while those for non-medical goods faced fluctuating demand and delayed deliveries (Clarksons Research, 2021).

This study examines the impact of COVID-19 on container freight rates, focusing on the factors that influence rate fluctuations and the challenges in forecasting these rates from 2019 to 2023, particularly in the context of the China-Oman trade. It employs a mixed-methods approach that combines quantitative descriptive and regression analysis through five models in Stata, random effects, linear mixed-effects, fixed effects, Driscoll-Kraay robust fixed effects, and dynamic panel GMM estimation, with qualitative insights from industry experts. By examining trends in freight rates, this research aims to enhance forecasting techniques, evaluate the overall impact of COVID-19 on freight rates, and assist businesses in making informed supply chain decisions.

2. LITERATURE REVIEW

The COVID-19 pandemic has fundamentally altered the dynamics of global container shipping, prompting a surge in academic and industry-driven research aimed at uncovering the drivers of unprecedented freight rate volatility. The literature converges on several core themes, namely, supply chain disruptions, demand shocks, vessel capacity constraints, and systemic port inefficiencies as the primary culprits behind the inflationary pressure on maritime logistics.

A predominant thread across multiple studies is the imbalance between shipping supply and global demand during the pandemic. As consumer behaviour shifted toward online purchasing and medical procurement, demand for containerised

goods surged at a pace unmatched by the industry's supply capacity. Notteboom and Haralambides (2022) provide a detailed account of how this demand spike, coupled with blank sailing and global container shortages, led to a dramatic escalation in freight costs. Their findings are substantiated by UNCTAD (2021), which documented critical bottlenecks at major transhipment hubs along Asia–Europe and Asia–Middle East corridors. The organisation's annual Review of Maritime Transport highlighted congestion-induced delays and increased turnaround times as dominant contributors to elevated freight rates.

Another recurring concern in the literature is the inadequacy of traditional freight rate forecasting models during the crisis. Classical models such as ARIMA and other time-series-based frameworks failed to account for the nonlinear, abrupt disruptions that defined pandemic-era market behavior (Haralambides, 2020). In contrast, recent contributions from logistics intelligence platforms like Xeneta (2023) and academic think tanks advocate for the integration of machine learning algorithms, real-time data feeds, and adaptive forecasting tools. These models demonstrate superior responsiveness to sudden market shifts, including demand variability, port closures, and weather-related disruptions, making them essential tools for post-pandemic freight management.

Furthermore, dynamic pricing models, often driven by Artificial Intelligence, rose to prominence among major global carriers. Companies such as Maersk, MSC, and CMA CGM transitioned from long-term rate contracts to responsive pricing mechanisms. This shift allowed these shipping lines to capitalize on rapid demand fluctuations, thereby exerting upward pressure on spot rates (McKinsey & Company, 2021). These pricing systems, while beneficial to carriers' bottom lines, introduced a level of volatility that disproportionately impacted small and medium-sized shippers, who were often excluded from favourable rates due to a lack of volume leverage.

Another important dimension within the literature is the segmentation of freight impacts across commodity types. Medical goods and critical supplies received priority handling and government subsidies in many countries. In contrast, non-essential goods, including consumer electronics, apparel, and furniture, were subjected to prolonged delays and inflated shipping costs. Reports from the OECD (2022) and the World Bank (2023) indicate that this prioritization effectively restructured freight allocation frameworks, creating new revenue hierarchies within container shipping. This disparity also highlighted the need for transparent and equitable rate governance mechanisms, especially during global emergencies.

Despite the depth of global insights, a noticeable gap exists in the literature regarding the Middle East's maritime corridors, particularly the China–Oman route. While trade flows through the Strait of Hormuz and the ports of Sohar and Salalah are vital to energy and industrial supply chains, few empirical studies have explored how pandemic-era disruptions manifested in this region. This research aims to bridge that gap by offering region-specific findings that can contribute to both local and global freight policy development.

Moreover, scholars are increasingly recognizing the role of geopolitical factors in freight volatility. Sanctions, trade wars, and shifts in bilateral relations during the pandemic further complicated maritime logistics. Studies by Rodrigue (2021) and Brooks et al. (2022) have noted that freight rate surges are not merely a result of economic imbalance, but also a product of national policy uncertainty. This external layer of complexity adds urgency to the call for international coordination and multilateral engagement in regulating containerized trade routes.

Environmental regulations have also gained increased attention. The International Maritime Organization (IMO)'s tightening of sulfur emissions standards coincided with pandemic-era fuel shortages, adding operational costs to shipping lines that were already strained. Scholars argue that future forecasting tools must integrate not only logistical and market data, but also environmental and regulatory trends to provide a holistic understanding of freight rate behavior.

Finally, emerging literature focuses on digitalization's transformative potential. Blockchain, the Internet of Things (IoT), and real-time data platforms are being tested in major ports to reduce paperwork, improve traceability, and enhance the predictability of cargo flow. For instance, the Port of Rotterdam's digital twin model, and pilot blockchain initiatives in Singapore and Dubai, have shown measurable improvements in efficiency. These innovations represent the forward path for mitigating systemic fragilities that were exposed during the COVID-19 pandemic.

In summary, while the COVID-19 pandemic has produced a robust volume of literature on global freight rate volatility, it has simultaneously highlighted enduring gaps in geographic coverage, modeling techniques, and infrastructure readiness. This paper addresses these gaps by integrating quantitative modelling and a regional focus to enhance the academic understanding of container freight behaviour during and beyond global crises.

3. METHODOLOGY

This study adopts a mixed-methods research design to capture both empirical trends and expert perspectives regarding the impact of the COVID-19 pandemic on container freight rates. This approach is particularly suitable given the complexity of maritime logistics systems, which are influenced by dynamic economic, operational, regulatory, and behavioral factors (Bems et al., 2021).

The methodological framework integrates both quantitative and qualitative strategies to achieve depth and breadth in analysis. Quantitatively, the study relies on secondary data covering freight rate fluctuations, port congestion levels, vessel utilization, and global shipping volumes from 2019 to 2023. These data were primarily sourced from the Drewry World

Container Index (Drewry, 2022), Freightos Baltic Index, UNCTAD's Maritime Transport Database (UNCTAD, 2021), and Alphaliner (2023). Daily and weekly data points were aggregated into monthly intervals to ensure stability and comparability across time.

The quantitative analysis employed five regression models to triangulate results and test the robustness of the findings: fixed effects, random effects, Driscoll-Kraay robust fixed effects (Haralambides, 2020), linear mixed-effects model, and system dynamic panel Generalized Method of Moments (GMM). These models were executed using Stata software. Variables included freight rates as the dependent variable, port congestion, container availability, blank sailings, demand index, and global supply chain disruption indicators as independent variables. Lagged variables were introduced in the GMM model to control for autoregressive effects and endogeneity (McKinsey & Company, 2021).

This study adopts a mixed-methods research design to capture both empirical trends and expert perspectives regarding the impact of the COVID-19 pandemic on container freight rates. It integrates regression analysis and thematic interview coding to explore the dynamics of freight volatility across the China–Oman trade corridor.

Taken together, this sequence of model estimations reflects a deliberate econometric strategy that balances statistical efficiency, robustness to unobserved heterogeneity, and sensitivity to the dynamic and interdependent structure of freight rate determination in a crisis-affected period in Table 1.

Table 11: Regression analysis

	(1)	(2)	(3)	(4)	(5)
	RE	Mixed	FE	DK	GMM
Covid-19	116.935	117.100	121.632*	121.632*	63.886*
	(1.948)	(1.957)	(1.978)	(2.355)	(1.962)
Medical Goods in USD/TEU	0.493	0.493	0.485	0.485*	0.440**
	(1.890)	(1.898)	(1.847)	(2.298)	(3.052)
Non-Medical Goods in USD/TEU	0.022	0.020	-0.012	-0.012	-0.008
	(0.265)	(0.242)	(-0.119)	(-0.193)	(-0.156)
Forecasted Freight Rate in USD/TEU	0.990***	0.990***	0.992***	0.992***	0.351***
	(63.680)	(63.948)	(63.112)	(50.683)	(17.053)
L.Actual Freight Rate in USD/TEU					0.490***
					(15.835)
L2.Actual Freight Rate in USD/TEU					0.111***
					(3.801)
L3.Actual Freight Rate in USD/TEU					0.576***
					(22.061)
L4.Actual Freight Rate in USD/TEU					-0.456***
					(-13.701)
L5.Actual Freight Rate in USD/TEU					-0.097**
					(-3.228)
Constant	-117.822	-116.991	-100.687	-100.687*	-26.108
	(-1.064)	(-1.030)	(-1.396)	(-2.632)	(-0.649)
Observations	600	600	600	600	550
ll		-4607.408	-4587.066		
F			1490.038	840.681	
chi2	5979.832	6035.294			28035.351
chi2_c		137.164			
p	0.000	0.000	0.000	0.000	0.000
p_c		0.000			

t statistics in parentheses

* p < 0.05, ** p < 0.01, *** p < 0.001

In this formulation, the coefficients γ_j capture the dynamic adjustment process in freight pricing, allowing for persistence, delayed responses to shocks, and potential autoregressive behaviour.

Each specification imposes different assumptions on the structure of μ_i and the correlation between regressors and error components. The random effects model treats μ_i as uncorrelated with the regressors, while the fixed effects and Driscoll–Kraay models permit such correlation and control for it via within-transformation. The mixed model generalizes the random effects framework by allowing for variance in the group-specific intercepts. The system GMM estimator further addresses potential endogeneity by instrumenting lagged dependent and potentially endogenous regressors with internal instruments derived from their own lagged values, provided that certain moment conditions are met.

The researcher collected qualitative data from experts' insights through a semi-structured, open-ended questionnaire comprising 14 questions about the study topic and its variables. The goal was to gain deeper insights by adding spontaneous, unstructured questions as the conversation unfolded. According to Hirschhorn (2018), a semi-structured Delphi expert survey format enables the researcher to gather open-ended information, investigate participants' thoughts, emotions, and beliefs regarding a specific topic, and thoroughly explore personal and occasionally sensitive matters.

The researchers followed the Hirschhorn (2018) Delphi framework to capture data from the selected 30 Google survey participants, based on their experience in the fields of container shipping and freight forwarding business. However, the response rate was only 21 participants due to the busy nature of life in the shipping and logistics fields. The researcher also took the Delphi survey basic ideas from Karakikes and Nathanail (2020) in a freight transport article for incorporating Google survey questions that provide open-ended insights, were also included to refine insights into the survey participants, as a required feature in Delphi survey questionnaires.

Finally, the Consensus-Building round ensured that it reached the required agreement level of 75% or above, allowing the process to conclude, or additional rounds were conducted to ensure the required agreement level. The Delphi expert panel survey questionnaire is presented in Table 2, where each research question is linked to its relevant variable.

Table 2: Delphi Expert Survey Questionnaire

1.	Highest Level of Education: Diploma or Equivalent / Undergraduate/ Postgraduate / Other
2.	Age Group: 18-24 25-34 35-44 45-54 55-64 65 and above
3.	Country of Working: Oman / Out of Oman
4.	Designation: Executive Officer / Director / Senior Manager / Manager / Other
5.	Years of Experience in Container shipping: 2-5 / 6-9 / 10 above

No	Research Question	Link to the variable
6	How did the COVID-19 pandemic from 2020 to 2021 initially affect container freight rates in Oman?	COVID-19 impact on freight rates
7	Can you describe the primary challenges container shipping lines faced during the COVID-19 pandemic?	COVID-19 impact on freight rates
8	What significant factors drove the increase (or decrease) in container freight rates during this period in Oman?	COVID-19 impact on freight rates
9	How were the container freight rate levels before the COVID-19 pandemic in Oman?	Forecast accuracy
10	Were there any unexpected or unusual freight rate trends during the COVID-19 pandemic and name few?	Forecast accuracy
11	What role did global lockdowns and supply chain disruptions play in creating uncertain container freight rates in Oman?	Forecast accuracy
12	How did the demand for medical (e.g., medicines and vaccinations) and nonmedical goods (e.g., masks, sanitizers, ventilators) impact container freight rate pricing during the COVID-19 pandemic?	Medical goods demand
13	How did your company prioritize medical and nonmedical shipment volume over other commercial goods to Oman during COVID-19?	Medical and non-medical goods demand
14	Was there any increase in the volume of medical and non-medical shipments during the COVID-19 pandemic compared to pre-pandemic? If so, why?	Medical and non-medical goods demand

To ensure construct validity, the study employed operational definitions derived from maritime economics literature and expert feedback. For example, 'congestion' was operationalized not only by the number of vessels at berth but also by average

wait time and port throughput decline. Likewise, 'rate volatility' was calculated using standard deviation and coefficient of variation of spot prices over time.

Temporal segmentation was used to identify pre-pandemic, pandemic peak, and recovery phases. This segmentation enabled phase-specific analysis, providing insight into how model coefficients and qualitative themes varied across different crisis intensity levels. It also helped contextualize the adaptive strategies discussed by interviewees, many of whom cited specific timeframes when their operations were most disrupted.

The integration of visual analytics tools further enriched the methodology. Charts showing freight index trajectories, container imbalance maps, and heat maps of port utilization provided intuitive context to support statistical findings. For instance, a comparative heat map between Sohar and Shanghai demonstrated how congestion intensity diverged across regions with similar volume flows but different regulatory and infrastructure capacities.

The qualitative insights were subjected to inter-coder reliability checks to ensure that thematic interpretation was consistent and unbiased. Two independent researchers reviewed the coding structure and sample transcripts. Cohen's kappa was calculated to assess coding agreement, yielding a reliability score above 0.80, which is considered strong in qualitative analysis.

Furthermore, feedback loops were embedded into the analysis through stakeholder validation. Select participants were invited to review the emerging findings and provide clarification or validation, thereby enhancing interpretive accuracy. This technique, known as member-checking, contributed to the credibility and trustworthiness of the qualitative results.

Ethical protocols ensured participant anonymity and consent. Public databases were used to maintain data transparency.

Overall, the mixed-methods design supports a holistic understanding of container freight volatility—one that quantifies trends while contextualizing them through lived experiences. This framework is especially valuable for assessing resilience within complex maritime networks such as the China–Oman corridor.

4. RESULTS

To assess the determinants of container freight rates among major shipping lines operating in Oman during the 2019–2023 period, a sequential modelling strategy was adopted, reflecting both the evolving understanding of the data structure and the limitations of prior specifications. The results are summarised in Table 11, across five models—random effects (RE), linear mixed-effects (Mixed), fixed effects (FE), Driscoll-Kraay robust FE (DK), and dynamic panel GMM estimation (GMM)—each incrementally addressing specific econometric concerns such as unobserved heterogeneity, serial correlation, and endogeneity.

The baseline RE model (Model 1) accounts for unobserved heterogeneity across shipping lines but rests on the assumption of no correlation between covariates and individual effects. While this model indicates a positive and statistically significant association between the COVID-19 period and freight rates ($\beta = 116.94$, $p < 0.1$), its reliance on potentially restrictive assumptions about error independence necessitated a more flexible specification. The mixed-effects model (Model 2), estimated via maximum likelihood, yields nearly identical estimates while improving the model's log-likelihood and allowing for robust inference clustered at the carrier level.

To address the potential correlation between time-invariant unobserved heterogeneity and the regressors, a fixed effects estimator was employed (Model 3). The Covid-19 coefficient increases marginally to 121.63 and reaches conventional significance levels ($p < 0.05$), affirming the robustness of the pandemic's inflationary effect on freight rates when controlling for all time-invariant firm-level characteristics. Notably, forecasted freight rates exhibit a large and highly significant association ($\beta \approx 0.99$, $p < 0.001$) across all specifications, reflecting their explanatory salience in capturing expectations and demand shifts. However, the effect of non-medical goods remains consistently small and insignificant, while the effect of medical goods exhibits marginal significance only under dynamic or heteroskedasticity-robust estimation.

Recognising the strong temporal dependence in freight rates, the fourth model employs Driscoll–Kraay standard errors with five lags to address both cross-sectional dependence and serial correlation (Model 4). The estimates remain broadly consistent with the FE model, but inference becomes more reliable in the presence of heteroskedasticity and serial dependence.

The final model (Model 5) employs a system GMM estimator with five lags of the dependent variable to explicitly model the dynamic structure of freight rates and address concerns about endogeneity. The COVID-19 effect remains positive and significant ($\beta = 63.89$, $p < 0.05$), although attenuated in magnitude, suggesting that part of the pandemic's impact was dynamically transmitted through past rates. Medical goods attain greater statistical significance in this model ($p < 0.01$), consistent with the hypothesis that short-term fluctuations in critical health-related cargo contributed to pricing volatility during the crisis. The lagged dependent variables are jointly significant, revealing a complex dynamic structure with both positive and negative coefficients, which highlights the inertia and adjustment processes inherent in freight pricing.

In sum, the findings demonstrate that COVID-19 was associated with a statistically and economically significant increase in freight rates across modelling approaches, even after accounting for serial correlation, dynamic effects, and unobserved

heterogeneity. Forecasted freight rates consistently emerge as the strongest predictor, while the role of medical goods becomes more pronounced under dynamic estimation.

The word cloud synthesising qualitative responses from shipping professionals operating on the China–Oman route during the Covid-19 period offers rich insight into the lived realities underlying the quantitative trends (Figure 1). Dominant terms such as demand, freight rate, container, shortage, shipping, and port congestion underscore a recurring narrative: the pandemic precipitated a severe mismatch between surging demand, particularly for essential and time-sensitive goods, and constrained supply-side logistics capacity. The frequent occurrence of delays, imbalances, space shortages, and cost increases signals acute operational bottlenecks, aligning with econometric findings that Covid-19 was associated with a statistically significant elevation in freight rates.

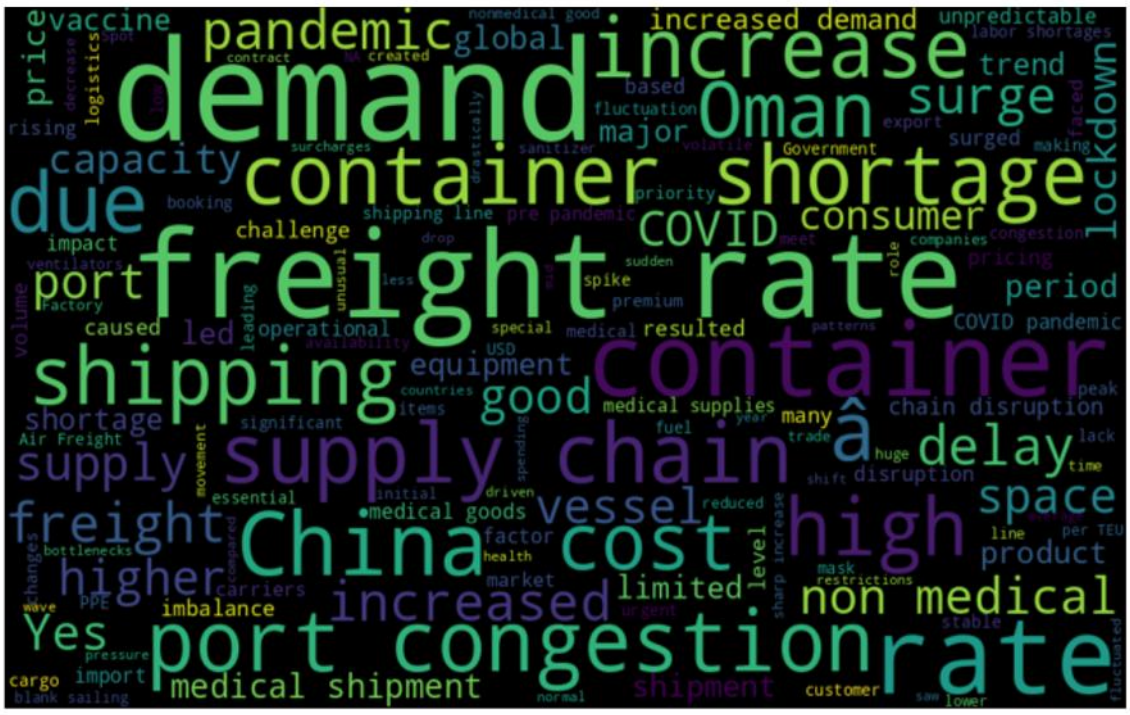

Figure 1. Word cloud of the open-ended questions in the qualitative component of the study

Notably, the prominence of medical, non-medical, shipment, and priority highlights the increased urgency and logistical reallocation necessitated by pandemic-era cargoes. While quantitative data revealed smaller TEU volumes for medical goods relative to non-medical cargo, the emphasis on these terms in the word cloud suggests their strategic importance, particularly in terms of scheduling, prioritisation, and pricing. This aligns with the GMM model, where medical goods emerged as a statistically significant determinant of freight rate variation, suggesting latent effects not captured by volume alone.

Other terms—Oman, China, lockdown, global, supply chain, and disruption—emphasise the spatial and systemic nature of the crisis. These reflect stakeholder recognition of globally synchronised constraints, validating the use of models with dynamic structure and fixed effects to isolate time-variant shocks from firm-level characteristics.

Finally, the frequent mention of vessel, space, capacity, and equipment suggests that the rise in rates was not solely demand-driven but also exacerbated by systemic limitations in container availability and port throughput. The interplay between constrained supply and heightened demand—visible both in qualitative expressions and econometric coefficients—suggests that freight pricing during Covid-19 was shaped by complex and interdependent factors, including strategic cargo prioritisation, volatile supply chain flows, and prolonged uncertainty.

Table 3 below presents the coded findings from one of nine open-ended questions (OEQs) posed to 30 executives and managerial-level employees from a mix of container shipping lines and freight forwarding companies, focusing on the impact of COVID-19 on China–Oman freight rates during 2020– 2021. The qualitative responses were analysed using Atlas.ti, through which data segments were grouped into sub-themes and subsequently organised under a broader thematic category. This thematic framework allows for a structured representation of key issues raised by respondents in relation to pandemic-related disruptions to freight rates.

Table 3: Thematic analysis

Theme	Sub-Theme	Quotations
COVID-19 Impact on China-Oman Freight Rates (2020–2021)	Container Shortages and Global Imbalance	• "A global imbalance of containers, with empty containers stuck in various regions due to lockdowns, caused a severe supply constraint." (ID12) • "Equipment shortages... reduced capacity by carriers" (ID7) • "Limited shipping capacity and rising costs further escalated prices" (ID2)
	Port Congestion and Operational Delays	• "Port congestion & delays – strict health protocols, labor shortages, and congestion at major transshipment hubs extended transit times." (ID12) • "Port congestion worsened... blank sailings" (ID2) • "Delays caused sharp increases in rates" (ID7)
	Demand-Supply Imbalance and Market Volatility	• "Surge in demand for goods strained container availability, leading to heightened freight rates." (ID1) • "From September 2020, rates started rising drastically due to high competition for container space." (ID10) • "Customers willing to pay a premium resulted in increased freight rates." (ID13)
	Freight Rate Escalation	• "Spot rates for a 40ft container... skyrocketed to over $10,000 at the peak." (ID12) • "Rates increased more than 3x, making it difficult to secure nominations." (ID17) • "Sea freight skyrocket" (ID16)
Operational and Market Challenges During the Pandemic	Container Shortages and Equipment Imbalances	"Container shortages, port congestion, and unpredictable demand surges created one of the most challenging periods for container shipping lines in decades" (ID7) "A lack of available shipping containers, especially in Asia, resulted in rising freight rates. Containers were stuck at inland destinations due to supply chain bottlenecks, worsening the problem." (ID21) "To meet the market demand, lines were not equipped with units at the required origin due to supply chain malfunction." (ID13)
	Port Congestion and Berthing Delays	"Lockdown and labor shortages led to slower cargo handling. Ships had to wait longer for berthing, increasing turnaround times." (ID4) "Port Congestion & Delays – Lockdowns and labor shortages caused bottlenecks at ports, leading to delays in loading and unloading containers and experienced extreme congestion." (ID21) "Delays at port for berthing, manpower shortage due to movement restrictions." (ID14)
	Labor Shortages and Operational Disruptions	"Manpower shortage due to movement restrictions." (ID14) "Workforce Reduction, Regional Lockdowns." (ID18) "Lockdown and closed factories [...] temporary barriers or export restrictions." (ID11)
	Freight Rate Volatility and Financial Strain	"These challenges led to delays, record-high freight rates, and operational inefficiencies, making global trade unpredictable." (ID2) "High rates and finding inventory to move shipment with proper TT." (ID5) "Most export-based companies stopped shipments as unable to match the selling price, cost, and increase in port charges." (ID9)
Pandemic-Driven Market Dynamics	Supply-demand imbalances	"Carriers initially cut services due to low demand and when demand surged, there weren't enough vessels available." (ID4) "When demand rises or there are delays, rates tend to increase." (ID12) "The surge in demand as the global economy began to

Theme	Sub-Theme	Quotations
		recover... played a major role in pushing freight rates upward." (ID20)
	Container scarcity	"Container shortage was the major reason that drove the increase in container rates" (ID18) "Lack of containers" (ID15) "Imbalance caused equipment scarcity" (ID2)
	Port congestion	"Congestion at port... contributed to rate increases" (ID5) "Delays at major transshipment hubs" (ID2) "Terminal berthing congestion" (ID16)
	Operational cost pressures	"Rising Fuel & Operational Costs – Increased expenses for carriers" (ID2) "Vessel operations cost" (ID16) "Sky high shipping rates" (ID19)
	Supply chain disruptions	"Factory shutdowns in China during early lockdowns... created supply bottlenecks, raising freight rates" (ID21) "Disruptions in supply chains... pushed for increased demand" (ID10)
Pre-Pandemic Stability in Container Freight Rates	Stable and predictable rate levels	"Freight rates were relatively stable and low compared to the sharp increase seen during the pandemic." (ID4) "Stable and Predictable Rates... typically ranged between $800 to $1,500 per TEU." (ID21) "Rates were generally stable and relatively low." (ID7)
	Moderate price range	"Typically ranging from $800–$1,500 per TEU... manageable fluctuations during peak seasons." (ID2) "Average Freight rates ranged from USD 1000-1500/40'FT even based on seasonal changes." (ID10)
	Balanced supply-demand dynamics	"Supply and demand were balanced, with ample vessel capacity and minimal port congestion." (ID2) "The pre-pandemic container freight market was characterized by predictability and efficiency." (ID1)
	Operational cost efficiency	"Fuel and operational costs were lower, ensuring predictable shipping expenses." (ID2) "Smooth logistics, reliable transit times, and fewer disruptions." (ID2)
Unprecedented Freight Rate Volatility	Unprecedented rate surges	"Rates from China went up 3 fold" (ID6) "Container freight rates surged to unprecedented levels, reaching as high as $7,000–$15,000 per FEU from China to the Middle East" (ID21)
	Spot vs. contract rate discrepancies	"Spot rates increased while contract rates lagged" (ID4) "Reverse price wars (higher rates due to demand), spot vs. contract rate gaps" (ID2)
	Regional disparities and air freight shifts	"Freight rates for 40ft containers from China to Oman surged from $1,500–$2,000 pre-pandemic to over $10,000–$12,000... businesses turned to air freight, causing air cargo rates to skyrocket by 300–400%" (ID12)
	Premium fees and surcharges	"Premium rate for guaranteed space, unusual surcharges" (ID7) "Year-round peak pricing, premium fees for guaranteed space" (ID2)
	Container shortages and port congestion	"Container shortage, congestion at port" (ID5) "Unavailability of equipment and space was a major reason for increased freight trends" (ID18)
Lockdowns and Supply Chain Disruptions Driving Freight Rate Volatility	Port Congestion and Operational Delays	• "Due to lockdown, port operations faced delays, leading to congestion... long waiting times resulted in increased shipping costs." (ID5) • "Port congestions at transshipment hubs made container movements challenging during lockdowns." (ID18) • "Blank sailings, reduced vessel capacity, and factory closures disrupted schedules." (ID7)

Theme	Sub-Theme	Quotations
	Labor and Equipment Shortages	• "Labor shortages and container imbalances directly impacted operations." (ID1) • "Ports operated with fewer staff, causing delays and container shortages." (ID11) • "Container shortages and equipment imbalances exacerbated supply chain bottlenecks." (ID21)
	Demand-Supply Imbalances	• "Factory shutdowns and sudden demand surges destabilized rates." (ID6) • "A huge disparity emerged between demand and supply due to disruptions." (ID13) • "Demand spikes and supply chain bottlenecks led to erratic rate fluctuations." (ID21)
	Increased Operational Costs	• "Congestion, labor shortages, and equipment imbalances drove up costs unpredictably." (ID20) • "Rates doubled or tripled within weeks; shippers paid premiums for guaranteed space." (ID21)
Impact of Pandemic-Driven Demand for Essential Goods on Freight Rate Pricing	Surge in Demand and Container Shortages	• "High demand for medical and nonmedical goods during COVID put pressure on global supply chains, making it challenging to meet demand. This caused shortage of containers and port delays, which leads to high freight rates." (ID5) • "This demand spike contributed to container shortages and high shipping costs globally." (ID2) • "Increased demand for medical and non-medical goods added pressure on shipping capacity, creating container shortages and higher prices." (ID7)
	Freight Rate Escalation and Carrier Pricing Strategies	• "Lines used [demand surge] as an advantage and priced high." (ID6) • "Medical goods [...] saw the highest priority and, consequently, higher shipping costs [...] surcharges and capacity constraints made freight rates volatile." (ID20) • "Peak pandemic (2020–2021): $6,000–$10,000+ per TEU, with some shipments reaching $15,000 per FEU due to extreme demand." (ID21)
	Priority Shipments and Capacity Imbalance	• "Priority Shipping- Medical goods often required expedited shipping to ensure timely delivery." (ID12) • "Medical goods [...] were paying very high freight to secure space, which [led to] space shortage for other products [...] eventually other products also had to pay high freight." (ID14) • "Capacity constraints and blank sailings led to higher freight rates across all sectors." (ID20)
	Introduction of Premium Rates and Spot Pricing	• "Spot premium rates were introduced by carriers for guaranteed space." (ID7) • "Governments and businesses prioritized urgent shipments [...] shifting to air freight & premium shipping costs." (ID21)
Prioritization Strategies for Medical Shipments During COVID-19	Regulatory & Contractual Compliance	"Government Directives & Contracts – Many governments secured shipping capacity for medical supplies, reducing space for other cargo." (ID2) "Implemented special measures... in line with our company policy." (ID7)
	Priority Booking & Space Allocation	"Containers carrying vaccines, masks, and sanitizers were given priority over regular consumer goods." (ID2) "Reserved space for medical supplies such as vaccines, medicines, ventilators, and PPE." (ID21)
	Air Freight & Charter Utilization	"Urgent medical shipments shifted to air cargo, while non-essential goods faced delays." (ID2) "Through air freight and UPS courier, [we] managed to arrange timely deliveries during COVID." (ID5) "Special charter flights for vaccines." (ID11)

Theme	Sub-Theme	Quotations
	Premium Pricing Models	"Shippers paid higher fees for quicker deliveries, often delaying lower-priority goods." (ID2) "Adjusting Booking Priorities & Pricing Models." (ID21)
	Humanitarian Freight Corridors	"Some carriers implemented 'humanitarian freight corridors' where medical shipments took precedence over commercial cargo." (ID21)
Surge in Medical and Non-Medical Shipments During COVID-19	Critical Demand for Medical Equipment and PPE	"PPE rose 300–500%, vaccines and equipment saw exponential growth" (ID2). "Urgent demand for medical supplies (PPE, ventilators) to combat the virus" (ID20). "Ventilators, oxygen concentrators, and diagnostic kits were in high demand, leading to bulk shipments" (ID21).
	E-Commerce Growth and Consumer Shifts	"E-commerce grew 30–50%" (ID2). "Surge in e-commerce and consumption of health-related products" (ID20). "Huge increase in non-medical items due to market demand" (ID18).
	Pharmaceutical and Vaccine Logistics	"Pharmaceuticals increased 50–100%" (ID2). "Vaccines required special temperature-controlled shipping solutions" (ID21). "Oman increased imports of essential medicines to ensure supply chain stability" (ID21).
	Government Stockpiling and Supply Chain Adjustments	"Government stockpiling and regional trade coordination led to heightened import volumes" (ID20). "Limited supply from Oman's manufacturers drove reliance on Chinese imports" (ID10).
	China's Manufacturing and Export Capacity	"China is the mass producer with availability of raw material" (ID14). "People relied on China's production capacity for survival-driven consumption" (ID13).

5. DISCUSSION

The findings highlight the multidimensional nature of freight rate volatility during the COVID-19 pandemic. Key disruptions, including supply chain bottlenecks, container shortages, and sudden shifts in consumption, acted in concert to reshape maritime pricing structures. Demand-side shocks, strategic capacity decisions, and dynamic pricing mechanisms created systemic volatility. Prior literature, including work by Notteboom & Haralambides (2022) and UNCTAD (2021), supports these conclusions, while the China–Oman case adds regional specificity.

The word cloud synthesising qualitative responses from shipping professionals operating on the China–Oman route during the Covid-19 period offers rich insight into the lived realities underlying the quantitative trends (Figure 2). Dominant terms such as demand, freight rate, container, shortage, shipping, and port congestion underscore a recurring narrative: the pandemic precipitated a severe mismatch between surging demand—particularly for essential and time-sensitive goods—and constrained supply-side logistics capacity. The frequent occurrence of delays, imbalances, space shortages, and cost increases signals acute operational bottlenecks, aligning with econometric findings that Covid-19 was associated with a statistically significant elevation in freight rates.

Notably, the prominence of medical, non-medical, shipment, and priority highlights the increased urgency and logistical reallocation necessitated by pandemic-era cargoes. While quantitative data revealed smaller TEU volumes for medical goods relative to non-medical cargo, the emphasis on these terms in the word cloud suggests their strategic importance, particularly in terms of scheduling, prioritisation, and pricing. This aligns with the GMM model, where medical goods emerged as a statistically significant determinant of freight rate variation, suggesting latent effects not captured by volume alone.

Other terms—Oman, China, lockdown, global, supply chain, and disruption—emphasise the spatial and systemic nature of the crisis. These reflect stakeholder recognition of globally synchronised constraints, validating the use of models with dynamic structure and fixed effects to isolate time-variant shocks from firm-level characteristics.

Finally, the frequent mention of vessel, space, capacity, and equipment suggests that the rise in rates was not solely demand-driven but also exacerbated by systemic limitations in container availability and port throughput. The interplay between constrained supply and heightened demand—visible both in qualitative expressions and econometric coefficients—suggests that freight pricing during Covid-19 was shaped by complex and interdependent factors, including strategic cargo prioritisation, volatile supply chain flows, and prolonged uncertainty.

Table 3 below presents the coded findings from one of nine open-ended questions (OEQs) posed to 30 executives and managerial-level employees from a mix of container shipping lines and freight forwarding companies, focusing on the impact of COVID-19 on China–Oman freight rates during 2020– 2021. The qualitative responses were analysed using Atlas.ti, through which data segments were grouped into sub-themes and subsequently organised under a broader thematic category. This thematic framework allows for a structured representation of key issues raised by respondents in relation to pandemic-related disruptions to freight rates.

6. RECOMMENDATIONS

In light of the findings, several comprehensive policies, operational, and strategic recommendations are proposed to mitigate future volatility in container freight rates and to build long-term resilience in maritime logistics systems.

1. IMPLEMENT PREDICTIVE, AI-DRIVEN FORECASTING TOOLS

Traditional forecasting methods, as seen during the COVID-19 pandemic, failed to anticipate the scale and scope of market disruptions. Stakeholders should invest in AI-powered analytics that combine real-time data feeds with machine learning models. These tools can detect early indicators of disruption, such as vessel congestion, demand surges, and geopolitical developments. Integrating such forecasting into port operations, shipping networks, and customer interfaces will improve agility and responsiveness across the supply chain.

2. DEVELOP REGIONAL DIGITAL FREIGHT PLATFORMS

Poor visibility and communication gaps across stakeholders exacerbated many disruptions. Governments and private operators should develop regional digital freight platforms to centralize information on vessel schedules, cargo availability, customs status, and equipment repositioning. Platforms like Port Community Systems (PCS) and Maritime Single Windows (MSW) can enhance transparency, minimise duplication, and expedite processing times. In Oman, a national digital freight exchange can facilitate seamless coordination among Sohar, Salalah, and Duqm ports.

3. STRENGTHEN MULTILATERAL COORDINATION ON CRISIS PROTOCOLS

The lack of coordinated international response during COVID-19 magnified the impact of localized decisions. Establishing multilateral agreements under institutions like the International Maritime Organisation (IMO) can support synchronised crisis protocols, such as harmonised port closure guidelines, shared digital health passports for crews, and regional rate stabilisation frameworks. A dedicated 'Maritime Resilience Task Force' could facilitate real-time coordination during global emergencies.

4. PROMOTE FAIR PRICING MECHANISMS FOR SMES

Dynamic pricing disproportionately benefits large-volume shippers while disadvantaging small to medium-sized enterprises (SMEs). Regulators should encourage carriers to publish benchmark pricing indices and require them to maintain transparent surcharge policies. In addition, governments can provide subsidies or cargo space guarantees to ensure SMEs retain market access during crises. Public-private dialogues should explore ‘equity in access’ as a core logistics principle.

5. EXPAND CONTAINER AVAILABILITY THROUGH REGIONAL HUBS

The severe shortage of empty containers during the pandemic revealed vulnerabilities in inventory and repositioning practices. Regional container depots, supported by digital tracking, should be established in key transit corridors. Pooling agreements among carriers could facilitate more efficient container reuse and reduce repositioning delays. In Oman, establishing inland container depots (ICDs) near industrial hubs could ease congestion at coastal terminals.

6. MANDATE EMERGENCY PREPAREDNESS AUDITS FOR PORTS

Ports must adopt and regularly update business continuity plans. These should include simulations for sudden cargo surges, labor shortages, and health-related shutdowns. Ports should be required to conduct annual stress tests, publish risk audit summaries, and coordinate emergency drills with customs, coast guards, and health ministries.

7. FOSTER PUBLIC-PRIVATE RESILIENCE PARTNERSHIPS (PPRPS)

A key weakness during the pandemic was the fragmented response between public infrastructure owners and private operators. Formal Public-Private Resilience Partnerships can facilitate shared risk assessments, co-investment in resilient infrastructure, and mutual support agreements. In Oman, a PPP framework involving the Ministry of Transport, the Oman Logistics Center, and shipping alliances can institutionalise such collaboration.

8. INVEST IN GREEN AND DIGITAL INFRASTRUCTURE SIMULTANEOUSLY

As decarbonisation becomes a global priority, maritime investments must align with both environmental and digital goals. Port modernisation programs should include automation technologies, cold ironing facilities, digital twins, and emissions tracking systems. These dual-purpose upgrades will enhance operational efficiency while reducing the environmental footprint, thereby building long-term sustainability into resilience planning.

9. CREATE MARITIME POLICY INNOVATION LABS

Policy agility is crucial for responding to rapidly evolving logistics crises. Governments and universities should create innovation labs that explore scenario modeling, simulate rate inflation pathways, and pilot new regulatory models. These labs can help inform evidence-based policy and ensure that maritime governance keeps pace with emerging challenges.

10. ELEVATE MARITIME LOGISTICS IN NATIONAL SECURITY STRATEGIES

Freight reliability is crucial for ensuring food security, maintaining medical supply chains, and promoting economic stability. Maritime logistics must be formally recognized as critical national infrastructure. This includes integrating freight flow continuity into national emergency plans, cybersecurity policies, and regional disaster response strategies. Maritime resilience should be a standing item in national security dialogues and budget allocations.

11. ENHANCE TRAINING AND CAPACITY BUILDING FOR FUTURE DISRUPTIONS

Human capital development remains a key factor in building resilience. Training programs in risk analytics, crisis coordination, and digital port management should be institutionalized. Regional certification standards and continuing education initiatives can ensure that the workforce is prepared for future disruptions.

12. DEVELOP CORRIDOR-SPECIFIC STRATEGIC FREIGHT PLANS

Ultimately, resilience must be tailored to the specific needs of individual trade corridors. For the China–Oman route, strategic planning should include agreements on port call reliability, container guarantees, and customs interoperability. Bilateral freight diplomacy can improve route efficiency while reducing exposure to unilateral rate shocks.

In summary, container freight resilience is not simply a function of supply and demand balance but a product of systems thinking, technological adoption, regulatory foresight, and cross-sector collaboration. The above recommendations, drawn from empirical findings and qualitative feedback, aim to provide a robust roadmap for governments, carriers, and logistics providers navigating future global disruptions.

7. CONCLUSION

The study examined the impact of COVID-19 on container freight rates, with a microscopic focus on the geographical route from China to Oman. It was clear that COVID-19 caused significant disruptions to global supply chains by paralyzing their mechanisms. The evaluation period for assessing the impact ranged from 2019 to 2023, as the influence of COVID-19 on container freight rates peaked from mid-2020 to early 2022, according to reliable rate indices, reports, and publications. However, the actual influencing factors remained unknown, posing a dilemma for the world and all stakeholders in the container shipping industry for an extended period. Subsequent research studies conducted by academics and other interested parties aimed to uncover the genuine reasons behind the freight rate inflation caused by the pandemic. Supply chain movements are core influencing factors in any economy, fulfilling people's wants and needs while generating primary revenue streams through export cargo shipments. Disruptions in the supply chains of any economy create ripple effects on the country's bottom line and the daily basic needs of the population, particularly in economies that heavily rely on imports. Countries like the Sultanate of Oman are more dependent on imports but manage to offset import expenditures by exporting their natural resources, primarily in raw material form. Conversely, China has a more export-oriented economy, manufacturing goods to meet the world's needs at competitive price levels in the global market. China is a significant importer from Oman, purchasing large volumes, while Oman is one of the leading exporters of raw materials to China. Consequently, the trade route between China and Oman is crucial; any disruptions to the supply chain will significantly impact both countries. The impact of COVID-19 on the China-Oman sea trade route was substantial during the pandemic, reflecting the state of global supply chains.

The research idea originated from examining the supply chain disruptions between China and Oman during the pandemic, as the researcher observed freight inflation within the supply chain industry. The determination to identify the real factors influencing the freight rate hike stemmed from mounting complaints against container shipping lines, which alleged that they manipulated freight surges to generate extra income and profits, using the pandemic as a scapegoat. The researcher was motivated by the research idea and, simultaneously, by the research problem of examining the real factors that cause freight rate inflation. The study employed a mixed research methodology to augment the reliability and validity of the findings by synthesising both qualitative and quantitative research approaches. This study aimed to fill the gap in previous literature and provide a comprehensive examination to derive the most accurate yet challenging outcomes.

Since the COVID-19 impacts talked about more numbers than words, the researcher has given priority to the quantitative analysis involving numbers published by reliable secondary sources in the field of shipping and maritime. On the other hand, the qualitative approach was adopted to enhance the rigour of the study and ensure that there are no gaps in the research methodology employed in this study. The research sample is crucial to a study's ability to represent real-world numbers and opinions accurately. The researcher selected the research sample from within the container shipping line industry itself, ensuring that the selected sample was aware of the factors that contributed to freight rate inflation during the pandemic. The research sample consisted of experienced professionals from leading container shipping lines and freight forwarding companies based in Oman who are involved in making day-to-day commercial and pricing decisions.

The Delphi expert panel survey was used among a large number of research samples to derive personal experience and insights on the subject topic; however, the response rate was limited to twenty-one participants due to the busy nature of work among shipping and logistics staff. The researcher developed the conceptual framework of the study by using one main driver, the COVID-19 pandemic, and three other sub-drivers: demand for medical and non-medical goods, freight forecast accuracy, and factors impacting freight rates. The quantitative study was conducted using statistical data published by reputable industry leaders, spanning nearly six months from data collection and analysis to the final results.

The study results proved that most of the study variables contributed to the freight rate inflation during the pandemic, with the most significant impacts occurring during mid-2020-late 2021 when the pandemic was at its peak. New findings revealed factors that influenced the freight rate hike, such as supply chain disruptions, container equipment shortages, port congestion, labor constraints, shifting consumer patterns, and erratic vessel schedules. There was some divergence between the two analyses regarding medical and non-medical goods. Medical goods achieved statistical significance only in dynamic models, yet qualitative data suggest that prioritizing medical shipments was a key operational strategy that distorted capacity allocation and pricing norms. Respondents noted that medical cargo often commanded premium rates and displaced commercial goods, while consumer demand for non-medical items—like home furnishings and electronics—was also influential. Despite these nuances, the overarching narrative remains consistent: the pandemic disrupted pre-existing market equilibria, exposing systemic vulnerabilities in global shipping and reshaping freight rate dynamics along the China–Oman corridor.

The results of the study are not only important to stakeholders in the container shipping industry, but they will also generate ideas for managing future similar pandemic situations globally. The new research findings will serve as a blueprint for potential futures, providing lessons learned from the past along with an adequate mitigation action plan to prevent chaos in freight rate inflation and to avoid negative experiences caused by supply chain disruptions during the past pandemic period, when essential medical supplies were significantly delayed due to extreme sea freight costs that skyrocketed beyond budgeted expectations. Although the research was conducted using a single trade line from China to Oman, the geographical territory of the Sultanate of Oman, its findings are broad and applicable to the global container shipping industry, which experienced similar shocks during the pandemic with freight rate inflation. The study will contribute to literature as the foundation for understanding the impact of the COVID-19 pandemic on container freight rates, providing valuable insights for businesses and scholars in related fields to inform future studies. The researcher is very confident and transparent about the vision of this study from start to finish, emphasizing that research studies and their empirical outcomes can impact the triple bottom line: people, planet, and profit.

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