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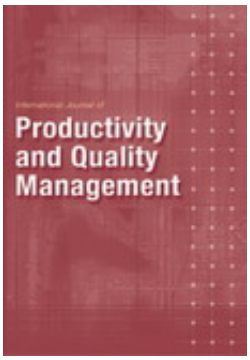

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Supply chain disruption at the US ports: an assessment of underpinnings using the fishbone approach

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Supply chain disruption at the US ports: an assessment of underpinnings using the fishbone approach

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Abstract: A unique supply chain disruption in the USA created shortages resulting in inflated prices of products regularly sourced from foreign production locations despite their availability at pre-pandemic levels at the US ports. This study uses the 'fishbone' or 'cause and effect' diagram, a graphical tool developed by Ishikawa, to analyse the underlying reasons for this unique disruption. Our analysis reveals that this disruption emerged from the interaction of lingering effects of the COVID-19 pandemic and structural limitations of US West Coast ports. Discussion of factors deemed responsible for the disruption is elucidated along with managerial implications and the study's limitations.

Keywords: supply chain disruption; blockage at US ports; effect of COVID-19; infrastructure challenge and application of fishbone approach.

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1 Introduction

Coordinating all activities and processes beginning from raw materials acquisition to manufacturing to distribution till the final product reaches the end-consumers, supply chain management (SCM) is regarded as the most critical intra-and inter-organisational function of firms. Propelled by improved technologies, trade agreements, raw material availability, favourable environmental, economic, political, and cultural conditions, and globalisation of production has made the supply chain networks increasingly complex (Colicchia and Strozzi, 2012; Srinivasan and Tew, 2018). The dynamic nature of today's business environment and the impact of the above factors make managing global supply chains challenging for businesses. Furthermore, several global events over the last decade such as the coronavirus pandemic, ongoing tariff wars, Middle East volatility, Brexit, and the world's overdependence on China as the producer of critical goods have made supply chains more prone to disruption and fragile (Burke, 2005; Kamalahmadi and Parast, 2016; Zhu et al., 2020). While it is hoped that the disruptive impact of these factors on global supply chains leading to the USA and Europe will be short-lived, the world's sheer inability to conceive alternative supply chains that are resilient to external threats remains to be materialised.

Logistics plays a vital role in global supply chains, and it has become an even more crucial business function because of the pandemic. Most goods flowing through supply chains take weeks through seaways to arrive at their consumption destinations. Therefore, any disruption at the sourcing locations and consumption locations is likely to create bottlenecks at those ends (Sheffi and Rice, 2005). Recently, according to Varley (2021), the USA and other western countries, due to blockages at their seaports stemming from lingering effects of the pandemic, experienced prolonged disruptions in goods arriving from sourcing countries. In particular, the seaports on the West Coast experienced weeks of disruption due to pandemic-induced limited functioning of seaports resulting in challenges for the US organisations to meet their consumer demand. Other than the media-reported reasons, comprehensive identification of reasons underlying the current supply chain disruption at these seaports would be helpful for SCM researchers and managers to plan against such disruptions in the future.

The cause-and-effect approach can assist in identifying causes that influence the blockage or ocean logistics disruption at the West Coast, and hence, the raison d'etre of the study. This approach has been found valuable in several supply chain studies (Bose, 2012; Desai et al., 2015; Srinivas and Sreedharan, 2018). The study proceeds as follows. First, we briefly discuss the importance of SCM. Second, we draw out the issue of West coast supply Chain disruption. Third, we apply the fishbone diagram to model the supply chain disruption and explain disruptive behaviour factors. Lastly, the study ends with managerial implications, conclusions, and limitations.

2 Supply chain management

SCM consists of planning and management of all activities such as sourcing and procurement, production, and logistics. Importantly, supply chains also include coordination and collaboration with channel partners, which can be suppliers, intermediaries, third-party service providers, and customers (Oliver and Webber, 1982; Beamon, 1998; Sumchi-Levi et al., 2008; Blackstone, 2013; Vitasek, 2013). Wisner (2017) describes a supply chain as a network of companies in the production of goods, services, and associated functions for the consumers. SCM furnishes the opportunity to capture the synergy of intra-and intercompany integration and management and thrives for total business excellence and relationships with other members of the supply chain network (Lambert and Cooper, 2000). The main objectives of supply chains are to enhance organisational performance and improve customer satisfaction by efficiently delivering products or services to them while each member of the network adds financial value (Sahin and Robinson, 2002). Additional supply chain goals include maximisation of responsiveness, customer satisfaction and flexibility to customers, cost minimisation, cycle time reduction, return on assets, and profit maximisation. The various risks associated with supply chains must be thoroughly understood and effectively managed along with quality assessments and control to be integrated at all stages of the supply chain to deliver these promises. A typical supply chain involves the management of five flows, materials, financial, value, and risk flows, which describe the production or conversion process taking place along the supply chain (SaiKrishna, 2016). Shibasaki and Kawasaki (2021) simulated an international intermodal container shipping model to study the impact of policies aimed at boosting the logistics infrastructure. They examined the

role of improving road and rail networks in India and cross-border barriers between India and Sri Lanka.

In the global supply chain, member organisations are located globally because of which, the management of SC has become more complex. The financial benefit from global supply chain networks comes with risk. Several other authors studied risks in global SCM (Jüttner, 2005; Tang, 2006; Sabahi and Parast, 2020). Manuj and Mentzer (2008) indicated supply risks, demand risks, and operational risks. Supply risks affect inbound supply elements, demand risks affect outbound supply elements, and operational risks affect elements within the supply chain. These studies suggest that factors that contribute to supply chain risk include environmental (e.g., natural disaster, weather, pandemic), geopolitical (e.g., political instability, trade restrictions, terrorism, corruption, and illicit trade), economic (e.g., demand shocks, price volatility, exchange rate, energy shortages) and technological (e.g., IT and communications technology disruptions). Moritz (2020) discussed the impact of COVID-19 disruptions on the supply chain. He points out a unique nature of this disaster – its global impact, making it hard for neighbouring or distant countries to offer significant help. He suggests that the suffering by locals in Japan impacted sales of luxury goods, resulting in the closure of luxury retail outlets in that country.

2.1 West Coast supply chain disruptions

What do the USA, Singapore, Dubai, Qingdao, Busan, and Surabaya have in common? They all have congested seaports, with scores of waiting ships; however, the West Coast port in the USA experienced a unique disruption. According to Velshi (2021), the effectiveness of global supply chains at the US West Coast ports was disrupted by port congestion and lack of workers, among other factors. However, we argue that the answer lies in the confluence of lingering effects of COVID-19 and the US logistics-related infrastructural arrangement on the inbound supply chain to the USA.

The COVID-19 pandemic that came into existence in late 2019 and early 2020, impacted Chinese plant workers resulting in significant production disruptions, which, in turn, disrupted consumption across the world. Subsequently, the spread of the COVID-19 infections in the USA and around the world kept people at home, resulting in significant changes to their shopping patterns. For instance, the growth rate of traditional retail sales in the USA slowed down to 2.1% and –3.5%, respectively, in the first and second quarter of 2020 from the third and fourth-quarter growth rate of 3.8% in 2019 (Young, 2021). This slump in sales was followed by a 16.6% spike in the second half of 2020 with total sales of $2.15 trillion, with e-commerce garnering $409 billion in sales – an increase of 21.9% over the first two quarters of 2020. This upward sales trend was expected to continue, but that did not materialise.

Traditionally, the US retailers have conducted over 50% of their yearly business during the four weeks between Thanksgiving and Christmas, for which they usually place orders with suppliers as early as in July. In the second part of 2021, the overall retail sales, fuelled by the spike in e-commerce, created a substantive surge in demand for products, most of which are shipped from China. While China resumed production to pre-pandemic levels in August 2021, the US ports, especially the West Coast ports, which unload about 40% of the incoming shipments, were unprepared to handle the incoming ships because of surging COVID-19 pandemic infections in the USA. As a result, these

ports were under-staffed conducting limited operations resulting in slow unloading of ships. Additionally, the COVID-19-related shortage of trucks and truck drivers exacerbated the slow movement of consignments from ports to the distribution centres. With an increasing number of ships waiting to be processed, the docks and transportation of consignments got swamped. In mid-November 2021, most stores throughout the USA. fell short of ordered merchandise, resulting in shoppers facing empty shelves, which resulted in inflated prices of the available products.

A few studies have offered solutions to deal with such problems in the future. For example, Midkiff (2021) suggests a 'control tower' approach to supply chains. He suggests a transparent, real-time data-based approach that can potentially improve performance and lower costs by the development of smart strategies (e.g., alternate routing, optimisation, etc.) to deal with issues like port congestion and delayed shipments. Rodriguez et al. (2022) offer a multi-criteria fleet deployment model that has the potential to simultaneously reduce costs and delivery times with minimal environmental impact. They tested their model on maritime and railway routes connecting US East/West Ports with China and reported that regulating carbon dioxide emission standards were found to impact shippers' lead times adversely while benefiting liners with lower costs. This study is of the view that a better way to deal with such a unique problem in the future is to use the Fishbone approach to identify the underlying reasons for such supply chain disruption at the receiving ports and propose workable solutions as this approach logically and visually depicts the impact of various factors that can put the supply chain in peril.

3 The fishbone diagram approach in supply chain disruptions

The 'fishbone' diagram, also called a cause-and-effect diagram, is a graphical tool used to analyse and present the possible causes affecting complex problems (see, e.g., Evans and Lindsay, 2020). In the context of the supply chain, this approach is used to analyse a business situation and/or quality issues under the major categories of materials, methods, equipment, environment, and humans. This graphical approach helps problem solvers understand the causes influencing a problem and the relationship among those causes. A limited number of studies incorporate the cause-and-effect relationship between transportation disruption factors. For example, Fartaj et al. (2020) analysed the critical supply chain transportation disruption factors of automotive parts manufacturing companies located in Ontario, Canada. Their findings indicate that infrastructural bottlenecks or congestion and scarcity of skilled labour are the most influencing factors of disruption in the transportation network in the automotive industry. In the absence of a rigorous academic study dealing with this unique supply chain disruption in the USA, it was deemed fit to use information from news channels, e-bulletin, blogs, national and international news segments, experts' interviews, social media, etc. to surmise and appraise various factors influencing the disruption.

Interlinking between the variables suggested by these sources made it imperative to apply the Fishbone diagram to capture the inter-relationship between variables. It is conceivable that various variables by themselves played a minor role; however, their combined effect 'broke the camel's back.'

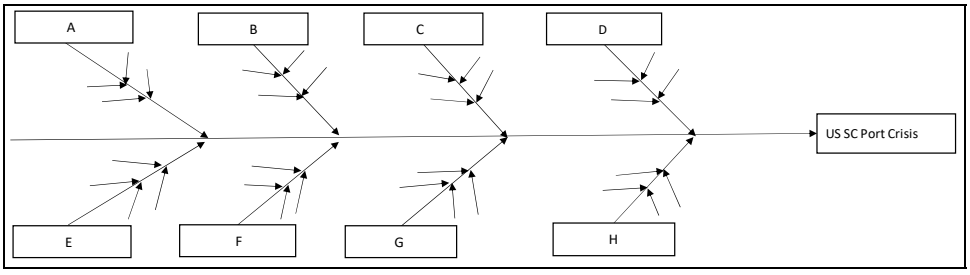
It would be worthwhile to demonstrate the hierarchical nature of dependence between various variables causing a major impact on this supply chains disruption.

Figure 1 depicts variables A (port operations), B (port design), C (technology), D (road infrastructure), E (consumer demand), F (fleet and operators), G (COVID), and H (external issues) as the plausible main causes for this US supply chain disruption. Each variable has several related issues or sub-causes that are also identified. The relative importance of each variable is not determined by its positioning in the fishbone diagram. For example, variables D (road infrastructure) and H (external issues) are deemed equally important to variables A (port operations) and E (consumer demand). A listing of each variable and their corresponding related issues are presented in Table 1.

Table 1 Summary of cause factors and sub-factors

Cause	*Course description*	*Sub-causes*
A	Port operations	Hours of operation
		Unionisation
		Working condition
		Employees shortage
		Regulatory issues
B	Port design	Space limitation
		Limited number of cranes
		Stack-ability of containers
		Structural limitation
C	Technology	Limited implementation of robotics
		Limited use of the implemented technology at port
		Employees' level of comfort to use technology at port
D	Road infrastructure	Quality of interstate highways and bridges
		Limited heights of the under-bridges
E	Consumer demand	Instant gratification mentality
		Pent-up demand due to COVID-19
		E-commerce uptake
		Fundamental shift in shopping habits
		Stimulus fund distribution
		Imbalance in demand and supply
F	Fleet and operators	Nationwide shortage of trucks
		Nationwide shortage of truck drivers
		Age limit of drivers
		Lack of diversity of drivers
		Regulations on hours of operations
		Limited technology inside vehicles
		Operators' compensation
G	COVID-19	Closed factories overseas
		Limited operation of manufacturing plans overseas
		Shortage of employees due to health/vaccine concerns
H	External issues	Seasonal demand
		Business practice

Figure 1 Cause and effect diagram for the USA supply chain port crisis



3.1 Port operations

A multitude of reasons underlies port-related contribution to the current supply chain disruption. The first reason is the traditional fixation with a 10 to 12 hours per day operation schedule at US ports. The rapid increase in the number of ships waiting to unload necessitated the 24 × 7 operation paradigm (Boak, 2021). However, the port unions are generally not amenable to pressures to change the status quo.

Second, the low US unemployment rate has created a lack of an available pool of port workers with desired skill set. Lastly, an ever-increasing plethora of port regulations related to the conduct of vessels, safety, order in the port area, protection of the environment, and loading and discharging of goods, among others, are likely to have slowed the port operations.

3.2 Port design

Most US ports were not constructed to accommodate the level of ship traffic being faced currently. These ports have limited free space for containers. Also, the safety regulations have traditionally limited stacking of containers to a maximum of three due to structural limitations of these ports. The problem is particularly intense at Los Angeles and Long Beach ports that process 40% of all goods arriving at the USA. To alleviate the congestion at the US ports, there have been musings about constructing inland ports. However, the lack of sufficient crane supply, and the construction time required, makes them an unlikely option. Guerrero et al. (2022) examined the impact of pandemic mitigation policies enacted by several countries on the maritime network. Their study offered suggestions and strategies for ports (e.g., port size, interconnected port density, etc.) and transportation. The study concluded that bigger and smaller closely connected ports withstood the pandemic crisis better than other port configurations. Their study demonstrates support for the construction of large ports in the USA.

3.3 Technology

Several innovative technologies such as the internet of things (IoT), artificial intelligence and machine learning, cloud computing, etc. have been incorporated into port logistics operations. Their operational effectiveness is determined in part by employees' age and work experience, exposure to technological training, and ability to learn innovative technologies and analytical skills (Fabiano et al., 2010). According to Sakar and Shankar

(2021), investment in infrastructure and technology should be prioritised. In addition, they recommend the development of common operational standards and employee's skill enhancement, and supply partner collaboration. For example, unlike Amazon, which uses robots to fetch customer order products, the US ports rely upon visual inspection and manual retrieval that is not necessarily optimally planned or executed (Day, 2021).

3.4 Road infrastructure

The existing state of disrepair in highways and bridges throughout the USA slows down the movement of trucking traffic (Pecorin, 2021). Despite the recent passage of the $1.1 trillion infrastructure bill by the US Congress, it will perhaps take several years before a significant impact can be realised. Most under-bridges in the USA were not constructed to permit the flow of stacked container traffic, which creates a significant impediment to alleviate the good congestions due to surging US consumer demand. Due to the growth of public-private-partnership (PPP), several states have constructed several well-paved toll roads. Trucking companies that seek to optimise their operating costs while transporting the goods take higher delivery times via poorly paved non-toll roads. To provide alternate funding for 46,876-mile interstate road maintenance, in addition to the 18.4-cent federal gas tax, several states are open to developing toll roads (Karklis and Wilson, 2014). In short, the existing road infrastructure exacerbated the recent supply chain disruption.

3.5 Consumer demand

The US consumer is used to instant gratification (Kacen and Lee, 2002; Liu et al., 2013). Once they purchase products, they expect expedited delivery of the ordered items. Delays are often 'deal-breakers' for sellers. This applies significant pressure on supply chains to be efficient with an optimal fulfilment rate.

While the spread of COVID-19 put significant brakes on retail shopping, it catapulted online shopping to new highs while preserving the instant gratification mentality. Additionally, a significant number of US workers have been moved to the telecommuter status, which further burdened the already heightened state of online ordering. The $1.9 trillion stimulus bill passed by the current US administration to jump-start the economy and put money in the hands of consumers also intensified the already existing increase in online ordering. Suppliers of several products have been caught, unprepared for the onslaught of online orders while dealing with workforce and global production challenges caused by the pandemic.

3.6 Fleet and operators

There is a nationwide shortage of trucks and truck drivers in the USA, which contributed to the supply chain disruption through delayed deliveries from ports to consumption destinations. There has been an attempt to increase the driver pool by lowering the minimum driving age requirement to 18 years from the current 21 years, and appealing to all demographic segments.

Additionally, to persuade more people to join the trucking pool, an attempt is made to boost the compensation, revamp the truck stops, modify the truck interior to facilitate the longer travel time comfortably and, with additional technology, and increase the

limitation on total travel time allowed per driver per day, etc. (Kelly, 2022; MacMillan, 2021). These purported improvements, however, would take time to materialise.

3.7 COVID-19

The COVID-19 pandemic has impacted the entire world in a cyclic manner. For example, at the time of peaking infections in China, the primary sourcing location for the US imports, the US exhibited troughs and vice versa. Since the first reporting of COVID-19 infections in China, the USA and the world have experienced at least three cycles of high and low infection rates. Since these infections have a debilitating impact on human health, including death, they have resulted in closed factories and offices overseas and in the USA due to workers' illness. Additionally, the host governments periodically used isolations and quarantines to control the spread of infections among their people. Collectively, the spread of the COVID-19 pandemic and the protection from infection strategies have resulted in a mismatch between supply and demand for products flowing through supply chains originating from sourcing locations to the USA. Since many US companies use China as their top source, we consider that these cyclical supply chain disruptions primarily created the recent product shortages resulting in inflated prices, and erroneous forecasting of supply and demand of the product, trucking services, and workers deployment at the ports.

3.8 Other issues

This category attempts to cover issues external to the supply chain disruption that assumed importance during the recent US supply chain disruption. We describe two issues, both of which are related to social media. The first among them is the abuse of social media in spreading misinformation about the lack of availability of products at stores, thereby contributing to inflated prices. The second one entails the spread of misinformation about the FDA-approved vaccines (Pfiser, Moderna, and Johnson & Johnson), resulting in almost 40% unvaccinated population in the USA as of December 2021. It is feared that this large swath of the unvaccinated population can become the breeding ground of new variants of the Coronavirus and also become its super-spreader. Lastly, a third issue relates to the retail store practices that create a sudden surge in demand by providing easier credit terms, layaway plans, special coupons (e.g., black Friday sales), and easy return policies to boost holiday sales. The net result of the combined effect of all these issues has contributed to workforce impairment throughout the global supply chains, including logistics networks.

4 Conclusions, implications, and limitations

The world has been accustomed to efficient global supply chains meeting their consumers' needs. The pandemic has fundamentally altered the functioning of the supply chain on several fronts.

The present study has attempted to identify and explain the behaviour of several impacting factors from the US perspective. In particular, the study focused on the congestion at the US ports and presented a plausible cause-and-effect model to explain the crisis. The study suggests several managerial implications.

First, the disruption problem is comprehensive in nature, whereby no quick-fix scenario seems plausible. Second, while COVID-19 plays a dominant role in the supply chain disruption, the 80-20 rule of Pareto optimal strategy may be implemented by individual ports to curb their supply chain disruption based upon relevant factors, including economic and geographic factors. While the attempt was made to identify the major factors based upon a thorough analysis of prevailing academic and practitioner-based literature and social media reports influencing port disruption in the Fishbone approach, the model makes provision for the inclusion of additional variables in future studies.

Supply chain disruption has become a topic of household discussion in the USA. Experts seem to agree about one thing – the problem will get worse before it gets better. The forecasts for resumption of normal functioning at ports range from February 2022 to July 2022. Meanwhile, the shoppers are advised to be patient and plan their holiday shopping, anticipating delays. Supply chains have certainly received adverse publicity in the USA since the spread of the COVID-19 pandemic. While the issues of inflation and shortages have taken assumed substantial importance, active search for potential solutions and plans to make the situation better continues (Helper and Soltas, 2021).

Like all studies, this study does entail limitations. First, although the study included several plausible reasons underlying the recent supply chain disruption, they do not form a closed set as other reasons might have been left out. The second source of limitations stems from the use of the cause-and-effect approach. Though it is a powerful technique for analysing complex problems, the fishbone approach has its own limitations, such as its inability to differentiate more significant from less important reasons (Islam et al., 2016) as well as non-systematic or non-business supply chain risks (Desai et al., 2015).

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