

Supply Chain Resilience: Warehousing Role and Regionalization Effect During COVID-19

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Abstract- This paper discusses supply chain resilience, how warehousing and regionalization plays a role during unforeseen disruptions. The paper includes a literature review that covers business continuity, a dive down into supply chain resilience and its strategies, as well as brief sections for the inventory management and supplier development roles. In addition, a study has been conducted that allowed us to derive key lessons learned from this case analysis where supply chain resilience strategies have had a major impact on determining the various supply chain parts roles and weight during the uncertainties brought by COVID-19 Pandemic and Global Financial Crisis. The findings indicated that warehousing and regionalization which are contradicting with JIT and globalization concepts contributed in the greater supply chain resilience.

Keywords- Supply Chain, Warehousing, Regionalization, Business continuity, Supply chain resilience, Safety stock

1. Introduction

Corona Virus Disease (COVID-19) has brought a worldwide crisis not only for human lives, but also economical activities like manufacturing, supply chain and logistics, and several other sectors. [21]. It was reported that as of early 2020, more than 90% of the Fortune 1000's companies were facing supply chain disruptions due to COVID-19. The high effect of COVID-19 occurrence brings forth the need of a resilient supply chain and to seek innovative approaches for supply chain recovery [21].

Warehousing function is a vital part of the supply/demand structure and plays a strategic role in supply chain management [18] this place it in a tactically important position for operational companies and helps them to mitigate negative impacts arising from unforeseen circumstances [19]. The logistics systems involving warehousing is critical in managing disruption and recovery of supply chain. As a supply chain can be understood as a network of organizations mutually and co-operatively working to manage the flow of materials and information from suppliers to end users, it

should be stressed that global supply chains and the associated complex material flows predominately rely on logistics infrastructure mainly transport and warehouse services [22]. Consequently, the warehousing function is an important part of supply chain resilience that focuses on mitigating risks associated with materials/ products availability and facilitates procurement economies of scales. [19].

Various researchers have investigated supply chain warehousing [20], however the literature is not well represented with regards to the persistence of the warehousing role during supply chain disruptions. Given the critical role of warehousing in supply chain management, there seems to be only limited research so far that specifically investigates the significant role of warehousing for supply chain resilience during the unprecedented disruption caused by COVID-19. In other words, there is a lack of understanding to what extent warehousing reacted to the disruption and what alternative strategies are in-place to ensure business continuity and survival of the supply chain. In this paper, we assess the impact of supply chain disruption caused by COVID-19 on the level of warehousing operations for Saudi Aramco. We examine to what extent warehousing reacted to the disruption and what alternate procurement strategies are in-place to ensure supply chain survival.

2. Literature Review

Several Journals, books, and websites have been reviewed concerning the business continuity program, the supply chain reliance definition and strategies as well as the warehousing, inventory management, supplier development and regionalization role as part of the supply chain resilience. The keywords that have been used in the research engines are "Supply Chain", "Warehousing", "Regionalization", "Business continuity", "Supply chain resilience" and "Safety stock".

2.1 Business Continuity

The recent years have re-ignited the interest of business continuity program, this program originated in the form of crisis management back on the 1970s and evolved to what we

know it today. One key event that had a huge influence in reshaping the business continuity program is the September 11 as it served as a validation for the need of business continuity practices [1]. 22301 is the International Organization for Standardization (ISO) code for Business Continuity Management program where it is described as a holistic management approach to assess possible risks, predict their implications and prepare for alternative ways to continue the business as usual in case it impacted key stakeholders, reputation, brand and business processes. ISO is following the “Plan-Do-Check-Act” method where it starts in the planning stage by creating business continuity strategy, defining overall goals, founding events control and launching procedures. The next stage is to implement and operate the business continuity strategies. Next, there is checking stage where monitoring and revising overall routine against strategies and goals which ensure reaching favorable results and governs suitable actions that should be followed. Lastly, maintenance stage and improvement which is guaranteed through appropriate corrective actions based on the results of stakeholders’ review and reassessing the scope of strategies and goals [2]. IT security is one of the main fields that got the most attention from the early business continuity practitioners, however after few years other fields took the same path [3]. One article reviewed a city current logistic model and possible consideration of associated risks to be incorporated [4]. Another article explored BCM in the healthcare sector and the effect of unforeseen events on hospitals where it revealed that there is an area for improvement that can be fulfilled through a well-rounded business continuity program considering possible risks [5]. A study was also conducted to assess the local Japanese governments response to earthquakes and tsunamis and their guidelines to utilized for such cases where it concluded that a clear business continuity plans should be established by the central government in alignment with ISO22301 methodologies [6]. Different fields are capitalizing on the business continuity practices as shown in the above, nevertheless one area was found to have a vital need for BCM which is the supply chain field, this need goes both ways as these two concepts (BCM & supply chain) require each other existence to thrive [7].

2.2 Supply Chain Resilience

There is no agreement within the literature community on the definition of supply chain resilience [9]. One definition described it as “the ability of a supply chain to both resist disruptions and recover operational capability after disruptions occur. “This definition considered two main parts, first is the “resist” which is focused on considering the present risks the might impact the supply chain operation and avoid

them or minimize their likelihood. The second part is “recover” which is focused on how can the operation go back to its normal state if the unforeseen event happen [8]. Another definition” supply chain resilience is the ability to proactively plan and design the supply chain network for anticipating unexpected disruption (negative events), respond adaptively to disruptions while maintaining control over structure and function and transcending to a post robust state of operations, if possible a more favorable one than that prior to the event, thus gaining a competitive advantage” [10]. Below figure 1 shows the timeline for supply chain resilience.

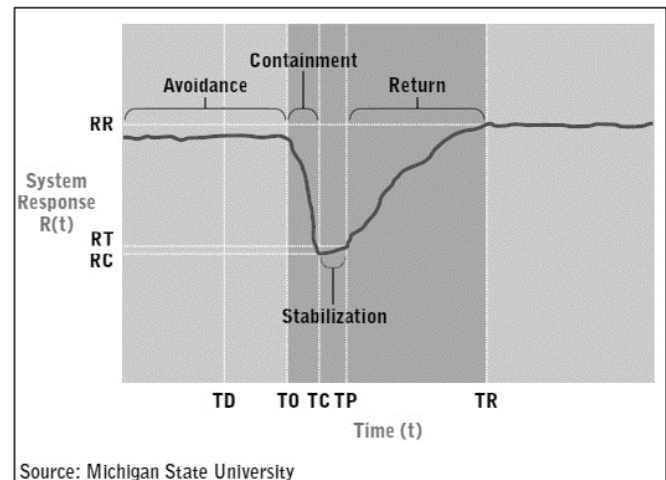


Figure 1. Timeline for Supply Chain Resilience

One researcher elaborated on the different supply chain resilience strategies including proactive, reactive and combination of both:

1. Proper supplier selection – Applying a selection criterion will support the reduction of unforeseen interruptions and their after effect, for example political steadiness in the suppliers’ areas, quality, abilities (e.g. technological), monetary stability, business continuity, dependability, etc.
2. Establishing security – Assessed through the protection of the supply chain against deliberate interruptions, e.g. robbery, terrorism and the infiltration of imitations
3. Establishing community capital and relational abilities – Active communication and data sharing prior to the interruption event increases risk awareness and minimize weaknesses, e.g. communication, collaboration, confidence between entities, interchangeability, etc.
4. Teamwork – initiating and sustaining teamwork between competitors to increase synergies, e.g. sharing

resources which will establish security net and overall resilience

5. Forming suitable contractual pacts – Long term and short-term contracts that will help in the resilience by decreasing potential shortages in the supply line.
6. Forming public-private collaborations – Contractual arrangement between public and private entities to jointly benefit from the available services, properties, hazards and rewards. This will increase the government involvement in the private entities' supply chain.
7. Forming a risk-oriented culture – this will help in the acceptance and awareness of supply chain potential risks and how to manage them, which will in turn lead to the upper management backing and firm collaboration
8. Increasing creativity – encouraging and nurturing the innovation culture as it will lead to new creative business solutions such as fresh goods, techs, methods and tactics that will decrease potential vulnerabilities.
9. Enrich visibility – having the capability to observe the whole supply chain network and functions which will increase the awareness of possible risks.
10. Inventory administration – The calculated arrangement of inventory administration capitalizing on structured approach to reduce any inventory threats
11. Data administration – nurturing information and awareness of supply chain processes (i.e. physical and non-physical), and the encourage the knowledge sharing culture by learning and educating others
12. Portfolio broadening– capitalizing on various equipment and products to minimize the dependency on specific equipment or suppliers
13. Supplier growth – Providing suppliers with monetary, educational and technical support to develop them further in terms of productivity, loyalty and dependency
14. Supply chain partnership – increase the interconnectivity between supply chain entities through knowledge sharing as well as other resources sharing which will minimize overall potential threats
15. Supply chain system construction/ strategy – building the supply chain system with the goal of resilience which can be accomplished by harmonizing redundancy, productivity, weaknesses, etc.
16. Sustainability oriented – adherence to the latest economical, social and environmental directions to alleviate related risks such as public relation and impact on nature risks
17. Growing logistics abilities – increase the efficiency and effectivity of the supply and data streams which can be achieved through decreasing cycle time, increasing delivery capability, managing data and improving customer service to swiftly rebound from any interruption
18. Contingency preparation – Foreseeing possible incidents and creating the needed plans to handle supply chain threats and interruptions prior to their actual occurrence by prediction and being alert to any alarming sign
19. Forming redundancy – The calculated and careful use of the additional volume and inventory which will help in the event of any business interruption, this can be done by having safety/additional stock, numerous suppliers and spare/additional facilities
20. Demand administration – alleviating the impact of interruption through persuading customer options by modifying prices, range preparation and quiet goods rollovers
21. Increasing supply chain agility – Having a quick supply chain response to any random events or threats that will impact demand or supply
22. Improving the flexibility – Having adaptable nature as a supply chain entity to any change within its environment requirements with no noticeable effort and minimum time allocated
23. Improving velocity – The speed of implemented adaptations can make a huge difference in the recovery swiftness of the supply chain from an interruption
24. Capitalize on information technology – Information technology improve the links between entities and help other resilience tactics such as visibility and collaboration, which can improve the coordination of responses to interruptions of business

It is worth noting that four strategies were highlighted as the most critical by the previous researchers, these strategies are Improving the flexibility, forming redundancy, Supply chain partnership and Increasing supply chain agility. [9]

Diving deeper we will look into three main supply chain areas and their roles as part of the supply chain resilience, these areas are the warehousing, inventory management and supplier development.

2.3 Warehousing & Inventory Management

Inventory management within warehouses have a direct impact on alleviating disruptions in the supply chain system. Primary position for manufacturing/production companies is to minimize on hand inventory and their associated cost which is in line with lean approach, taking this path means accepting potential disruption risks. This risk can be mitigated for one product system by having two suppliers in the short term, however in the long term, holding excess inventory would be the optimal approach [11]. Depending on the nature of sourcing alternatives in term of easiness for development, conducting a level of safety stock assessment will be required. This assessment of safety stock level and holding strategic inventory might be the most viable short-term approach [13]. In the era after COVID 19 pandemic, a survey showed that 47% of supply chain leaders believe that there will be an increase in critical product inventory due to the sensed impact from COVID 19 [17]. Another study considered environmental sustainability by comparing safety stock and carbon emission where it showed that for brief business interruptions, the ideal safety stock range will be impacted by the current holding cost. In addition, the price of carbon emission is reliant on the number of interruptions, the different entities' geographical distribution, and the public perspective of carbon at the time of business interruption [12].

2.4 Supplier Development and Regionalization

Supplier development was defined as “the determination by manufacturers to enhance the supplier’s numbers and to improve their performance” [14], which include setting their goals, evaluating them, measuring their performance, training them, and other relevant activities [15]. Four main strategies can be utilized to further improve the supplier development, first is through increasing the competitive pressure by having multiple supplier compete between each other which will drive them for enhancing their products and services further to attain the buyer/customer. Second strategy is having a clear assessment method where it ensures reaching the preferred performance. Third is through having a good award system either by sharing cost savings, considering them further business or just basic recognition, theses will help in motivating suppliers to excel in their performance. Lastly is to be directly involved with the suppliers through direct investment or developing joint ventures [14]. Supplier development can be divided into two categories, one is reactive approach where it focuses on fixing the supplier issues and challenges, it is usually short term in nature and consider one supplier at a time, some triggers for this reactive approach can be a missed due date, a quality issue or even bad

customer review/feedback. The other approach in supplier development is strategic where it takes into consideration the whole organization (all suppliers) and improving on it; this is long term focused and it can be driven by advancement in the supply chain, continuous improvement strategy or technological progress [16].

3. Warehousing Workload During Pandemic

To test whether there was a significant role for warehousing during the supply chain interruption periods as part of the supply chain resilience, the authors compiled data about Saudi Aramco’s warehousing goods issues (activities) for the past 20 years and associated each data points to the level of oil production during the same year. The tested variable is the yearly rate of warehousing activities to the average produced million oil barrels per day. Figure 2 presents the collected data for the variable and figure 3 presents the variable distribution in boxplot format.

Number	Year	Warehousing to Oil Production Rate
1	2002	8.567029
2	2003	6.393319
3	2004	5.532139
4	2005	5.645557
5	2006	6.134903
6	2007	6.779102
7	2008	18.591252
8	2009	7.619686
9	2010	6.073165
10	2011	6.035165
11	2012	7.464655
12	2013	8.631131
13	2014	10.470919
14	2015	9.703489
15	2016	9.453369
16	2017	7.809129
17	2018	9.070212
18	2019	11.219737
19	2020	8.688582
20	2021	9.195997

Figure 2. Warehousing to Oil Production Rate

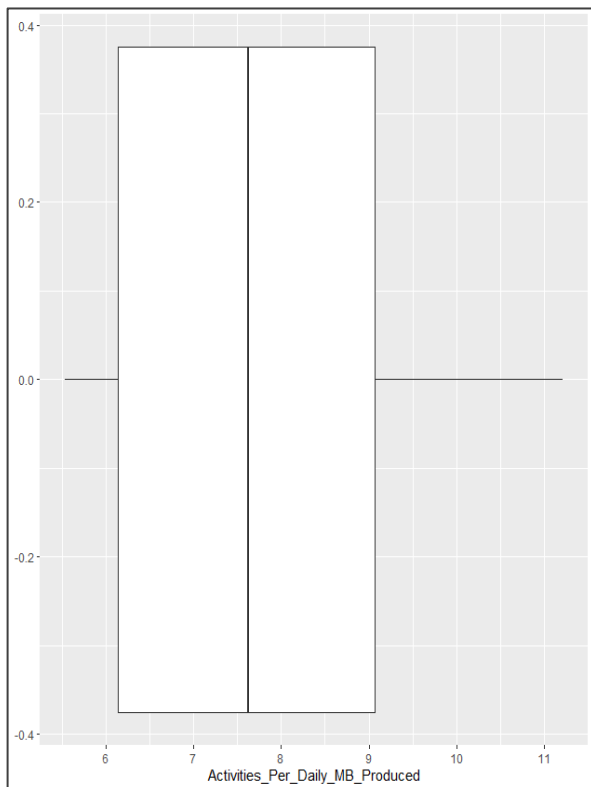


Figure 3. Rate Distribution

The three points highlighted in the Figure 2 for the years 2008, 2020 & 2021 were examined as they pertain to major supply chain interruption periods, specifically economic crisis in 2008 and COVID-19 pandemic in 2020 & 2021. The statistical test “one sample t-test” was utilized to test the

significance of changes in warehousing activities during 2008, 2020 & 2021. The dataset was tested for normality using Shapiro–Wilk test that indicated presence of normal distribution ($p\text{-value} = 0.31$).

The specific study objectives are summarized as following:

- a) To examine if warehousing played a significant role in supply chain resilience during the COVID-19 pandemic interruptions.
- b) To explore the impact of other supply chain resilience strategies implemented.

In this study, we tested two hypotheses for each of the years 2018, 2020 & 2021 data points:

H1: The mean of warehousing activities per daily million barrel produced is the same during the supply chain interruption periods (2018, 2020, 2021).

H2: The mean of warehousing activities per daily million barrel produced is significantly different during the supply chain interruption periods (2018, 2020, 2021).

Figure 4 below indicates that, the rate of warehousing activities per daily million barrels produced is significantly different than the mean during the year 2008 accepting the null hypothesis. However, for years 2020 and 2021, we can't reject the null hypothesis as the tests indicated a $p\text{-value}$ is above or at 0.05 percent as shown in Figure 5 and Figure 6.

T	df	p-value
-25.195	16	2.65E-14

Figure 4. T-Test for Year 2008

T	df	p-value
-2.0743	16	0.05455

Figure 5. T-Test for Year 2020

T	df	p-value
-3.259	16	0.004927

Figure 6. T-Test for Year 2021

4. Conclusion

This paper had examined the impact of warehousing on the continuity of the business during major crisis; the case study revealed a potential significant role of warehousing during 2008 aligning with the literature review in term of warehousing role as part of the supply chain resilience and business continuity in general. This can be contributed to the strategic allocation of critical materials throughout the warehousing network. On the other hand, warehousing function played a role with a lower significance based on the case study test during 2020 and 2021. This reduction of significance can be elucidated through Saudi Aramco efforts in developing and supporting its supplier base and the national market, In Kingdom Total Value Add (IKTVA) Program is an accumulation of these efforts. IKTVA objective is “prioritization of domestic value creation. It is designed to drive increased investment, economic diversification, job creation, and workforce development within the Kingdom. It aims to achieve 70% localization of all spending, creating a business environment that will provide thousands of new jobs, and increase international business attraction.” The strategic benefits of this program were evident in pandemic years [23]. Furthermore, this program is minimizing the environmental impact created by globalized supply chain approach.

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