Synchronized versus unsynchronized reopening of facilities in a global supply chain affected by a pandemic

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Table of Contents

Introduction
Impact of COVID-19 on supply chains

- COVID-19 pandemic took the whole world by storm resulting in severe global medical and economic crisis
- One of the most talked about issues from the beginning of pandemic has been its impact on supply chains all over the globe
- Supply chains all over the world had to face unprecedented challenges due severe uncertainty in demand, labour shortage and lockdown restrictions

Introduction

Uniqueness of pandemic as a disruption

- A global disruption like a pandemic is unique because the disruption timelines are different for different geographical regions (Ivanov 2020)
- The pandemic disrupted the facilities at different echelons with different timelines presenting a unique challenge to them. This opened up very interesting questions
- Further, on reopening, supply chains had to face severe labour shortage combined with uncertain low demand

Introduction
Positioning of study

- In this paper, we will analyse the impact of global disruption like a pandemic on key performance indicators (KPIs) of a global supply chain.
- Ivanov(2020) analysed the impact of reopening delay duration on supply chain performance with a single period simulation model
- To analyse the behaviour of supply chain in case of low, uncertain demand as well as capacity restrictions, we have used multi period discrete event simulation experiments.

Table of Contents

Literature Review

Reference	Insights
Simchi-Levi (2020)	Majority of supply chains are facing severe supply chain challenges and struggling with the recovery period
Ivanov (2020), Golan et al. (2020)	Uniqueness of pandemic lies in the varying timelines of disruption at various geographical locations
Simchi-Levi (2020), Remko (2020)	Most companies had to face severe challenge of a very low varying demand and limited production capacities on reopening

Literature Review

Reference	Insights
Klibi and Martel (2012)	Simulation modelling is very effective in analysing SC performance in dynamic situations
Ivanov (2020)	Different echelons having synchronised re-opening timeline has a positive impact on SC performance
Remko (2020)	There is very little research on proactive strategies for supply chain recovery for a global disruption like a pandemic

Table of Contents

Simulation Model
Problem Description

- We model a multi stage global supply chain with supplier, factories, distribution centers (DC) and retailers located in different geographical regions.

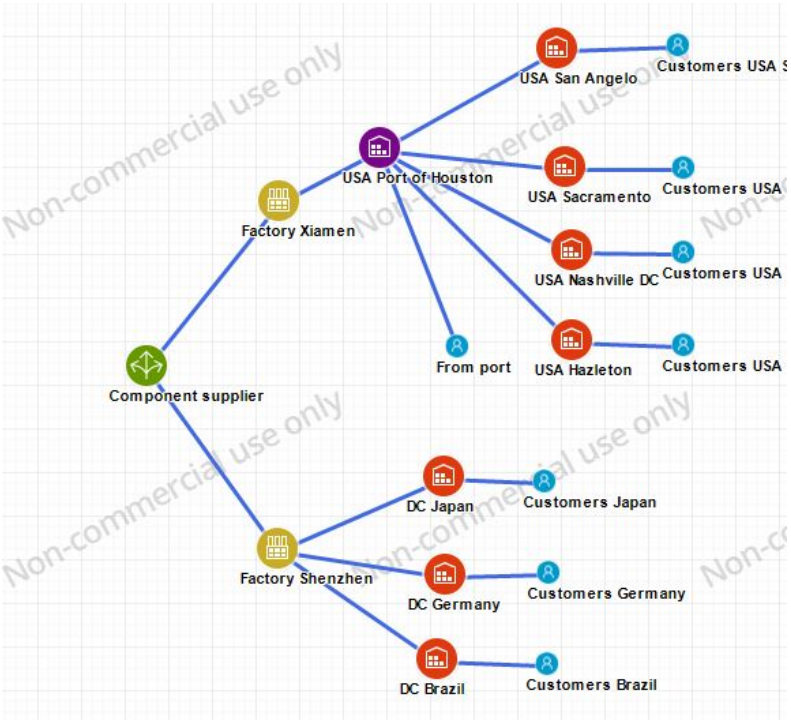

Figure: Supply chain network

Simulation Model
Problem Description

- The supply chain is of a company selling five different types of products namely lighting, furniture, small home appliances, large home appliances and gardening equipment.
- The supply chain network consists of two producers in Xiamen and Shenzhen who are supplied by a single local supplier in China.
- The producers deliver to the DCs with an average transportation time of 10 days
- The retailers order from DC every 5 days with an expected lead time of 14 days. The demand is deterministic and varies between 4 to 80 units for different retailers

Simulation Model
Problem Description

- We use multiple periods in our model in order to simulate the different demands and production capacities in different phases of lockdown and unlock
- The input data used in our model is borrowed from 'SIM Global Network Examination' scenario present in anylogistix simulation software
- In our analysis, the pandemic first disrupts the Chinese supplier and then affects the facilities located in different parts of the world after some delay.

The timeline of disruption is given in table 1

Simulation Model
Timeline of Disruption

Date	Event
3rd February, 2020	Closing of Chinese facilities
13th March, 2020	Closing of DCs and retailers all over the world
1st May,2020	Reopening of chinese facilites

Table: Timeline of events in the model

- We consider 5 different scenarios where the downstream facilities reopen after reopening of Chinese supplier with a delay of 0, 15, 30, 45 and 60 days.
- We are interested in examining the impact of time delay in reopening of facilities at different echelons in a supply chain network.

Simulation Model
Model Design

- We have used discrete event simulation modeling methodology to create a multi stage global supply chain model using anyLogistix simulation software
- All the facilities have certain amount of risk mitigation inventory with quantity depending on the transportation time between upstream and downstream member
- We assume that the DCs and retailers follow min-max inventory control policy. The DCs and retailer keep inventory level of 15-20 days
- In this model, the demand of an upstream echelon members is visible to the downstream echelon members

Simulation Model
Events Timeline

Date	Event
3rd February, 2020	Closing of Chinese facilities
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Table: Timeline of events in the model

- Reopening time of distribution centres and retailers vary in different scenarios.
- We consider 5 different scenarios where downstream facilities reopen after reopening of Chinese facilities with a delay of 0, 15, 30, 45 and 60 days

Simulation Model

Events Timeline

Time Period	Demand Coefficient
1st January, 2020 - 31st April, 2020	1
1st May, 2020 - 31st May, 2020	Varies from 0.1-0.4
1st June,2020 - 30th June, 2020	0.5
1st July, 2020 - 31st Decemeber, 2020	1

Table: Demand coefficient in each period

- We vary the demand and capacity coefficients from 0.1 to 0.4 in the second time period and see its impact on the various key performance indicators of the supply chain

Table of Contents

Experimental Results and analysis

- In this section, we will analyse the impact of global disruption like a pandemic on key performance indicators (KPIs) of a global supply chain.
- We conducted various experiments varying the delay period in reopening times as well as demand and capacity coefficients in each period
- .The delay period is the time lag between reopening of upstream facilities located in China and the downstream facilities located in different parts of the world

Experimental Results and analysis

Major insights

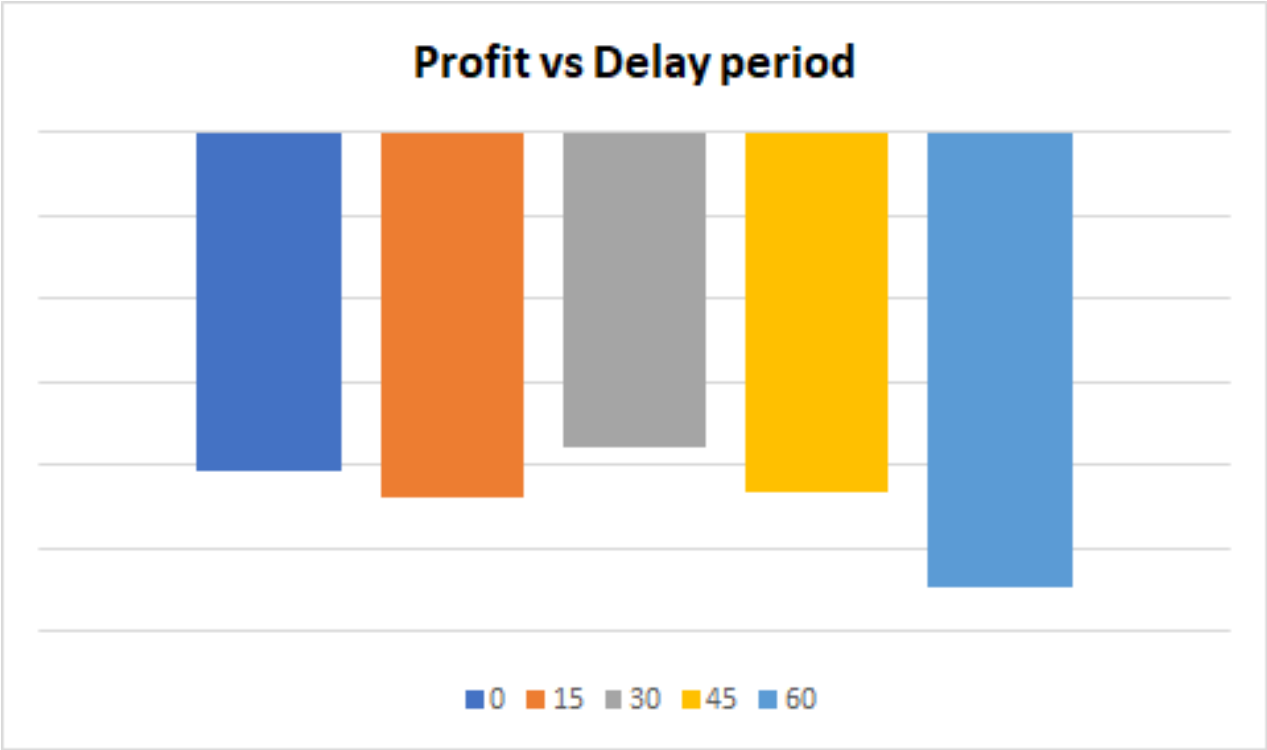

Figure: SC profit at different delay periods for demand coefficient 0.1

Experimental Results and analysis

Major insights

- For scenario with demand coefficient 0.1, the losses incurred by the supply chain is lesser when the delay period is 30 days relative to the scenario when there is no delay.
- Ivanov (2020) suggested that for lowest decrease in SC performance due to disruption, the reopening of facilities need to be synchronized in time but the results in our analysis suggest that the reopening of facilities need not always be synchronized in time specially in the case when the demand coefficient is low.

Experimental Results and analysis

Major insights

- Intuitively, SC profit should decrease with increase in disruption duration
- In our analysis, we observed that in all scenarios with demand coefficient less than 0.3, the SC profit with delay duration of 30 days is giving better SC profit than the SC profit with delay duration of 15 days.
- This behaviour can be attributed to the change in demand coefficient after 3o days.
- Thus, we observed that if the demand and capacity is low, the supply chain performance is better if the reopening time of downstream echelon is closer to the demand recovery phase.

Implications

- This study expands on previous literature by comparing synchronised and unsynchronised reopening times of different echelons in the case of multiple periods with varying demand and production capacities
- In case of low demand, we observed that unsynchronised reopening with certain delay duration between reopening of facilities at upstream and downstream echelons gives between SC performance than in the case of synchronised reopenings.

Implications

- Previous literature suggests that the SC performance dips with increase in disruption duration.
- Through our experiments, we show that SC performs better when the reopening time of downstream echelons is closer to the demand recovery phase.
- This study gives interesting insights to managers to formulate reopening strategies of their facilities when faced with a global disruption. Our study gives conditions under which managers could push for synchronised reopening of facilities if it is possible.

Conclusion

- COVID-19 pandemic presented a very unique challenge to supply chains all over the world.
- The results obtained in our study suggest that for lowest decrease in SC performance due to disruption, the reopening of facilities need not be synchronized in time when the demand or capacity upon reopening is very low.
- Further, we observed that till the demand increases to a certain limit, the SC performance doesn't show a linear drop with the increase in disruption duration.

Limitations and Future Work

- As for the limitations of this study, we have not considered different reopening times for facilities located in different geographical locations in downstream echelons so as to improve the interpretation of the results.
- Due to computational limitations, we have compromised a little bit on the complexity of the global supply chain as well.
- In future, the results obtained in our study could be verified with mathematical modelling techniques.

Select References I

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