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DISRUPTIONS FACED BY INDUSTRIES IN THE GLOBAL SUPPLY CHAIN DUE TO COVID-19

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ABSTRACT

Most of the manufacturing world is a part of the global supply chain, this vast interconnectedness has always been a helping hand to everyone in this world. The spread of COVID -19 put much more than a dent in the supply chain, in situations like these it becomes imperative to know what exactly damaged our supply chains and is there a way to reinstate the supply chain in this pandemic. The COVID-19 crisis has caused major supply chain disruptions. The purpose of this paper is to analyze disruptions in the global supply chain due to the pandemic and suggest strategies/solutions to mitigate those disruptions.

***Index Terms*— COVID-19, Global Supply Chain Disruption, MCDM & TOPSIS method, Supply chain risk**

INTRODUCTION

The last decades of the twentieth century witnessed a considerable expansion of supply chains into international locations, especially in the automobile, computer, and apparel industries. This growth in globalization, and the additional management challenges it brings, has motivated both practitioner and academic interest in global supply chain management.

The spread of COVID-19 has impacted global economics greatly. Industries like tourism, airline, and manufacturing industry have suffered in the first quarter. It is different from SARS that the continuous contagiousness of the coronavirus has imposed a profound impact on the manufacturing industry, since low-cost country sourcing, globalization and minimal inventory management have been key tenets of supply chain management for industries like auto, electronic, etc.

For the manufacturing industry, risks have risen including supply chain interruption due to production stop for raw material and spare parts, various setbacks in logistics, and the unknown timeline for recovery. With the continuous escalation of the pandemic, conditions have changed from supply and demand recession in China to global supply shortage under which supply chain interruption already happened in the auto and semiconductor industry. The coronavirus has affected manufacturing industries in China, the US, and Germany greatly. Consulting firms and scholars have explored COVID-19's impact on the manufacturing industry. Particularly, industries like electronics, machinery, and auto will be hit greatly. Due to necessary quarantine measures taken in place, the negative impact on countries that are regional industry chain centers will gradually spread to other countries and cause supply chain interruption. The volume and structure of demand have changed and the supply chain planning for the manufacturing industry has been disturbed. Hence, analyzing how to cope with the pandemic and recover afterward from a supply chain perspective is quite necessary. This paper attempts to

analyze COVID-19's initial impact as well as its aftershock on the manufacturing supply chain particularly. The purpose of this paper is to analyze disruptions in the global supply chain due to the pandemic and suggest strategies/solutions to mitigate those disruptions.

Design/methodology/approach – Based upon the views of Industry experts, Executives and Managers, supplemented with surveys and publicly available data points about COVID-19 impact on the supply chain, we explore challenges in the industry and found disruptions based on expert interviews and literature and have done analysis on topmost and which is the lowest disruption. Based on ranking strategies, solutions are suggested to mitigate that disruption.

Originality/value – This article offers an initial empirical exploration of supply chain risks experienced in the context of COVID-19 and approaches considered in the industry to improve supply chain resilience. Opportunities for empirical, event-based, and less conceptual research that has been called for years, are identified. This research can help close the gap between supply chain resilience research and efforts in the industry to improve supply chain resilience. Hopefully, the research opportunities identified can inspire the flurry of research that can be expected in response to the multiple special issues planned by journals in our field.

METHODOLOGY

A. Survey

We looked at various restrictions implemented by the government guidelines and deeply analyzed the effects of each of the regulations. We carefully prepared a questionnaire to give us an insight into the problems faced by various industries and what were the causes of major disruptions faced by each one of them.

We split the questionnaire into two parts. The first part was aimed at understanding the company's background, organizational strengths, and tangible disruptions such as a reduction in demand and perishing inventory. The second part of the survey was about ranking the different types of disruptions or problems faced by businesses. This would give us quantitative data to rank the disruptions for each industry. The severity and impact of each disruption varied from industry to industry and also varied according to the size of the organization.

B. Questionnaire

When you submit your final version, after your paper has been accepted, prepare it in Single column format, including figures and tables.

1. Type of Company
2. Are your products or services a part of Essential goods or services?
3. By how much percent has the demand of your company's product decreased? (Due to COVID-19)
4. How much longer can the company's inventory last? (assuming that the lockdown continues indefinitely)
5. How much time does the company need to recover the global supply chain ?
6. Has there been a surge in demand of a particular service / product? If yes then by how much percent? Please specify the product name in OTHER box.
7. What is the supply chain model used in your company?
8. What will be your future supply chain model to tackle this kind of pandemic situation?
9. Does the company have any strategies to face any such pandemic in future ? (If you can say any of them can add it in OTHER column)
10. Rate the Impact of disruption on your supply chain due to covid 19.

(Where 1 = low , 2 = Medium , 3=High , NA= If impact is not faced)

a. *Reduction in Inventory*
b. *Reduction In trade*
c. *Unavailability of Transport*
d. *Buying Inventory for high cost*
e. *Unavailability of Workers / Labour*
f. *High overheads cost*
g. *Increase in Vehicle parking expenses.*
h. *Customer demanding for Rate reduction in contract*
i. *Increase in Medical and sanitization cost*
j. *Communication Gap between company employees*

11. How has the company dealt with the global supply chain disruptions?
12. What are the technologies your company will be using in the future to overcome global supply chain disruptions?
13. Have you considered moving away from a Global supply chain to a local one?

Once the data was collected, we sorted the data as per industries. The Manufacturing Industry and the IT industry have different work ethics. While the IT industry can adapt to working from home, the manufacturing industry would find it difficult to do so. Hence we chose these two industries for comparison to the total average rankings from our data set. We used TOPSIS Multi-Criteria Decision Making method to rank the different disruptions and compared these with the weighted average method to verify the ranking.

We also asked them for the possible solutions that their company has undertaken or plan to undertake to curb the losses caused by the disruption of the supply chain. These solutions are stated in the solutions section.

II. CALCULATIONS

Multi-criteria decision making (MCDM) refers to making a choice of the best alternative from among a finite set of decision alternatives in terms of multiple, usually conflicting criteria. The main steps in multi-criteria decision making are the following-

- establish system evaluation criteria that relate system capabilities to goals,
- develop alternative systems for attaining the goals (generating alternatives),
- evaluate alternatives in terms of criteria,
- apply one of the normative multiple criteria analysis methods,
- accept one alternative as “optimal” (preferred),
- if the final solution is not accepted, gather new information and go to the next iteration of multiple criteria optimization.

The **Technique for Order of Preference by Similarity to Ideal Solution (TOPSIS)** is a multi-criteria decision analysis method.

In general, the process for the TOPSIS algorithm starts with forming the decision matrix representing the satisfaction value of each criterion with each alternative. Next, the matrix is normalized with a desired normalizing scheme, and the values are multiplied by the criteria weights. Subsequently, the positive-ideal and negative-ideal solutions are calculated, and the distance of each alternative to these solutions is calculated with a distance measure. Finally, the alternatives are ranked based on their relative closeness to the ideal solution.

Step 1- Construct the decision matrix and determine the weight of the criteria.

Let $X = (x)_{ij}$ be a decision matrix and $W = [w1,w2,....,w_n]$ a weight vector, where $x_{ij} \in \Re$ $w_j \in \Re$and $w1+ w2 +..... + w_n = 1$

Criteria of the functions can be: benefit functions (more is better) or cost functions (less is better).

Step 2- Calculate the normalized decision matrix.

This step transforms various attribute dimensions into non-dimensional attributes which allows comparisons across criteria. Because various criteria are usually measured in various units, the scores in the evaluation matrix X have to be transformed to a normalized scale. The normalization of values can be carried out by one of the several known standardized formulas. Some of the most frequently used methods of calculating the normalized value n_{ij} are the following:

$$n_{ij} = \frac{x_{ij}}{\sqrt{\sum_{i=1}^{m} x_{ij}^2}},$$

$$n_{ij} = \frac{x_{ij}}{\max_i x_{ij}},$$

$$n_{ij} = \begin{cases} \dfrac{x_{ij} - \min_i x_{ij}}{\max_i x_{ij} - \min_i x_{ij}} & \text{if } C_i \text{ is a benefit criterion} \\ \dfrac{\max_i x_{ij} - x_{ij}}{\max_i x_{ij} - \min_i x_{ij}} & \text{if } C_i \text{ is a cost criterion} \end{cases}$$

for i = 1, … , m; j = 1, … , n.

Step 3- Calculate the weighted normalized decision matrix. The weighted normalized value vij is calculated in the following way:

$v_{ij} = w_j n_{ij}$ for i = 1, … , m; j = 1, … , n

where w_j is the weight of the j-th criterion, $\sum_{j=1}^{n} w_j = 1$.

Step 4- Determine the positive ideal and negative ideal solutions. Identify the positive ideal alternative (extreme performance on each criterion) and identify the negative ideal alternative (reverse extreme performance on each criterion). The ideal positive solution is the solution that maximizes the benefit criteria and minimizes the cost criteria whereas the negative ideal solution maximizes the cost criteria and minimizes the benefit criteria.

Positive ideal solution A^+ has the form:

$$A^+ = (v_1^+, v_2^+, \ldots, v_n^+) = \left(\left(\max_i v_{ij} \mid j \in I \right), \left(\min_i v_{ij} \mid j \in J \right) \right)$$

Negative ideal solution A- has the form:

$$A^- = (v_1^-, v_2^-, \ldots, v_n^-) = \left(\left(\min_i v_{ij} \mid j \in I \right), \left(\max_i v_{ij} \mid j \in J \right) \right)$$

where I is associated with benefit criteria and J with the cost criteria, i = 1, … , m; j = 1, … , n.

Step 5- Calculate the separation measures from the positive ideal solution and the negative ideal solution.

In the TOPSIS method a number of distance metrics can be applied. The separation of each alternative from the positive ideal solution is given as

$$d_i^+ = \left(\sum_{j=1}^{n} (v_{ij} - v_j^+)^p \right)^{1/p}, \quad i = 1,2, \ldots, m.$$

The separation of each alternative from the negative ideal solution is given as

$$d_i^- = \left(\sum_{j=1}^{n} (v_{ij} - v_j^-)^p \right)^{1/p}, \quad i = 1,2, \ldots, m.$$

Where p ≥1. For p= 2 we have the most used traditional n-dimensional Euclidean metric.

$$d_i^+ = \sqrt{\sum_{j=1}^{n} (v_{ij} - v_j^+)^2}, \quad i = 1,2, \ldots, m,$$

$$d_i^- = \sqrt{\sum_{j=1}^{n} (v_{ij} - v_j^-)^2}, \quad i = 1,2, \ldots, m.$$

Step 6- Calculate the relative closeness to the positive ideal solution.

The relative closeness of the i-th alternative A_j with respect to A+ is defined as

$$R_i = \frac{d_i^-}{d_i^- + d_i^+},$$

where $0 \leq R_i \leq 1$, i = 1,2, … , m.

Step 7- Rank the preference order or select the alternative closest to 1. A set of alternatives now can be ranked by the descending order of the value of Ri.

III. ANALYSIS

A. Ranking Disruptions using TOPSIS Method and Weighted Average Method-

Disruptions	Weighted Avg. Method	TOPSIS
Increase in Medical and sanitization cost.	1	1
Unavailability of Transport	2	3
Unavailability of Workers / Labour	3	2
Reduction In trade	4	4
Communication Gap between company employees	5	6
Customer demanding for Rate reduction in contract	6	7
High overheads cost	7	5

Buying Inventory for high cost	8	8
Reduction in Inventory	9	9
Increase in Vehicle parking expenses.	10	10

Table 1.- Ranking Disruptions using TOPSIS Method and Weighted Average Method

The ranking was done by two methods and the ranks are comparable. There is a minute difference in certain rankings, but it can be noticed that there is only a difference of 1 place. The overall ranking trend is constant in both the methods of ranking. Hence it can be concluded that the rankings obtained are reliable. The inconsistency can also be caused by calculation errors and the fact that the data obtained had a larger number of entries from the manufacturing industry, making the rankings biased.

Furthermore, we will consider the rankings obtained by the TOPSIS method as our average ranking and compare it with the rankings obtained by doing a similar analysis on data pertaining to the Manufacturing and IT industry separately.

B. Ranking Disruptions in Manufacturing Industry (vs Average)-

Disruptions	Manufacturing	Average
Increase in Medical and sanitization cost.	1	1
Unavailability of Transport	2	3
Unavailability of Workers / Labour	3	2
Communication Gap between company employees	4	6
Reduction In trade	5	4
Buying Inventory for high cost	6	8
Reduction in Inventory	7	9
Customer demanding for Rate reduction in contract	8	7
Increase in Vehicle parking expenses.	9	10
High overheads cost	10	5

Table 2.- Ranking Disruptions in Manufacturing Industry (vs Average)

1) Increased sanitization costs is the major problem faced by everyone. Trend is same as seen in calculations from complete data.

2) The manufacturing industry is majorly affected by the hampering of the transportation. Due to the transportation the following 3 disruptions are caused -

A. Unavailability of labour due to lack of commute

B. Increase in transportation cost of raw materials

C. Increase in transportation of final product.

3) Higher overhead costs have been ranked much lower than the ranking in the overall data.

4) The Customer demanding a rate reduction is ranked towards the end. This may be because the manufacturing industry is tangible and quantifiable.

C. Ranking Disruptions in Information Technology (IT) Industry (vs Average ranking)-

Disruptions	IT	Average
Customer demanding for Rate reduction in contract	1	7
Reduction In trade	2	4
Communication Gap between company employees	3	6
Increase in Medical and sanitization cost.	4	1
Unavailability of Transport	5	3
High overheads cost	6	5
Unavailability of Workers / Labour	7	2
Buying Inventory for high cost	8	8
Increase in Vehicle parking expenses.	9	10
Reduction in Inventory	10	9

Table 3.- Ranking Disruptions in Information Technology (IT) Industry (vs Average ranking)

1. IT industry is more or less intangible and customers have more bargaining power. This is clearly reflected in the rank 1 of the disruptions. This is ranked very higher as compared to the average ranking
2. With the declining income, if people can not afford the reduced costs, they will want to discontinue their services, hence that has been correctly ranked at no. 2
3. Communication gap has been ranked higher than the average ranking. With the iT industry working from home, communication gaps have increased.
4. Since they can work from home, the disruptions caused by unavailability of labour and increased medical and sanitisation costs have been ranked towards the lower end of the rankings, and lower as compared to the average rankings.
5. IT industry does not have a declining inventory and hence they are not affected by reduction in inventory.

D. Extent of disruption of sector wise ranking-

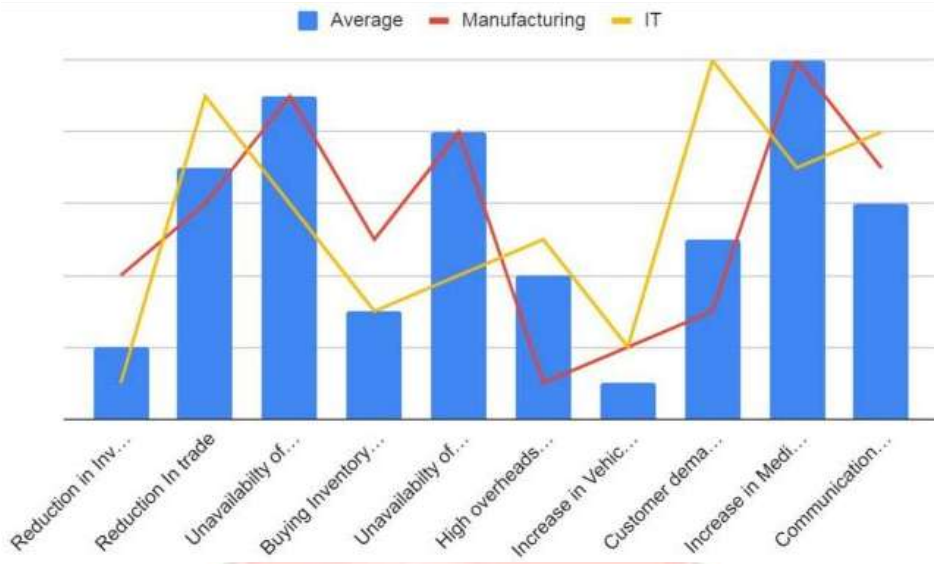

Fig. 1- Extent of disruption of sector-wise ranking

The graph depicts the extent of disruption caused to the industry by each of these factors. It also compares how significant a particular disruption is to the industry as compared to the average impact on all industries. The bar graph represents the extent of impact in all the industries, whilst the line graph represents the data for 2 particular industries.

IV.STRATEGIES AND SOLUTIONS

Supply chain disruptions create scary and uncertain times for businesses and consumers alike. They also draw attention to our supply chain dependencies that we are otherwise not aware of when everything is operating like a well-oiled machine. Sometimes these disruptions are small and localized and may affect only a few businesses or industries. Other times they are globally felt, especially when the hard-hit region is a source of a diverse range of supplies, as with many Asian markets. The COVID-19 global pandemic has caused a major upheaval in the supply chains of many businesses.

We've seen in recent months how COVID-19, the novel coronavirus outbreak, has impacted global supply chains. The effects of global pandemics or other public health crises can have massive supply chain impacts because of the number of people, regions, and global companies affected which can upend normal operations at every stage of the production line.

A. Medical Supplies Are the Priority

The choking of supply chains is "a second-order problem," and the foremost priority is to ensure the availability of medical supplies, Senthil Veeraraghavan, Wharton professor of operations, information and decisions, said in an interview with the Wharton Business Daily radio show on SiriusXM. (Listen to the podcast using the player above.) "The first-order problems have to do with medical devices, medical products, productive equipment, masks, screeners, disinfectants [and so on], which are critically necessary for providing care for people we are going to see getting infected over the next few months," he said.

B. COVID-19's Aftershock on Manufacturing Supply Chain

The impact is kept pumping with the globally continuous escalation of COVID-19. Even though the time-frame and extent of COVID-19's full impact are not fully revealed yet, the pandemic has already posted profound ramifications to the manufacturing supply chain in two ways.

- Transformation from Globalization to Regionalization
- Acceleration of Supply Chain Digitalization

C. Countermeasures for Recovery of Manufacturing Supply Chain

Many enterprises may face the second wave of impact due to a shortage of key materials and a decrease of export orders from overseas caused by the continuous spread of COVID-19. Also, there will be profound changes to the economy and social life after the pandemic. Hence, a two-step corresponding action is needed including immediate response to address the most pressing impact in order to maintain smooth supply chain operation and enhance the resilience of the manufacturing supply chain in order to recover and thrive in the post-crisis world.

Responding to Crisis and Ensuring Business Continuity-

Companies have to address the most immediate and pressing challenges caused by COVID-19, and ensure continuous business operation among all supply chain members. By ensuring employees' safety, supporting their supply chain partners, and maximizing the usage of favorable policies implemented within the period, the supply chain operation is expected to be gradually recovered at some extent.

a) Adjusting Work Mode and Taking Necessary Precautions During Operation Recovery
b) Providing Aid to Supply Chain Partners
c) Maximizing the Benefits of Government Policies to Resume Operation
d) Implement digital and automated manufacturing capabilities paired with strong manufacturing excellence
e) Evaluate and adjust procurement category strategic priorities
f) Invest in more collaborative and agile planning and fulfillment capabilities

V. CONCLUSION

When the supply chain is operating undisrupted, it's easy to take it for granted. However, in times of trouble, having a good long-term plan in place (or being able to create a strong crisis management strategy in the moment) is essential.Supply disruptions are inevitable, but by planning the response carefully, evaluating potential supply chain risks, and diversifying suppliers, can help prepare for even the most unprecedented of circumstances.Assessing COVID-19's impacts from a supply chain perspective and exploring countermeasures is critical for the manufacturing industry. Interruption of raw material and spare parts, setbacks in logistics and demand fluctuation are gradually intensified within the period. Also, the manufacturing supply chain is likely to become regionalized and digitalized in the post-crisis world. As such, countermeasures are suggested in this paper. First is to ensure the continuous supply chain operation at present. Second is to enhance supply chain resilience for better preparation to recover and thrive afterwards.

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