Recognizing Critical Drivers to Mitigate Supply Chain Disruptions in Pharmaceutical Industry During COVID-19

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Abstract

COVID-19 pandemic has significantly interrupted the global production and supply chain operation in all aspects of the consumer market. Along with other domains, the pharmaceutical industry has experienced its outbreaks on supply chain drivers impacting sustainable production and consumption patterns during the post-pandemic era. This motive stimulated the necessity for analyzing supply chain disruptions that severely affected logistics, procurement, production and distribution in the supply chain. Elimination of these disruptions in the supply chain may depend on many critical drivers which can accelerate the implementation of sustainability thus enhancing the performance of the supply chain in the context of an impending environment. In order to improve the resilience and performance of the supply chain, this study identifies and addresses those critical drivers and characterizes them based on their percentage implemented by Pareto analysis. Furthermore, a grey based Decision Making Trial and Evaluation Laboratory (DEMATEL) model is proposed to establish the causal relationships among these critical drivers. The findings of this work will demonstrate the structure and interrelationships between drivers and identify the most critical drivers for a long term sustainability of supply chain to eliminate disruptions in the supply chain. The findings can pave a way to business managers, policymakers and other stakeholders in numerous industries to identify critical drivers in attaining undisrupted business environment in the pandemic context.

Keywords
Supply Chain Disruption, Multi Criteria Decision Making, DEMATEL, Grey theory, Supply Chain Sustainability.

1. Introduction
A global life threatening pandemic known as COVID-19 has globally affected all aspects of our life. In the course of a year, global economy has witnessed a severe shock due to disruptions in all sort of operations and business practices. Supply chain practice has been massively disrupted in all stages including procurement, operations, distribution and other services. Business organizations have been facing a huge challenges to maintain a fluent supply chain across different stages due to unprecedented disease outbreaks in recent decades thorough out the world. This pandemic has made substantial negative impacts on businesses and supply chains, including reducing their efficiency and performance (Guan et al., 2020; Sodhi, 2016) and propagating disruptions across the supply chains that widely affect their resilience and sustainability (Ivanov, 2020).
Pharmaceutical industry with their effort to supply medicine and medical equipment is always in a top priority in this COVID1-9 situation. The demand for necessary items such as personal protective equipment (PPE), ventilators, and dried and canned foods have been added on the top of regular medicines. However, the firms are continuously facing numerous challenges that reduce their capacities. border closures, lockdown in the supply market, interruption in vehicle movements and international trade, labor shortage, and the maintaining of physical distance in manufacturing facilities are some of the major crisis these pharmaceutical firms are facing during the pandemic (Paul and Chowdhury, 2020). It is quite evident that due to these multidimensional impacts on supply chains, along with other economic and financial challenges (Dontoh et al., 2020), the pandemic has had a severe effect on global pharmaceutical supply chain.

Pharmaceutical firms in Bangladesh acquire many of the ingredients from local suppliers as well as from abroad and due to COVID-19, many of the areas have been facing outbreaks causally resulting in lockdowns which forced them to close down operations and distribution. Moreover, due to the crisis, there is a huge shortage of manpower and in many of the regions because of lockdown and quarantine laws. Due to limitations in delivery and logistics, order are being clogged causing a severe effect on order fulfillment, warehousing and inventory management. All these vulnerabilities together caused a propagation in the disturbance in business revenue, efficiency, responsiveness and service level. Therefore, Sustainability in pharmaceutical supply chain is under a big shock because of COVID-19 outbreak. These difficulties have risen a huge concern to the supply chain partners who are constantly struggling to find way out to solve these issues by adopting changes through importation decision making within and beyond the supply chain of the firms. To bring back the normal flow in the production, logistics and customer service by mitigating the risks and vulnerabilities caused by COVID-19 in supply chain, the most crucial task is to explore the critical supply chain drivers and interrelationships between them in order to accelerate important operational and business decision to ensure sustainability and productivity in supply chain.

1.1 Objectives

This research focused on exploring those crucial supply chain drivers from the root level that are indispensable to reduce supply chain disruptions. Pareto analysis has been used for short listing the most critical drivers in supply chain that enable a rapid recovery in the performance and bring back sustainability within the practice. Finally, to explore the complicated causal interrelationship between the drivers, a novel grey-based DEMATEL (the decision making trial and evaluation laboratory) approach has been taken.
The objective of the study is to explore all the vulnerabilities and disruptions faced by pharmaceutical supply chain during COVID-19 and mitigate them by recognizing the most critical supply chain drivers that will help supply chain partners to take important decisions and adopt with new practices to smooth out the supply chain performance and ensure sustainability.

2. Literature Review

Due to the disruptions in all aspects and stages of supply chain in pharmaceutical firms, to tackle all the changing market situations, consumer behavior and operational difficulties, a interconnected socio-environmental and financial approach is desperately needed to be incorporated within the supply chain practice (Mitchell & Walinga, 2017). This requires an urgent call on the implementation of sustainability with the supply chain. Due to the outbreak of COVID-19, suitability has been disrupted more than ever in the practice leading to overall drop in the productivity, responsiveness and efficiency (Govindan et al., 2020). All these disruptions affect the procurement, distribution and production of the firms in a large scale(Ivanov, 2020). Ivanov (2020) in his article stated that different supply chain processes and activities due to this disruptions has been stopped because of inaccessibility. Therefore, it is the foremost duty of the industrial managers to adopt policies and practices that will resilience in the supply chain in this dire situation (De Sousa Jabbour et al., 2020). However, in order to adopt this policies for the betterment, industrial managers must recognize the most important and crucial drivers which determine the level of resilience and suitability in the business.
This drivers accelerate the risk management and economic performances of the firms and will help to battle uncertainties that may arise in the business environment (Tseng et al. 2019). As a result, there is a dire need to explore methods and techniques to identify and recognize these critical supply chain drivers and their relationships. In order to sort out the possible candidates for the most crucial drivers, opinions and recommendations have been taken from supply chain practitioners, experts and academicians. In order to differentiate the critical drivers and short list the most vital drivers from the candidates Pareto analysis was carried out. Pareto analysis helps to differentiate extraneous features from a primary list (2015; Bajaj et al., 2018).
The most important objective of this research is to find out the interrelationship between those vital drivers. In order to find out the interrelationships, a causal modelling approach (CMA) has been employed in this research. A grey based decision making trial and evaluation laboratory (DEMATEL) approach has been proposed for determining the cause and effect between the drivers. DEMATEL can fit perfectly in causal analysis, cognitive mapping and structural modelling. Structural modeling techniques are very helpful in learning complex relationships (Horton et al., 1993).

Unlike many interpretive structural modeling (ISM), variations are allowed in strength of relationships amongst factor and two-way-relationships in DEMATEL. DEMATEL is versatile and it is noted with the potential to integrate many post-application approaches. The application of DEMATEL has been seen in multiple criteria decision modeling approaches such as scoring approaches and the analytical network process (Yang et al., 2008; Falatoonitoosi et al., 2012). DEMATEL has been used as precursor to causal and structural analysis tool (Wei et al., 2010). Temme et al. (2006) used DEMATEL in path modeling tool. DEMATEL has been used in Bayesian network analysis (Wu,2010).
However, DEMATEL is unable to tackle uncertain situations that has lack of information and conflict between opinions. Ambiguous value can also be expressed in a DEMATEL model. This shortcomings can be resolved by incorporating a fuzzy technique such as grey. Grey theory (Deng, 1982) is widely used with various multicriteria

decision making (MCDM) approaches, and has been very extremely in literature. Therefore, to resolve the ambiguity, a grey-DEMATEL process has been proposed in this research in order to solve the problem in a fuzzy environment. Therefore, this work expands the scope of DEMATEL by integrating a linguistic variables and a fuzzy aggregation method. As a result, the complexity of the problem can be addressed properly.

3. Methods

3.1 DEMATEL method

DEMATEL was first introduced by the Battelle Memorial Institute (Gabus and Fontela, 1973). It's a method of comprehensively building and analyzing a structural model involving causal relationships. The model uses matrices between a set of factors. These matrices can show relationships between components of the system with strengths of relationship.

The DEMATEL method assumes a system contains a set of components $X = \{X_i | i = 1,2, \dots \dots n\}$. Then pair wise relationship can be developed and evaluated. There are mainly four steps in DEMATEL:

(1) Generating the direct-relation matrix
(2) Normalizing the matrix
(3) Obtaining a total relation matrix
(4) Illustrating cause-effect diagram

3.2 Grey theory

Grey theory is used to solve systems with incomplete and discrete data. It can produce satisfactory outcome using a relatively small amount of data (Li et al., 1997).

In a grey system, x is denoted as a closed and bounded set of real numbers. A grey number $\otimes x$, is defined as an interval with known upper and lower bounds but unknown distribution information for x (Deng, 1989). That is, $\otimes x = [\underline{\otimes} x, \bar{\otimes} x] = x' \in x | \underline{\otimes} x \leq x' \leq \bar{\otimes} x$, where $\underline{\otimes} x, \bar{\otimes} x$ are lower and upper bound of $\otimes x$ respectively.

3.3 Grey-based DEMATEL

In this research, A grey-based DEMATEL approach has been developed through following framework:

Step-1: A fuzzy direct-relation matrix has been developed fort all the vital supply chain drivers.

- Firstly, a grey linguistic scale is employed. We used a five level scale where grey numbers are assigned and the values are shown in table 1.

Table 1: Linguistic scale using grey numbers

Linguistic scale	Grey Numbers
No influence	[0,0]
Very low influence	[0,1]
Low influence	[1,2]
High influence	[2,3]
Very high influence	[3,4]

- A direct-relationship matrix has been established to determine the interrelationship between the drivers, $X = \{X_i \mid i=1,2,\dots n\}$. A grey matrix Z has been implemented with grey numbers as elements. It is called the initial direct-relation matrix Z. Z can be expressed by:

$$Z = \begin{array}{c} X_1 \\ \vdots \\ X_n \end{array} \begin{bmatrix} [0,0] & \cdots & \otimes z_{1n} \\ \vdots & \ddots & \vdots \\ \otimes z_{n1} & \cdots & [0,0] \end{bmatrix} \tag{1}$$

Where $\otimes z_{ij}$ is the grey number for influence of ith driver on jth driver.

Step-2: A normalized grey direct relation-matrix is formed from overall direct-relation matrix Z. A normalized grey relation matrix can be expressed as

$$Z\otimes s = [\underline{s}, \overline{s}] = \frac{1}{\max\limits_{1\leq i\leq b} \sum_{j=1}^{n} \otimes z_{ij}}, i, j = 1, 2, 3 \ldots\ldots, n \tag{2}$$

$$N = \otimes s.Z \tag{3}$$

$$\otimes n_{ij} = [\underline{s.z_{ij}}, \overline{sz_{ij}}] \tag{4}$$

Step-3: A total relation matrix(T) is formed where I represents an n-by-n identity matrix. It can be expressed by:

$$T = N(1 - N)^{-1} \tag{5}$$

Step-4: A causal influence and diagraph diagram is implemented.

- Firstly, Row($\otimes R_i$) and Column($\otimes C_j$) sum are determined from total relation matrix(T) by following:

$$\otimes R_i = \sum_{j=1}^{n} \otimes t_{ij} \forall i \tag{6}$$

$$\otimes C_j = \sum_{i=1}^{n} \otimes t_{ij} \forall j \tag{7}$$

- Overall importance or prominence($\otimes P_i$)and net-effect (($\otimes E_i$)) are determined by eqn. (8) and (9):

$$\otimes P_i = \{\otimes R_i + \otimes C_j \mid i = j\} \tag{8}$$

$$\otimes E_i = \{\otimes R_i - \otimes C_j \mid i = j\} \tag{9}$$

The values $\otimes Pi$ show the level of overall prominence of driver i in terms of overall relationships with other drivers. The values $\otimes Ei$ shows the net effect or cause of drier i. If $\otimes Ei > 0$ then drive is a net cause, or foundation, for other drivers. If $\otimes Ei < 0$ then driver i is net effect of other drivers.

- Finally, the overall prominence-causal graphs are drawn from the values in the overall matrix(T). Values only exceeding the threshold value (θ) are considered to be taken for the cause and effect. Threshold value has been calculated from by taking the mean value of the total relation matrix(T).

4. Data Collection

4.1 Selecting Drivers

All the critical driver for supply chain related to disruption have been selected in two-step approach. In the first step, some of the critical and influential drivers have been identified from previous researches and studies. A few emerging drivers have also been found out from the opinions of academician and supply chain practitioners. Table 2 shows the list of all candidate drivers.

Table 2: List of Candidate drivers

Candidate Drivers		Reference	Candidate Drivers		Reference
X1	Initiating funding for Pharmaceutical lending and healthcare	Yu et al. (2010), and Bardey et al. (2010)	***X11***	Reducing implied demand uncertainty in a changing market environment	Suggested by academician
X2	Facilitating with training courses and institutions to train personnels to tackle COVID-19 crises	Govindan et al. (2014)	***X12***	Dealing with changing consumer behavior under COVID-19 situation	Suggested by industry expert
X3	Developing substantial supply chain strategic planning to ensure agility and resilience under COVID-19	Baumgartner and Korhonen (2010).	***X13***	Developing and incorporating Sustainable procurement strategies in COVID-19 crises	(de Sousa Jabbour et al., 2020)
X4	Building rigid legislation facility for vital industry stakeholders to deal with COVID-19	(Ivanov & Das, 2020)	***X14***	Developing policies and protocols related to health and compliance for stakeholders	Suggested by academician
X5	Incorporating value chain concept in healthcare and pharmaceutical manufacturers and distributors	Sushmita A.Narayana , Rupesh KumarPati , Prem Vrat (2012)	***X15***	Dealing with the complexity of distribution in critically affected area in COVID-19	Suggested by industry expert
X6	Expanding scope of applying data analytics in forecasting and distribution under COVID-19	(Bag et al., 2020; Ivanov & Dolgui, 2020)	***X16***	Ensuring health security of employees of firms	Suggested by academician
X7	Reducing the propagation of disturbance caused by ripple effect	(Ivanov & Dolgui, 2020)	***X17***	Increasing vertical and horizontal collaboration between different supply chain partners under COVID-19	Suggested by industry expert

X8	Maintaining lead time during COVID-19 for achieving higher customer satisfaction	(de Sousa Jabbour et al., 2020)	***X18***	Planning efficient risk management capacity under disruption	(de Sousa Jabbour et al., 2020)
X9	Developing and activating alternative supply sources under crises	Suggested by industry expert	***X19***	Reducing bullwhip effect within supply chain considering COVID-19	Suggested by industry expert
X10	Updating policies and planning parameters for inventory considering COVID-19	Suggested by industry academician	***X20***	Ensuring government support to adopt sustainable supply chain practice	Prakash and Barua(2015), Govindan et al. (2013).

In the second step, a team consisting 15 experts has been formed using purposive sampling method. The occupation or interest and number of the experts have been show in figure 1. All the experts have industry and research experience more than 8 years.

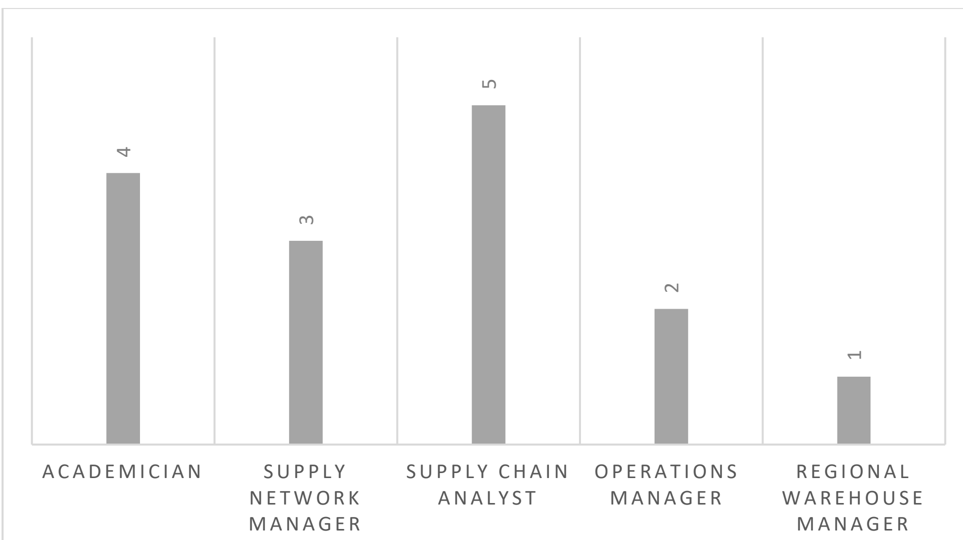


Figure 1: list of experts participated in scoring

All the driver were given a relative scores by all the experts and from their judgments, a pareto analysis has been carried out and top driver for the top 80% score has been chosen from the plot. Figure 2 shows the illustration of Pareto analysis from which ten drivers for 80% scores have been chosen for developing a causal relationship.

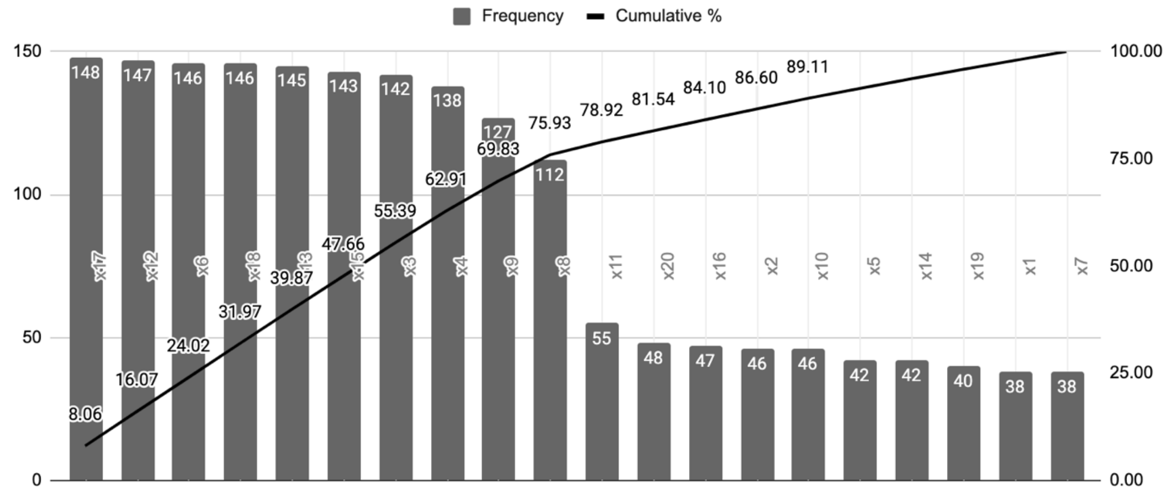


Figure 2: Pareto analysis of candidate drivers

5. Result and Discussion

From the selected 10 vital drivers, a causal relations ship has been developed. Table 3 shows the grey direct relation matrix which has been established equation (1).

Table 3: Grey Direct Relation Matrix

	X17	***X12***	***X6***	***X18***	***X13***	***X15***	***X3***	***X4***	***X9***	***X8***
X17	[0,0]	[3,4]	[3,4]	[2,3]	[3,4]	[2,3]	[2,3]	[1,2]	[2,3]	[2,3]
X12	[3,4]	[0,0]	[3,4]	[0,1]	[0,1]	[2,3]	[0,1]	[0,1]	[0,1]	[2,3]
X6	[0,1]	[3,4]	[0,0]	[2,3]	[2,3]	[3,4]	[1,2]	[0,1]	[0,1]	[2,3]
X18	[0,1]	[1,2]	[2,3]	[0,0]	[0,1]	[1,2]	[1,2]	[2,3]	[2,3]	[1,2]
X13	[2,3]	[0,1]	[2,3]	[1,2]	[0,0]	[0,1]	[2,3]	[0,1]	[3,4	[1,2]
X15	[3,4]	[1,2]	[2,3]	[2,3]	[0,1]	[0,0]	[0,1]	[0,1]	[0,1]	[2,3]
X3	[2,3]	[2,3]	[1,2]	[2,3]	[2,3]	[1,2]	[0,0]	[0,1]	[0,1]	[1,2]
X4	[0,1]	[0,1]	[0,1]	[1,2]	[1,2]	[2,3]	[0,1]	[0,0]	[0,1]	[0,1]
X9	[2,3]	[0,1]	[1,2]	[0,1]	[2,3]	[0,1]	[1,2]	[0,1]	[0,0]	[0,1]
X8	[0,1]	[2,3]	[0,1]	[0,1]	[0,1]	[2,3]	[1,2]	[0,1]	[0,1]	[0,0]

Using eqn.(2)-(4), we obtained the normalized direct relation matrix, which has been used to establish the total matrix(T). Total matrix has been show in Table 4. From the total matrix we obtained the threshold value, $\boldsymbol{\theta}$ **= [.11,.03**]. Values only exceeding the threshold value are being considered to illustrate in the causal diagram. From Table 5, we obtained prominence($\otimes P_i$)and net-effect ($\otimes E_i$)which has been used to plot in the relationship diagram. Overall DEMATEL prominence–causal and interrelationship between drivers have been shown in the figure 3 and 4.

From the prominence–causal and interrelationship graphs, it is quite evident that 'Increasing vertical and horizontal collaboration between different supply chain partners under COVID-19 (***X17***)' is the most significant and prominent drivers amongst all the driver which have a direct relation from and to many of the drivers. In a dire situation like COVID-19, ensuring agility and resilience through developing strategic planning (***X3***) isn't possible if firms don't take steps to collaborate horizontally and vertically with different supply chain partners. Which will also ensure Sustainable procurement strategies in COVID-19 (***X12***) if firms move forward to collaborate in operations, logistic and other strategic planning. Horizontal collaboration in the distribution channel also tackle the complexity of distribution in critically affected area in pandemic (***X15***).

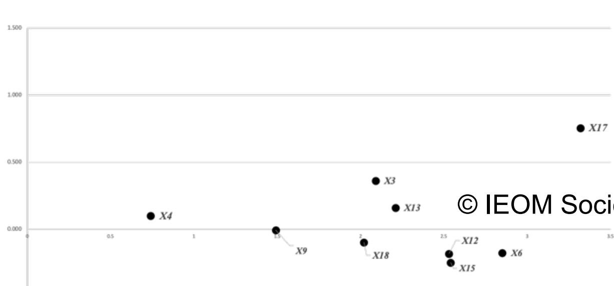
Table 4: Total Relationship Matrix

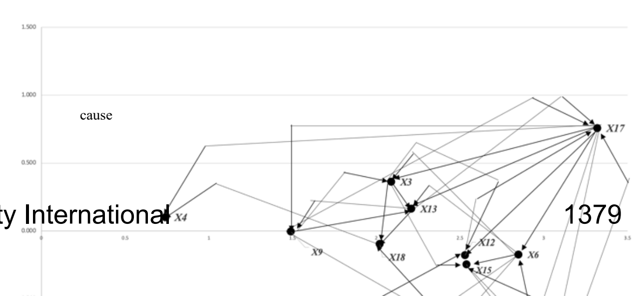
	X17	*X12*	*X6*	*X18*	*X13*	*X15*	*X3*	*X4*	*X9*	*X8*
X17	**[0.4,.2]**	**[0.28,0.35]**	**[0.3,.3]**	[0.2,.29]	**[0.24,.32]**	**[0.24,.32]**	**[0.18,.27]**	**[0.08,19]**	**[0.17,.26]**	**[0.23,.31]**
X12	**[0.1,.20]**	**[0.1, 1.17]**	[0.23,.3]	[0.07,.18]	[0.07,.17]	[0.19,.26]	[0.05,.16]	[0.02,.12]	[0.04,.15]	[0.18,.25]
X6	[0.1,.21]	[0.23,.30]	**[0.11, 1.19]**	**[0.16,.25]**	**[0.14,.24]**	**[0.23,.30]**	**[0.1,.20]**	[0.02,.13]	[0.05,.16]	**[0.19,.26]**
X18	[0.6,.1]	[0.11,.21]	[0.16,.25]	[0.05, 1.13]	[0.05,.16]	[0.12,.22]	[0.08,.18]	**[0.11,.18]**	[0.12,20]	[0.1,.20]
X13	**[0.7,.2]**	[0.09,.20]	[0.18,.27]	**[0.11,.21]**	**[0.08, 1.15]**	[0.08,.20]	[0.16,.23]	[0.02,.13]	**[0.19,.25]**	[0.12,.22]
X15	**[0.2,.27]**	[0.14,.23]	[0.19,.27	**[0.16,.24]**	[0.06,.17]	**[0.09,1.17]**	[0.05,.16]	[0.03,.13]	[0.05,.15]	**[0.18,.25]**
X3	[0.7,.2]	**[0.18,.26]**	[0.15,.25	**[0.16,.24]**	**[0.15,.24]**	**[0.14,.23]**	[0.06,.13]	[0.02,.13]	[0.06,.16]	[.13,.22]
X4	[0.3,.1]	[0.02,.14]	[0.04,.15	[0.07,.16]	[0.06,.15]	[0.12,.20]	[0.02,.12]	**[0.01,1.06]**	[0.02,.11]	[0.03,.13]
X9	**[0.4,.2]**	[0.06,.16]	**[0.11,.20**	[0.05,.15]	**[0.15,.21]**	[0.05,.16][	**[0.09,.17]**	[0.01,.11]	**[0.04,1.10]**	[0.05,.16]
X8	[0.5,.1]	**[0.13,.21]**	[0.05,.16	[0.03,.13]	[0.02,.13]	[0.15,.21	[0.06,.15]	[0.01,.10]	[0.01,.11]	[0.04,1.11]

Table 5: The degree of prominence and net cause/effect of drivers

Drivers	*Ri*	*Ci*	Prominence(*Ri*+*Ci*)	*Net-Cause(Ri-Ci)*	*Cause-effect*
X17	[2.040,3.92]	[1.274, 3.170]	[3.32, 7.09]	[0.77,0.75]	Cause
X12	[1.175,3.04]	[1.354, 3.220]	[2.53, 6.26]	[-0.18,-0.18]	**Effect**
X6	[1.330,3.23]	[1.523, 3.390	[2.85, 6.62]	[-0.19,-0.16]	**Effect**
X18	[0.956,2.90]	[1.072,2.970]	[2.03, 5.87]	[-0.12,-0.07]	**Effect**
X13	[1.199, 3.09]	[1.019, 2.940]	[2.22, 6.03]	[0.18,0.15]	Cause
X15	[1.148, 3.03]	[1.395, 3.270]	[2.54, 6.3]	[-0.25,-0.24]	**Effect**
X3	[1.238, 3.11]	[0.858, 2.770]	[2.09, 5.88]	[0.38,0.34]	Cause
X4	[0.423,2.36]	[0.320, 2.260]	[0.74, 4.62]	[0.10,0.10]	Cause
X9	[0.752, 2.64]	[0.737, 2.660]	[1.49, 5.3]	[0.01,-0.02]	**Effect**
X8	[0.544, 2.47]	[1.252, 3.120]	[1.8, 5.59]	[-0.71,-0.65]	**Effect**

Collaboration between firms in the operation level might enable them to rapidly choose alternative to their established sources which has been severely disrupted by inaccessibility due to COVID-19. Another prominent driver to tackle the rapidly changing consumer behavior and upward trend in the demand of pharmaceutical products is 'Expanding scope of applying data analytics in forecasting and distribution (***X6***)'. This driver mainly is an effect to a joint collaboration between stages for a smoother and better information flow which may help the firm to accurately forecast the demand in the changing market and help the firms to develop and incorporate sustainable procurement plan in the uncertain business environment (***X13***). Advanced use of data analytics will ensure the firm to prepare efficient distribution plan to main the lead time for order shipments (***X8***).





cause

Prominence

effect

effect

Figure 3: Overall DEMATEL causal-graph

Figure 4: Overall DEMATEL causal-graph with relations

Developing sustainable strategic plan will substantially help the pharmaceutical firms to deal with the changing consumer behavior in the vulnerable market situation under COVID-19 (***X12***). Nevertheless, Building a rigid legislation facility (***X4***) all the vital stakeholder will allow the firms to plan an efficient risk management capacity which can withstand all the unwanted supply chain disruptions due to a global pandemic(***X18***).

6. Conclusion

COVID-19 has thrown a huge challenge to the decision makers to make major decisions in the disrupted supply chain environment. Sustainability and performance of supply chain in pharmaceutical firms are at stake. On the other hand, to battle the casualty of the pandemic, pharmaceutical firms are one of the most important sectors to perform their operations, distributions, logistics and inventory management more responsively to better cater their consumers. As a result, It has become a prime task for the decision makers to explore and prioritize the most critical supply chain drivers which if adopted and executed in the supply chain practice will facilitate the firms to better perform between stages, respond quickly changes and run the operations efficiently with all the strategy to withstand disruptions caused by COVID-19. The purpose of this study was mainly to help the supply chain decision makers by providing them insights about the impactful drivers in supply chain, there level of prominence and most importantly to show the interrelationships between these critical driver. This study may help them to recognize the cause-effect relationship between these drivers. Decision makers, from the insights, can differentiate the drivers that effect the other drivers and prioritize them accordingly while implementing. We used a grey-based DEMATEL approach to establish the interrelationships between the drivers.

However, there are inevitable limitations in this research which can be addressed in the future works. While developing the relationships, only ten drivers were considered to explore which might not always be enough for the decision makers if there is a heavily damaged business scenario in a firm. Opinions and recommendations from more experts could result in a more comprehensive findings from the research. Data and information from more studies could allow a broader generalization of the outputs. Using DEMATEL method might not ensure a consistent comparison between pairs. Other fuzzy techniques could have been incorporated in the model. Drivers can be assessed with relative weight and prioritization. Apart from these limitations, this hybrid approach of grey based DEMATEL model handles the complexity of the problem and effectively evaluated the interdependencies between the drivers which will be beneficial for supply chain decision makers to fight COVID-19.

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