Research Title

# An Integrated Model for Exploring supply Chain Sustainability Drivers Using Big Data Analytics Capacities in the Context of thinking Beyond COVID-19 In An Emerging Economy: Total Interpretive Modeling Approach

Presented by

**Asmaa Abd El-Monem Mohamed Serag**

**Lecturer of Accounting**

**Faculty of Commerce**

**Tanta University**

## Abstract

Sustainability of supply chain (SCS) has been an important research topic in the last two decades due to the changes in the surrounding environment. This research aims at exploring the drivers of SCS to tackle supply chain disruption in such pandemic in the context of particular emerging economy to achieve that total interpretive structuring model is used (TIPSM). The proposed methodology is used to testing the opinions of supply chain practitioners as well as a experts about the drivers of SCS in the emerging economy. The results reveal that there are 20 drivers of (SSC) that have influential relationship and indispensable links,in addition to the results have showed that financial support from the government and the supply chain partners are the most influencing drivers of SSC to tackle the situation of COVID-19. Then, Matricide Impacts Cruoses

Multiplication Applique a un classement (MIMAC) analysis is used to classify drivers into different groups based on the driving power and dependence power. These results will assist industrial managers, practitioners, policy makers and government intuition to take initiatives for applying SC and SSC in the emerging economy by considering the recommended drivers.

**Keywords: Supply chain sustainability SCS-Emerging Economies- Sustainability drivers-Total Interpretive Structuring Modeling (TISM).**

## 1- Introduction

In recent years, Big data (BD) helps in gaining competitive advantage, because vast volumes of strategic, operational and tactical information consistently share across supply chain phases. Most managers started to invest heavily in the sophisticated data analytics to leverage BD to extract and derive valuable insights to decision making process in order to achieve successful SC performance including sustainability .

Most researches promote the future of BD and BDA applications to reduce uncertainties in SC networks based on more accurate and reliable predictions (Chong, et.al 2016; Sanders, 2016; Wang, et.al, 2016). However, many managers have a limited understanding of the required BDA that is necessary to extract value from BD. Thus, successful implementation of BD is required to build BDA capabilities (BDAC) integrated within SC Functions. (BDAC ) play a vital role in SCM that will create

relevant insights for decision making. Literature fails to actually show the direct link between BDAC and SCM. There are only a few papers that define and test the interrelation between BDAC and operational performance. These limited sets of studies focused on the benefits, which organization attain through using BDAC like decision making, better risk management, visibility, and value to organization. The researchers should give more attention to sustainability issues in SCM. (Zhao, et al., 2017; Remko, V. H. 2020; Guan, et al., 2020; Gupta, et al., 2020; Saeed and Kersten, 2019; Zimon, et al, 2020).

The existing literature has failed to respond to environmental, economic and social issues, as well as, a new emerging technologies are becoming the key driver of supply chain sustainability.

The COVID-19 not only has shatter scs strategies and operation, but proven to be a challenge for decision makers and policy makers as well. The current situation highlighted the severe effect of pandemic on scs particularly emerging enemies aspects. Thus, the researcher has motivated that it is deemed necessary to develop a framework to investigate the drivers of scs to tackle the situation same as pandemic. The COVID pandemic is an utterly devasted disruption, which determines. It is important to take steps for the protection of logistics capabilities, transportation responsiveness, and warehouse management. Thus, it is important for emerging economies to concentrate on the sustainability drivers to achieve the relevant level of

competitiveness before implementing sustainability practices and strategies. Therefore, this research aims to enrich knowledge by:

1. Identifying the list of scs drivers from the literature and selecting the most relevant drivers according to the expert opinion.
2. Building the model of ISM to classify the drivers based on their driving power and dependent power.
3. Deducing the hierarchical structure of relationships.
4. Providing decision makers and policymakers with information to make tactical and strategic decisions to know the sustainability drivers in the emerging.

2- **Research problem**

Some existing empirical researches indicate the influence of BDAC on three dimensions of sustainability (i.e, environmental, social, and economic) but they are fragmented. Part of these researches concentrate on the relationship between pollution, waste, resource depletion and ecology dissipation and the other part of these researches focus either on the relationship between BDA and economic performance or BDA and transparency or integrity of supply chain and the impact of this en financial performance (Gupta, et. al. 2020; Bag, et. al, 2020; Jabbour, et. al, 2020).

The topic of SCS has caught the attention of scholars and practitioners currently. Such as (Bag. et. al, 2020) that explored operational excellence to improve sustainability, (Jabbour, et. al,

2020) addressed the trends and challengers in SCS, and examined sustainability innovation to support policy makers in decision making. Recently, most of supply chain leaders must invest more in different technology (blockchain, 3d, printing solution, automation, supply chain digitization). However, these researches on assessing SCS drivers are not adequate for these chaining days. Over the past years, organizations are based on cost reduction strategies and commercial best outcomes for optimizing SCS. However, the newly COVID-19 pandemic has changed old assumptions about SCS. This pandemic is challenging policymakers, and governments and disrupting overall operations, systems, and SCs. As COVID-19 is a unique and novel disease it has number of different unique characteristics that will have an essential impact on SCS. The implications of COVID-19 on the sustainability of supply chain should by analyzed. To achieve that a conceptual model and analytical model should be developed and new methodology can be introduced to extract new insights creating new forms of value in ways that have influenced supply chain sustainability. To achieve this aim, there is a need to new methodology. A proposed methodology is is based on the pareto analysis and total interpretive structured modeling (TISM). Total interpretive structural modeling mainly originates from interpretive structural modeling (ISM). ISM depends on developing a structural model through which hierarchical relationships among variables are

built. In addition to that TISM interprets the interactions among variables Singh and sushil, 2013).

In this paper, the researcher aims to analyze the effect of using BDA on SCS in the Contact of an emerging economy. This study will reveal the divesting impact of COVID-19 pandemic on SCS by developing a an integrated model to assess the essential drivers of SCS that will support SCS a against future disruptions. Following the COVID-19 pandemic this study has raised the following questions:

RQ 1: How can BDA be used to build integrated model that involve the key drivers of SCS in the following the COVID-19 pandemic in the context of an emerging economy?

RQ2: what are the primary and secondary drivers for establishing sustainability in SC In the COVID-19?

RQ3: How are the drivers of sustainability in SC interconnected with each other?

Organizations Can use big data analytics techniques to deal with the uncertainties Conditions that were caused by the current COVID-19 pandemic. For example, organizations manage and mitigate uncertainties and bottlenecks in supply chains. These pandemic COVID-19 not only demands a review of the existing range of methods and approaches, but also pursues an innovation in methodology to faster a better understanding of new global challenges. Against this backdrop, the purpose of this paper is to analyses the literature to extract sustainability drivers in SC to

build an integrated model, based on total interpretive structural methodology. To achieve this methodology, this is structured as follows:

In section 1 : The research background of COVID-19 and the essential drivers of SCS in the COVID-19.

In section 2: Bigdata analytics applications in the supply chain.

In section 3: Presented the models and methods for data collection and analysis.

In section 4: Development of conceptual and analytical model of (TISM)

In section 5: The results and significance of this study are portrayed.

The final section the conclusion and shortcoming of the study.

## 3 Literature Review:

### 3/1 Supply chain Sustainability Drivers in context of COVID-19

The literature of SCM has developed through a number of remarkable transformation. This transformation has begun with lean; the legality, resilience and sustainability of SCS. Then, in the context of industry4.0 and the application of data analytics especially in the COVID-19 virus outbreak and global pandemic the concentration focused on sustainability, digitalization and viability of SC (Chesbrough, 2020; Choi; Currie, et. al, 2020; Ivanov, 2020a; Ivanov and Dolgui, 2020b; Sarkis, et. al, 2020).

The researcher of SC raised many questions about SC sustainability drivers and SC viability.

The next figure (1) depicts the transformation of major SC management over time.

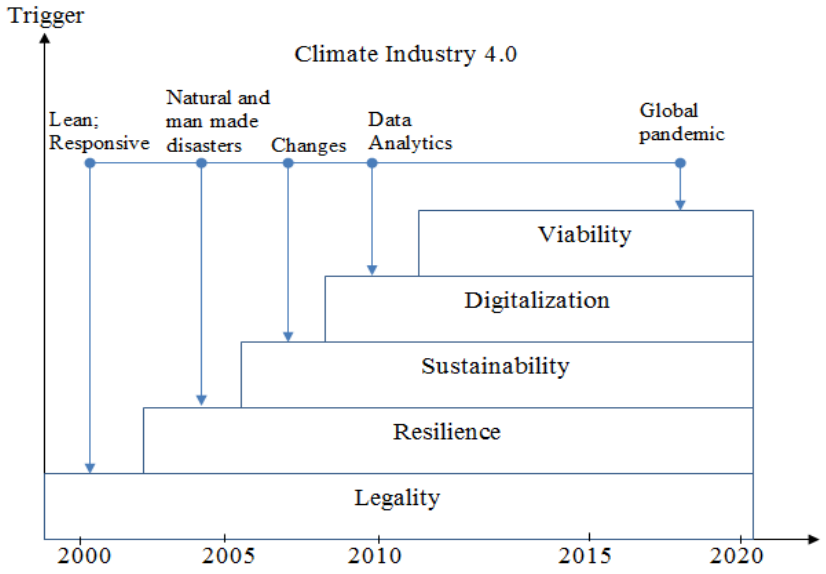


**Figure (1) Transformation of major SC management development over time (Source: Ivanov, 2020)**

Supply Chain Sustainability drivers should be identified carefully in days of COVID-19 pandemic because of rapidly changing market situations and customer awareness regarding health issues and environmental and social Concerns, production end goods and services the implementation of SCS relate to the organisations may relate to many essential indicators (drivers) that are associated with the organizations. Most organization look for achieving

sustainability through addressing Social and environmental concerns and they hope to increase their financial performance by achieving efficiency in the social and environmental performance in dynamic, Complex, and uncertain environment. Thus, to build SCS is not a single destination, but it is a continuous improvement journey with long trajectory . In fact, many organizations are beginning to place greater emphasis and the implementation of sustainability drivers, because of multiple pressures and awareness (i.e, vendor collaboration and procurement tactics) change in consumer preferences and perception.

Improvement of regulations, and procurement tactics change in Consumer preference and perception, improvement of regulations and the policies of organizations explore the critical contextual actors or essential drivers of sustainable supply chain Factors are very important and there is a pressing need to have further research on this front . So to brige these gaps, in this section, an attempt to identify most important constricts of sustainable supply chain performance based on institutional theory and resource based view were conducted.

Resource- based view theory and institutional theory are the natural best fit to build the conceptual modeling for sustainable supply chain performance, because the first one focuses on economic factors and capability building based on resources and the second one considers the social environmental factors of sustainability. SCS drivers should reflect many dimensions like

efficient operational, economic performance, quick response to uncertain environment, a fulfillment of sustainability expectations, and risk management .

In Emerging economies there has been insufficient attention on key sustainability drivers for the successful implementation of SCS . Thus, it is Critical to deduce the drivers of sustainability, especially in tackling the effects of pandemic on supply chains. These drivers should support and enhance sustainability initiatives and improve overall sustainability performance.

To extract the basic drivers for SCS, both extant literature and expert opinions and feedback were taken into considerations. Thus, a literature review has been-Carried out in the initialization phase using several fundamental terms: Drivers and enablers for sustainability In the next phase, 20 crucial drivers of SCS drivers have been selected based on the existing literature and expert opinions table (1) showed the sustainability drivers identified in the context of the COVID pandemic from the previous literature: to reach to these drivers. A high quality literature review follows a multi procedures were conducted as depicts in Figure (2)

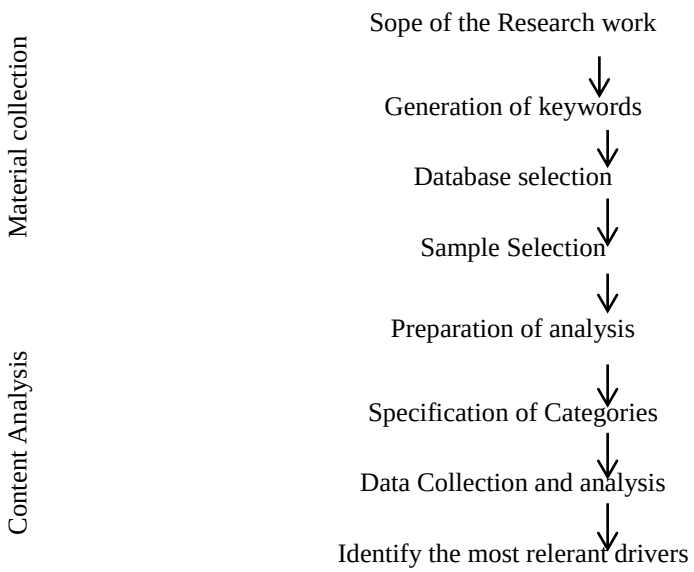


**Figure (2). (The procedures to explore SSCD**
**(Source the researcher based Saeed and Kersten, 2019)**

After conducting literature review in the initial phase using several key words like drivers and enables for sustainability improvement or critical factors or critical motivates. Then, for literature search, google scholar and research gate have been used. Finally, in the content analysis, eleven crucial drivers have been deduced based on the reviewing of existing literature and expert opinion. Table (1) shows the sustainability drivers determined in the context of the COVID-19 pandemic from the existing literature.

From Figure 1 the maternal collection phase was used to identify and select the most relevant literature associate to the drivers of SCS. It involves four steps: defining the scope of the research work, generations of keywords, selection of database and sample

selection. After that a four step content analysis approach was adopted: preparation of analysis, specification of categories, and data collection and analysis were conducted to deduce the most crucial drivers of SSC have been selected based on reviewing the literature as showed in table (1) presents the sustainability drivers identified in the Context of COVID-19 pandemic

**Table (1) Sustainability Drivers in Sc in the Context of COVID-19 pandemic**

| Drivers | Description |
|---|---|
| 1- Supply chain partners Financial support. | To achieve sustainability, collaborative financing among different tiers collaboration is the basic rule |
| 2-Building health products for stakeholders across supply chain. | Effective health products should be developed to influence the supply chain sustainability |
| 3- Build resilient transportation and logistics facility. | To increase the efficiency of global positioning system (GpS) accuracy and the radio, frequency REID should be used. |
| 4-provding personal protective Equipment to increase employee's safety. | Social distances should built to maintain sustainability in the supply chain. |
| 5-Expanding the application of interment of things (10T)<br>Internet of things (IOT) | Modern technologies will get the priority to prevent the spread of the pandemic an enhance efficiency of sup chain |
| 6- Application of new technologies in manufacturing and services such as automation and robotics. | Using robotics in manufacturing make supply chain more productive and safety |
| 7- Application of 3D printed technology for rapid manufacturing | 3D printing will help organizations to be more responsive to the changs in supply chain |
| 8- Financial fund and support from the government through offering incentives, tax, cut, loans | Government show help organization to recover looses |

## 3/2 SUPPLY chain sustainability DRIVERS IN THE CONTEXT OF COVID-19

COVID-19 has now generated a global supply chain crisis a cross a huge number of organisations, stemming from a lack of

understanding and flexibility of the multiple layers of their global supply chains, a lack of diversification in their sourcing strategies and inability to maintain the dimensions of sustainability. Therefore, building a smarter and more resilient supply chains are becoming more important and future tendencies, that includes the increasing of a sustainable consumption perspective are highlighted.

SCS looks for reducing the negative **impacts** of supply chain operations and to improve social, economic and environmental Performance of organizations . Supply chain sustainability management (SCSM) requires enterprises across supply chain to report not only on profit, but also on environmental, social and economic tools. To achieve SCSM, enterprises should set long term goals, unsustainability should be transparent in their reporting, develop a culture of sustainability and manage supply chain risks appropriately whereby in Piror researches, SCSM has been examined and a four-factor model. Whereby transparency, risk management, strategy and culture were identified as the four dimensions of (SCSM). The strategy dimension calls on firms to incorporate sustainability in their corporate strategy (Megete, 2021; Carter and Rogers, 2008; Dazen, et.al,2016) Risk management can be improved by balancing between economic and environmental goals on the other hand , transparency requires a balance between economic, social, and environmental goals they are involved in the corporate strategy and organisational culture of the firm, thus, to achieve sustainability,

it is necessary to the firm to seek for balancing between the three goals with three measurable metrics across the four

Facets The topic of sustainability has been addressed by many researchers and academic that signaling it is important in the contemporary business Environment (Mafini, 2018; Secuning and Muller, 2008; Svastawa, 2018; securing and Muller, 2008; Svastwa, 2007) Although, there is a limited number of studies that examined the drivers of sustainable. Supply chain (SCS) to tackle supply chain disruptions and how big data analytics has any inference an the SCSM practices of supply chain. This remains the focus of this research.

**3/2/1 Identification of drivers TO SCS in terms of COVID-19**

Essential drivers for SCS Can be taken both from extant literature. A literature study should be survived out in the initialization phase using Several Fundamental terms: "drivers" or "enablers" or" Indicators" or "determinations" of improving supply chain sustainability. These drivers are the key success factors for the sustainability of supply chain following the COVID-19 Pandemic to extract the drivers of SCS the following

**steps in Figure (2) will be made consequently.**

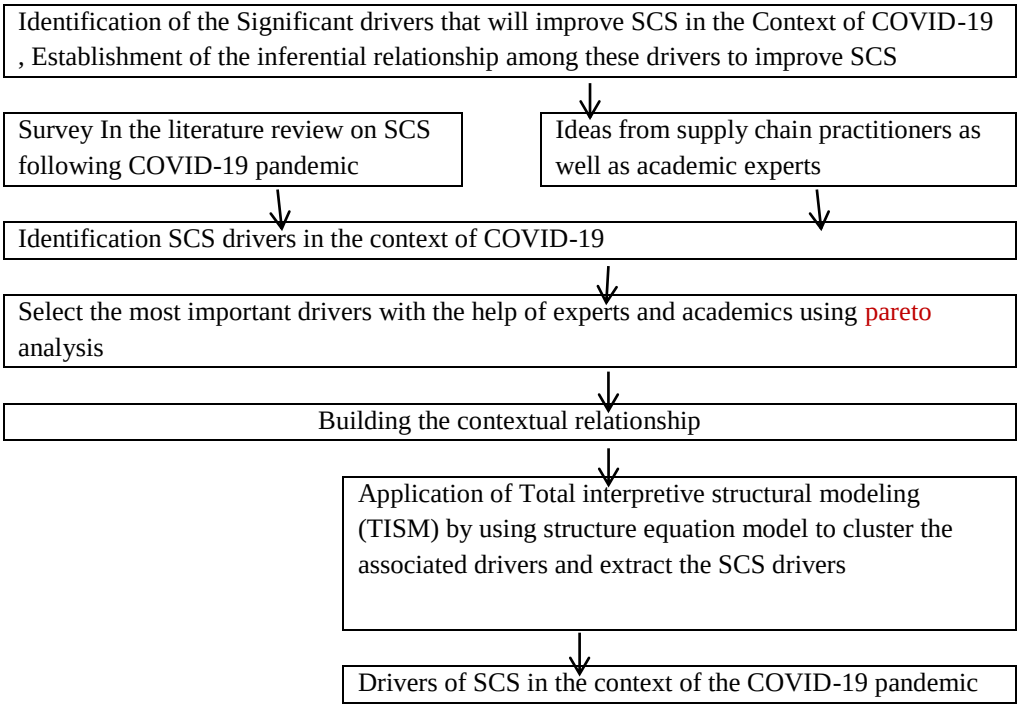


**Figure (3) flow diagram of SCS drivers selection**
**(Source. The researcher based on carmaker, et.al,2021)**

## 3/3 Selection of the drivers to SCS

To select the drivers of SCS by employing two-step methodology. At first stage the drivers of SC were identified. At the second stage, the contextual relationship was drawn based on ISM model.

In the beginning of data collection, to identify the most relevant drivers of SCS, a survey and questionnaire were performed by the expert group and practiannairs. Those experts should have

experience up to ten years, the expertise have knowledge in supply chain management, risk management sustainability by sharing in related project or publishing researches in related topics, and the job position academic an, supply chain manager, production manger, and chief operating officer. A primarily questionnaire was designed that initially contained eleven rivers based on revering the literature of SCS the context of the emerging economy.

The questionnaires were sent to 30 experts via email and interviews. The experts were asked to analyze and examine the drivers to check their relevance in improving SCS in the Context of COVID-19 pandemic. They have the choice to add or cancel any item from the yes/no base list. The participants in answering the question were accept 11 drivers deduced from the literature from $D_1$ to $D_{11}$ and add nine drivers from $D_{12}$ TO $D_{20}$ to the list of drivers to become 20 drivers in total. Table (2) shows supply chain sustainable drivers in the context of the COVID-19 pandemic.

**Table (2): Supply chain Sustainability drivers in terms of the COVID-19 Pandemic:**

| No. | Drivers | Description | References |
|---|---|---|---|
| $D_1$ | Efficient disruption risk management capacity. | How to pursue the firms to create the culture of continuous risk assessment due to COVID-19 and the effect of it on supply chain. | (De-sous, et.al, 2020, Ivanov, 2020a) |
| $D_2$ | Customer support, awareness and community pressure. | Consumers' awareness for sustainable products increases the pressure on firms to adopt sustainability practices. | (Zimon, et. al, 2020, Moktadir, et. al, 2018) |
| $D_3$ | Build legislation strongly to tackle COVID-19 for industry owners. | Strong regulations to bound the firms to adopt sustainability practices regarding labor relations, employment conditions and management during COVID-19. | (Ivanov and Das, 2020) |
| $D_4$ | Blockchain technology adopting | Blockchain will help ensure data privacy and process integrity among supply chain partners, thereby increase reliability and transparency. | ( Bai and Sarki, 2020, Ivanov and Dolgi, 2020a, Saberi, et. al, 2019) |
| $D_5$ | Increasing the applications of data analytics in the supply chain | The use of modern and real time data analytics helps the firms reduce lead time and unnecessary transportations. | ( Bag, et. al, 2020, Ivanov and Dolgui, 2020) |
| $D_6$ | Supply chain agility. | Agility in supply chain increases network visibility within production and distribution networks to maintain supply to fluctuating market demand during pandemic 19. | ( De-sousa, et. al, 2020, Golan, et. al, 2020, Ivanov, 2020b, Ivan and Dolgui, 2020b) |
| $D_7$ | Increasing the application of data analytics in the supply chain. | The use of real time data analytics that helps in reduction of lead time and unnecessary transportations. | ( Bag, et. al, 2020, Ivanov and Dolgui, 2020a) |
| $D_8$ | Supply chain virtualization and digitalization. | Digitalization and virtualization of supply chains create a vast amount of data that make supply chain more sustainable. | (Attaran, 2020, Schniederjans, et. al, 2020) |
| $D_9$ | The level of Collaboration among supply chain partners to ensure material supply. | Collaboration among the partners to ensure smooth material and production flow. | (De-sous, et.al, 2020, Moktadir, et. al, 2018) |
| $D_{10}$ | Devolving sustainable procurement strategies during COVID-19. | Firms should build new alternative suppliers and sustainable procurement strategies to face the impact of COVID-19. | (De-sousa, et.al, 2020) |
| $D_{11}$ | Delivery reliability. | Delivery reliability during COVID-19 that will satisfy the customer's requirements and increasing the supply chain sustainability. | (Craighead, e. al, 2021) |
| $D_{12}$ | Enable employees' safety by providing personal protective equipment (PPE). | Firms should ensure a social distance enabled working environment and provide PPE to the workers for retaining supply chain sustainability. | Contributed driver |
| $D_{13}$ | Build resilient transportation and logistics facility. | Enhance the Global Positioning System( GPS) accuracy and radio frequency identification (RFID) enable better tracking transportation system and sharing physical Internet (PI) improves the logistic capabilities. | Deduced Driver |

| No. | Drivers | Description | References |
|---|---|---|---|
| $D_{14}$ | Building the protocols for stakeholders across the supply chain. | Firms have to develop effective protocols throughout the entire supply chain sustainability driver. | Deduced Driver |
| $D_{15}$ | Policy- development to recover the impact over COVID-19. | Firms must rethink supply chain policy development to be prepared for any future pandemic 19. | Deduced Driver |
| $D_{16}$ | Financial support from Supply chain partners. | Collaborative financing among different tiers of supply chain to achieve sustainability. | Deduced Driver |
| $D_{17}$ | Expanding the application of the internet of things (IOT). | IOT and automation technologies will get priority to prevent the spread of future pandemic and increased efficiency. | Deduced Driver |
| $D_{18}$ | Application of smart manufacturing and usage of robotics in manufacturing and logistics serves. | Smart manufacturing reduce the transmission of pandemic and makes the supply chain more automation ensures safety and improve the productivity. | Deduced Driver |
| $D_{19}$ | Usage of rapid manufacturing 3D printing. | 3D printing helps in making more responsiveness to the changes in supply and demand after pandemic 19. | Deduced Driver |
| $D_{20}$ | Governments provide organizations with financial support, such as in incentives tax cuts and loans. | The financial supports of governments will help firms to recover the losses due to COVID-19. | Deduced Driver |

**Source: (The researcher based on Karmaker, et. al, 2021, Mattew, 2019, Ivanov, et. al, 2020)**

After identifying the 11 drivers based on the reviewing the literature in the context of emerging economy. Then the questionnaire was sent to experts to examine their relevance in supporting SCSs in the context of COVID-19 pandemic. They had the option to add or cancel the driver from Yes/NO – based list. The participants add 9 drivers from the list. Thus, the total drivers of sustainability drivers 20 drivers in the context of COVID-19 pandemic from the expert panels, the 20 drivers were ordered by using pareto analysis to differentiate between vital few and much vital.

**3/4 Usage of Pareto Analysis to Identify the Most Important Drivers Using Pareto Analysis**:

To identify the most important driver of Pareto analysis was performed to order the drivers according to their importance. So, another questionnaire was designed and sent to the experts, academics and practitioners to Express their opinions in prior priority weights on all drivers using (five points Likert scale) (Appendix 2). In Likert scale: 1 indicates the least important, and 5 indicates the most important driver using Pareto analysis. The Pareto principle is often termed that 80/20 rule as 20% of factors are responsible for 80% of problems. This rule is effective in technique with the ability to differentiate between essential and non-essential drivers. After data collection for expert responses, cumulative percentage and highest mean value score for all drivers were calculated. Based on the percentage of score, significant drivers (comprising 80%) of SCS in the context of COVID-19 pandemic were deduced. Depending on Pareto principle among twenty drivers, the most vital drivers that will increase the sustainability in SC were ordered as follows to make more analysis in Table 3.

**Table (3): The Drivers Arrangement According to their importance:**

| | |
|---|---|
| **Building health protocols for stakeholders across the supply chain.** | $D_{14}$ |
| **Government provides organizations with financial support, such as incentives, tax cuts and loans…** | $D_{20}$ |
| **Efficient Disruption risk management capacity.** | $D_1$ |
| **Financial support from supply chain partners.** | $D_{16}$ |
| **Build resilient transportation and logistics facility.** | $D_{13}$ |
| **Application of smart manufacturing and usage in manufacturing and logistics services.** | $D_{18}$ |
| **Adoption blockchain technology.** | $D_4$ |
| **Policy development to recover the impact of COVID-19.** | $D_{15}$ |
| **Building sustainable procurement strategy strategies considering COVID-19.** | $D_{10}$ |
| **Collaboration among supply chain partners to ensure materials supply.** | $D_9$ |
| **Customer support, awareness and community pressure.** | $D_2$ |
| **Supply chain agility.** | $D_6$ |

To order the drivers accurately, the researcher will use the relative importance index (RII) in case of five points Likert scale as in the questionnaire the following equation can be applied as follows: (Akadiri, 2011)

$$R_{II} = \sum_{An}^{w} * 100$$

$$= \frac{5n_5+4n_4+3\,n_3+2n_2+1n_1}{5*N}$$

$$0 \leq R_{II} \leq 1$$

Where:

W: Is the weight given to each items by the respondents range from one to five.

A: Is the highest weight (five in five point Likert scale)

N: Is the total number of the respondents.

The results from table (3) depict that the most essential driver is building health protocols for stakeholders across the supply chain and the least driver is supply chain agility.

**3/5 Development of the contextual relationships among the drivers:**

The researcher in this study tries to develop a precise model for the assessment of the drivers of SC to promote a more and entirely intelligent SC to address the Situation of COVID-19 using interpretive structuring modeling (ISM). ISM is an integrated multiple criteria decision making (MCDM) that was developed by Warfield and further illustrated by Malone (1975) via Judgment of experts and practitioners. Total interpretive structural modeling (TISM) derived from (ISM).

ISM depends on developing structural model through which hierarchical relationships among the variables are constricted. ISM Investigates the cause and effect relationship among different variables by converting them into several levels and finding the possible relationships. The hierarchical relationships among the variables are showed. ISM is an effective tool to deduce the contextual relationships among drivers (Singh and Sushil, 2013)

In this research, ISM is used for the following reasons:

1- ISM techniques puts priorities factors based on their importance without requiring any history.
2- ISM can classify the complex structure into different levels and build understandable diagram by considering the realistic knowledge.
3- ISM classify a complex structure into different levels and develops understandable diagram by considering the realistic knowledge and opinion of professionals.

**3/5/1 The steps of the (TISM):** to apply (TISM) the next steps should be followed:

Step1: Defining the scale for establishing the contextual relationships among drivers.

Step2: preparing self-structure interaction matrix (SSIM) based on the responses of the experts and practitioners.

Step3: Assessment of SSIM and development of the final reachability matrix.

Step4: calculating the level of partitioning and during power.

Step5: Formulating the total interpretive structuring model (TISM).

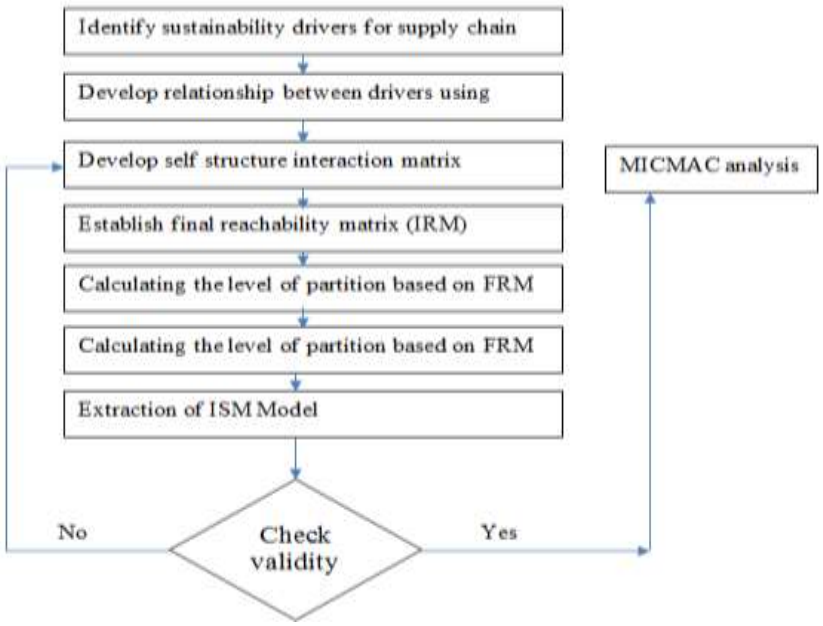


**Figure (4) : ISM Approach**

**These steps can be depicted in figure (3) as follows:**

**Step1: Defining the scale for establishing the contextual relationships among drivers.**

To identify the contextual relationships, Crisp method and linguistic method scale is used. The Proposed linguistics has five options for showing the degree of impact/ influence of one criteria over another: (very high influence (VH), high influence (H), low influence (L), very low influence (VL), no fluence (N)). Table (4) shows the linguistic scale for the influence:

**Table (4) The Linguistic Scale for the influence**

| Linguistic terms | Expected number |
|---|---|
| **No influence (N)** | **[ 0.0, 0.25]** |
| **Very low influence ( VL)** | **[ 0.25, 0.50]** |
| **Low influence (L)** | **[ 0.50, 0.75]** |
| **High influence (H)** | **[0.75-1]** |
| **Very high influence (VH)** | **[1]** |

**Source (Li, 1999)**

## Step2: Preparing self- structure interaction matrix (SSIM):

Self-structure interaction matrix (SSIM) can be developed based on responses of experts to find the relationships between SCS drivers. Four Symbols were used to explain the relationships among two factors (j and i)

The direction of the relationship between two factors:

(a) v: Factor (i) affects factor (j) (very high (VH), high (H), low(L), very low (VL)) ( i is linked with j)

(b) A: Factor (i) is affected by factored by factor j. (j is linked i)

(c) O: factors (i) and j are unrelated. (Both are not linked)

(d) X: factors (i) and j affected each other. (Both are linked)

(SSIM) can be showed as follows Table (5)

**Table (5) Self Structure Interaction Matrix**

| No | 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9 |
|---|---|---|---|---|---|---|---|---|---|
| $D_1$ | | V | V | A | A | A | V | V | A |
| $D_2$ | | | | V | V | V | A | A | A |
| $D_3$ | | | | A | V | V | V | A | V |
| $D_4$ | | | | | A | V | V | V | V |
| $D_5$ | | | | | | V | V | O | V |
| $D_6$ | | | | | | | A | V | V |
| $D_7$ | | | | | | | | V | A |
| $D_8$ | | | | | | | | | X |
| $D_9$ | | | | | | | | | |

**Step3: Evaluation of SSIM and construction of final reachability matrix:**

To assess SSIM, First: initial reachability Matrix (IRM) should be formulated. Second: final reachability matrix is developed (FRM). Initial reachability Matrix (IRM) To build IRM, the data from SSIM is converted into binary digits (0, 1) to establish an IRM by following some conversion rules that are mentioned below:

**Rule 1**: If the link between (i, j) is presented by symbol "v" in the SSIM, then this cell (i, j) entry converted into 1 and the cell (j, i) in IRM becomes 0.

**Rule 2**: If the link between (i, j) is represented by symbol "A" in the SSIM, then this cell (i, j) transformed into "0" and the cell (j, i) entry transformed into "1" in the IRM.

**Rule 3**: If the link between (i, j) is presented by the symbol "x" is the SSIM then the cell (i, j) transformed into "l" and the cell cell (j, i) is converted in IRM to one also.

**Rule 4**: If the link between (i, j) is represented by symbol "0" in the SSIM, then the cell (i, j) transformed into 0 and the cell (j, i) also transformed into 0 in the IRM. The Initial reachability matrix is depicted in Table (6 )

**Table (6) The Initial Reachability Matrix (IRM)**

| No 1 | 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9 |
|---|---|---|---|---|---|---|---|---|---|
| $D_1$ | 1 | 1 | 1 | 0 | 0 | 0 | 0 | 1 | 1 |
| $D_2$ | 0 | 1 | 1 | 1 | 1 | 1 | 0 | 0 | 0 |
| $D_3$ | 0 | 0 | 0 | 1 | 1 | 1 | 0 | 0 | 0 |
| $D_4$ | 1 | 0 | 1 | 1 | 0 | 0 | 1 | 1 | 0 |
| $D_5$ | 1 | 0 | 1 | 1 | 0 | 0 | 1 | 1 | 0 |
| $D_6$ | 0 | 1 | 1 | 0 | 0 | 0 | 1 | 1 | 0 |
| $D_7$ | 0 | 1 | 1 | 0 | 0 | 1 | 1 | 1 | 0 |
| $D_8$ | 0 | 1 | 1 | 0 | 0 | 0 | 0 | 1 | 1 |
| $D_9$ | 1 | 1 | 0 | 0 | 0 | 0 | 1 | 1 | 1 |

## Final Reachability Matrix (FRM)

The FRM is calculated by incorporating the transitivity rule on IRM. The basic rule of ISM showed that if attribute 1 is linked to 2 and attribute 2 to 3 rule then 1 is inevitably connected to rule 3. The FRM is showed on the next Table (7)

**Table (7) The (FRM)**

| No | 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9 | Dri |
|---|---|---|---|---|---|---|---|---|---|---|
| $D_1$ | 1 | 1 | 1 | $1^*$ | $1^*$ | $1^*$ | 1 | 1 | 0 | 8 |
| $D_2$ | 0 | 1 | 1 | 1 | 1 | 1 | $1^*$ | 0 | $1^*$ | 7 |
| $D_3$ | $1^*$ | 0 | 1 | $1^*$ | 1 | 1 | 1 | $1^*$ | $1^*$ | 8 |
| $D_4$ | 1 | $1^*$ | 1 | 1 | $1^*$ | 1 | 1 | 0 | 0 | 7 |
| $D_5$ | 1 | 1 | 1 | $1^*$ | 1 | 1 | $1^*$ | 0 | 1 | 8 |
| $D_6$ | 1 | 1 | 0 | 0 | $1^*$ | 1 | 1 | 1 | $1^*$ | 7 |
| $D_7$ | 1 | 1 | $1^*$ | 1 | $1^*$ | 1 | 0 | 0 | 1 | 7 |
| $D_8$ | 1 | 1 | 1 | $1^*$ | 1 | $1^*$ | 1 | 1 | 0 | 8 |
| $D_9$ | 1 | 1 | $1^*$ | 1 | $1^*$ | 1 | 0 | 0 | $1^*$ | 8 |
| Dep | 8 | 8 | 8 | 8 | 9 | 9 | 7 | 4 | 6 | 68 |

In the final reachability matrix is formed and converted one and zero values based on aggregated values of Columns and rows.

**Step 4: Calculation of the driving power and level of partitioning:**

To extract the driving power, the final reachability matrix used to extract the reachability set, antecedent set, and intersection set. The reachability set is calculated based on of value 1 in each row and the antecedent set is depend on value of each column and the intersection set is developed by matching the values of the antecedent and reachability set. Thus, the different factors assigned to different levels. The level partitioning of drivers can be should in the following table:

**Table (8): Level partitioning of drivers:**

| Drivers | Reachability Set | Antecedent Set | Intersection Set | Level |
|---|---|---|---|---|
| $D_2$ | 2 | 1,2,6,7,10,11,13,14,15,16,18,20 | 2 | 1 |
| $D_5$ | 5 | 5,6,7,10,14,18 | 5 | 1 |
| $D_1$ | 1,11,13 | 1,6,7,10,11,13,14,15,16,18,20 | 1,11,13 | 2 |
| $D_{13}$ | 1,13 | 1,7,10,11,13,15,16,18,20 | 1,13 | 2 |
| $D_{11}$ | 11,16 | 7,10,11,15,16,20 | 11,16 | 3 |
| $D_7$ | 7,10,16,20 | 6,7,10,14,18,20 | 7,10,16,20 | 4 |
| $D_{10}$ | 7,10,16,20 | 7,10,14,15,16,18,20 | 7,10,16,20 | 4 |
| $D_6$ | 6,18 | 6,14,15,16,18,20 | 6,18 | 5 |
| $D_{18}$ | 6,16,18,20 | 14,15,16,20 | 6,16,18,20 | 5 |
| $D_{20}$ | 16,20 | 14,15,16,20 | 16,20 | 6 |
| $D_{14}$ | 14,16,20 | 14,15 | 14,15 | 7 |
| $D_{15}$ | 14,15 | 14,15 | 14,15 | 7 |

**Step5: The formulation of total interpretive structuring model (TISM):**

The relationship among drivers can be extracted using two tools. The first is bath analysis existed in structuring equations modeling using SPSS and the second is Matriced Impacts Cruoses Multiplication Applique a un classment techniques (MIMAC). The MICMAC analysis is a systematic tool that is used to dividing the factors or drivers into different domains on the basis of their dependence and driving power. In MIMAC the relation between two drivers are defined in binary forms either 0 or one where one defined the drivers that are related and zero for no relationship between two drivers. In this research, the contextual relationship among drivers are extracted based on the driving power and dependence power of each driver separately from FRM. The driving power and the interdependence values were entered to SPSS program and Bath analysis applied to extract the contextual relationships among drivers as depicts in figure (4).

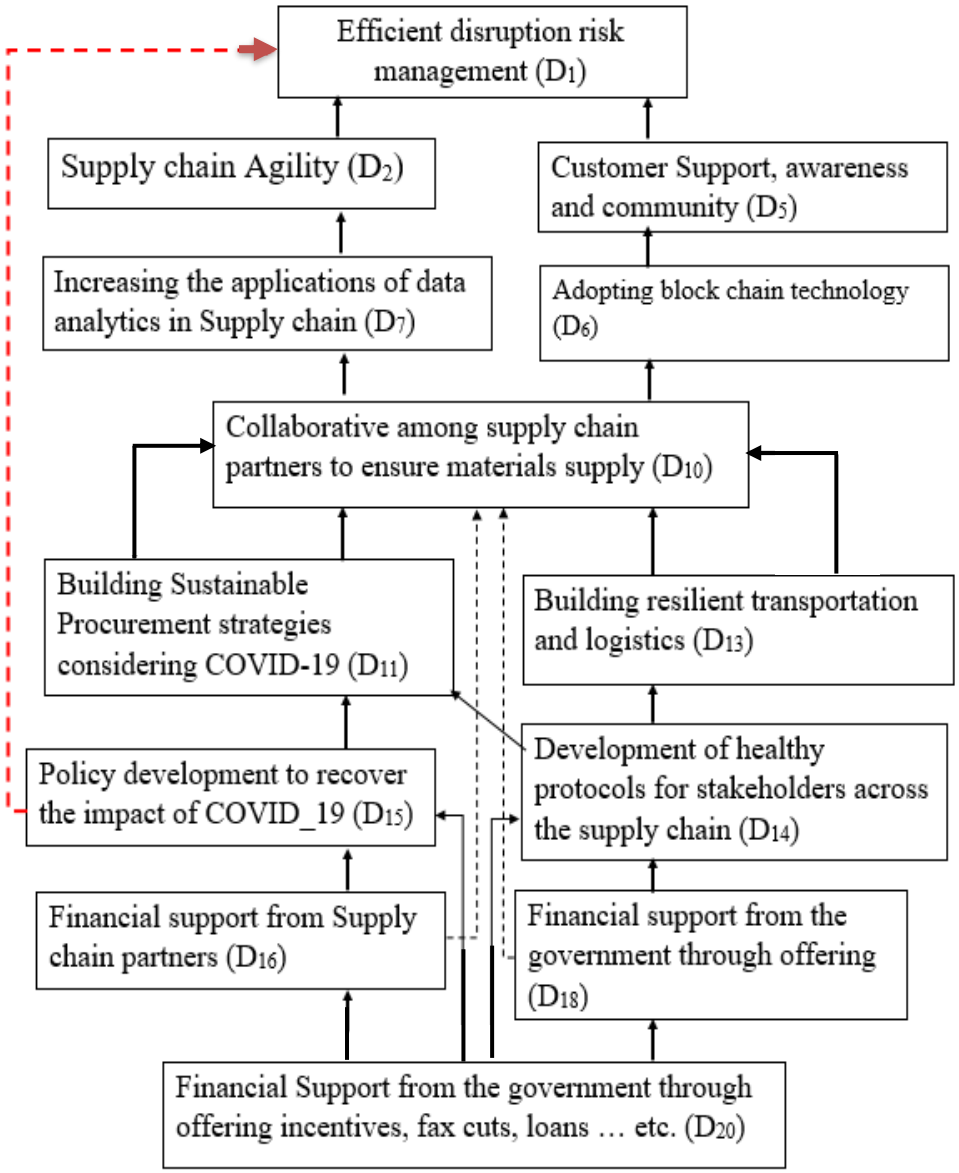


**Figure (4) a proposed Model of (TISM)**

### 3/6 Results and discussion

The present paper has outlined drivers that would be more effective in development of strategies to strengthen sustainability of supply chain SCS in the emerging economy by take into consideration COVID-19. As shown in the previous figure, "financial support from the government through offering incentives, tax cuts, loans …. $D_{20}$", has got the highest driving power and the foundation of ITSM model so that existed in the bottom of the model. It is the most important driver among all others. Respectively, "Development of health protocols for stakeholders across the supply chains "$D_{11}$" and policy development to recover the impact of COVID-19 have the second and the third most driving power value, respectively. The driver with the most driving power has the ability to effect on other drivers is "Supply chain agility" $D_2$ and "Customer support awareness and Community pressure $D_5$" were found to have the lowest driving power values. On the other side, it was found that "supply chain agility" $D_2$ has the highest dependence value "Efficient disruption risk management Capacity" $D_1$ has the second highest dependence value, Although $D_{14}$ and $D_{15}$ have the lowest dependence values.

#### 3/6/1 Model validation

The hierarchical model has required further validation (Rajesh, 2202) For this validation process, 20 academics and professionals from various institutions and firms that have experience more ten

years in the supply chain management that have experience more than 15 years in the topic of supply chain.

They were asked to review and check the contextual relationships among drivers and give scores between 1 and 5 to each link where 1 indicates "highly disagree" and "5" indicates "highly agree". Next, the average scores were calculated and those with score more than 3 and 60% were selected. The results were showed that the validation of the hierarchical model.

**3/6/2 MICMAC Analysis**

After checking model validation, MICMAC (M'atce ce d'impact croise multiplication applique an classmet) or cross effect matrix multiplication analysis) is used that is graph model has four quadrant and classify each driver in different quadrant based on their dependence and their driving power as shown in the following Figure:

There are four main quadrant of MICMAC, which are:

(1) Autonomous Category
(2) Dependent Category
(3) Linkage Category
(4) Driving Category

1- Autonomous Category :

In autonomous quadrant, the weak dependence and the weak driving power. In this quadrant has failed to achieve any driver due to strong dependence and driving power in a model

**2- Dependent Category:**

In this quadrant has strong dependence and low driving power. None of any driver shows in this quadrant due to high dependence power and strong driving power.

3- Linkage Category:

All 14 drivers existed in the linkage category depend on their strong dependence and driving power. Its means that any impact on these variables will affect to whole models. In this category all drivers are existed.

4- Driving Category:

The quadrant has weak dependence and strong driving power. None of any factor emerge in this category due to strong dependence power.

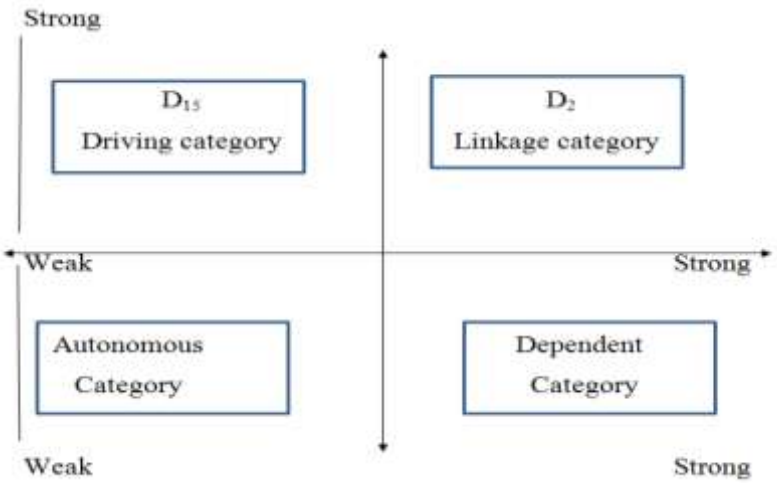


**Figure (5) MICMAC analysis for SCS**
**(Source: the researcher)**

The MICMAC analysis classified drivers in different quadrant based on their driving and dependence power. This classification will help decision makers additional freedom to further investigate the degree of impact on the other driver.

In addition, the results will help the policymakers to constrain the disruptions of the pandemic in an emerging economies. The basic and the essential drivers that companies need to focus on are "policy development to recover the impact of COVID-19" and development of health protocols for stakeholders across supply chain" to improve flexibility, resilience and disruption risk management capacity in the SCS, which would assist in business sustainability. Firms should rethink supply chain policy development to be prepared for any future pandemic situations COVID-20 and employees should educate health protocols that have an effect on SCS. Furthermore, firms should apply digital communications and modern technology that play an essential role in increasing the drivers of sustainability in the supply chain. The classification and prioritization of sustainability drivers will help in the correct combination and sequencing of goal-setting actions are strategies.

**3/7 Future Research**

This current research provides a valuable insight for SCS, however it is still has some limitations. In this research, we considered only twenty drivers from previous literature and professionals, thus the drivers can be increased in the future research.

Different methodologies and techniques can be used such as AHP, PLS (SEM) and Fuzzy approach, that will result in variations of results.

Another limitation in this paper is related to research design. The research design was depend on Cross-Sectional design, so the research can be designed used a longitudinal research design. The research model will be designed from developing countries perspective and can generalize the results.

Future research in supply chain may be directed toward intertwined supply chain network (ISN) that are characterized by structural dynamics. ISN is different from static structures as the firms in ISN may exhibit multiple behaviors in buyer-supplier relations (i.e., behavioral dynamics) that behavior should be supplemented by investigations in flexible production / Service technologies and human robotics collaborations for changing environment and switching behavior.

Clearly, these adaptable structures and technologies are expected to be supported by facility designs and innovative product engaging all actors in the SC ecosystem.

Another hot topic research area for SC viability is the utilization of digital data-driven technologies like additive manufacturing, robotics and smart manufacturing and warehousing to uncover their potential in decision-making support in times of pandemic like severe disruption.

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**Appendix (1)**

Primary question:

1. Background information of the respondent:

(a) Name:

(b) Name of the companies:

(c) Designation:

(d) Years of experience:

(e) Major job responsibilities:

**Appendix (2)**

Selection of drivers to supply chain sustainability (SCS) following the COVID-19 outbreak: Please select the most relevant drivers to the supply chain sustainability following the COVID-19 outbreak from the Yes/No-based list. You may add/remove any driver.

| No. | Drivers | Is it relevant? (Yes/No) |
|---|---|---|
| 1 | Efficient disruption risk management capacity | |
| 2 | Supply Chain Agility | |
| 3 | Delivery reliability | |
| 4 | Build strong legislation facility to tackle COVID-19 for industry owners | |
| 5 | Customer support, awareness and community pressure | |
| 6 | Adopting block chain technology | |
| 7 | Increasing the applications of data analytics in supply chain | |
| 8 | Supply chain digitization & virtualization | |
| 9 | Support from international forums (i.e. World Economic Forum) | |
| 10 | Collaboration among supply chain partners to ensure materials supply | |
| 11 | Build sustainable procurement strategies considering COVID-19 | |
| | Add relevant drivers if necessary | |

## Appendix (3)

Identification of the most significant drivers to SCS using Pareto analysis.

| No. | List of identified drivers to SCS | Code | 5: Very High important and 1: Very weakly important | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9 | 10 |
| 1 | Efficient disruption risk management capacity | D1 | | | | | | | | | | |
| 2 | Supply chain agility | D2 | | | | | | | | | | |
| 3 | Delivery reliability | D3 | | | | | | | | | | |
| 4 | Build strong legislation facility to tackle COVID-19 for industry owners | D4 | | | | | | | | | | |
| 5 | Customer support, awareness and community pressure | D5 | | | | | | | | | | |
| 6 | Adopting block chain technology | D6 | | | | | | | | | | |
| 7 | Increasing the applications of data analytics in supply chain | D7 | | | | | | | | | | |
| 8 | Supply chain digitization & virtualization | D8 | | | | | | | | | | |
| 9 | Support from international forums (i.e. World Economic Forum) | D9 | | | | | | | | | | |
| 10 | Collaboration among supply chain partners to ensure materials supply | D10 | | | | | | | | | | |
| 11 | Building sustainable procurement strategies considering COVID-19 | D11 | | | | | | | | | | |
| 12 | Enable employees' safety by providing PPE | D12 | | | | | | | | | | |
| 13 | Build resilient transportation and logistics facility | D13 | | | | | | | | | | |

| No. | List of identified drivers to SCS | Code | 5: Very High important and 1: Very weakly important | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9 | 10 |
| 14 | Development of health protocols for stakeholders across the supply chain | D14 | | | | | | | | | | |
| 15 | Policy development to recover the impact of COVID-19 | D15 | | | | | | | | | | |
| 16 | Financial support from supply chain partners | D16 | | | | | | | | | | |
| 17 | Expanding the application of internet of things (IoT) | D17 | | | | | | | | | | |
| 18 | Application of automation and robotics in manufacturing and logistics service | D18 | | | | | | | | | | |
| 19 | Use of 3D printing for rapid manufacturing | D19 | | | | | | | | | | |
| 20 | Financial support from the government through offering incentives, tax cuts, loans etc. | D20 | | | | | | | | | | |