



# **The Role of Artificial Intelligence in Managing Supply Chain Risks occurred due to Covid-19 pandemic in Automobile industry**

**Dr. Shivani Kapoor<sup>1</sup>, Dr. Ruchika Rastogi<sup>2</sup>, Dr. Alok Kumar<sup>3</sup>**

<sup>1</sup>Professor, School of Business, Galgotia University, Greater Noida, Uttar Pradesh, India

<sup>2</sup>Associate Professor, , Department of Business Administration, PSIT, Kanpur, Uttar Pradesh, 209305, India

<sup>3</sup>Assistant Professor, Department of Computer Science and Engineering, University Institute of Engineering and Technology, CSJM University, Kanpur, Uttar Pradesh, 208024, India

---

## **Introduction**

Covid-19 has been the most challenging disruption for the industries in last few years. Lockdown, disruption in supply, meeting demand of the customers were some main issues for the production managers and that's why they are looking for sustainable solutions in manufacturing units. This disease was found in Wuhan city on 31<sup>st</sup> December, 2019 and left the entire world infectious in January and February, 2020. WHO has declared Covid -19 as a pandemic in March 2020 and from then the instructions from the government in terms of lock down and social distances started. Enormous changes took place in the industries due to halt in production, shortage of raw material, no transportation and no staff (Ivanov, 2020 and Kumar et al., 2020). Volatility, uncertainty, complexity and ambiguity (VUCA) was seen everywhere and it was very tough to survive in this environment. Number of studies have been conducted in last few years but no study was found to be conducted for automobile industry in Indian market. This study will be useful for the managers of automobile industry to find out policies and other measurements based on the problems found in the Covid-19 pandemic.

The supply chain (SC) is the foundation of the economy and society because it strongly involves the environment. The interactions of the ecosystem SC are complex and rely on feedbacks and interactions between SC, environment, society and economy. The current state

of the ecosystem is the result of various transformations that went from lean and agile to resilient and sustainable SC, reaching the current state of digitized and viable SC (Ivanov, 2020 b). COVID-19 led to potential negative impacts on the global supply chain, with the global economy facing a negative supply shock that led to the closure of various factories and a subsequent disruption of the global network of SC (Chowdhury et al., 2020). Companies need to redesign SC and make it adaptable for the coming challenges in trade. In the long term, companies need to develop and implement capabilities and action plans related to data sharing and digital readiness for SCs (Betti & Ni, 2020). Digitization can increase the efficiency of the response to the COVID -19 outbreak by improving the flexibility of SC in such situations (Ivanov, 2019). Recent technological developments such as "Cloud Computing (CC), Internet of-Things (IoT), Big Data (BD), Blockchain (BC), Robotics and AI" help to integrate isolated SC developments into intelligent and networked Systems of Systems (SoS).

One of the major disruption events of the previous two decades, the COVID-19 pandemic demonstrated the susceptibility of multinational manufacturing corporations to their business operations and supply chains. Global supply chains have been impacted by the COVID-19 epidemic at an unprecedented rate and scope. It has shown that big businesses undervalue the need for resilient and sustainable operations. Significant disruptions have been caused by the epidemic, particularly in the automotive sector.

After Covid-19 pandemic, organizations have adopted contactless methods for mitigating the risk and for the effective supply chain operations (Chen & Biswas, 2021). These actions of the organizations motivated the researcher to go through the supply chain operations in automobile industry. This study focuses on finding out the methods and techniques used by the automobile industry during covid-19 in handling and mitigating risk.

Researcher has been with the informal interview of many industries like food, travels energy, and automobile (Sombultawee et.al., 2022). Based on the feedback take from the managers of the different industry, research is able to decide the industry to work on as supply chain management was highly disturbed in automobile industry (Nayak, 2022). Initially there was no sharp decline in the demand and supply in the automobile industry but later on as the restrictions declared by the government, significant fall took place. Based on the reason mentioned above, research questions framed in the study are:

- What was the impact of this pandemic on the supply chain activities of automobile industry?
- What was the impact of work from home in supply chain operations during Covid-19 in automobile industry?
- What practices can be helpful to survive after this kind of pandemic in automobile industry?
- What is the impact of AI on supply chain operations in automobile industry?

## **Literature Review**

Covid-19 has impacted the supply chain and operational activities of automobile industry. Companies who have established themselves in other countries in last few years have faced shut down and few of them have declared bankrupt as well (Eldem et al., 2022). Most of the automobile companies who have their manufacturing units in India are suffered more initially. Indian economy was already shrinking due to Covid-19, GDP fall from 7.4 percent in 2016 to 4.2 percent in early 2019. It was the time when IMF declared Indian economy to be shrunk by 10.3 percent in the fiscal year 2020-2021 (Sharma, 2022). Many industries got affected and it is not only limited to FMCG, energy, oil, and automobile industry. This supply chain got affected as Wuhan is the major supplier of auto components to the automobile companies like Toyota, Hyundai, and General Motors etc. Disturbance in China and especially in Wuhan affected the entire automobile sector (Sombultawee et al., 2022).

Due to plant shutdown and border seize, companies in India are informed for the late deliveries, these deliveries have impacted the manufacturing of the companies. Late deliveries have created the imbalance in supply and demand and disturbed the complete supply chain management. Automobile companies were not able to continue their operations which led to the big losses. It was the environment of uncertainty and ambiguity and companies were not able to predict anything for the future. Consequences were admitted by the automobile firms in terms of shortage of raw material, availability of spare parts, problems of staff to come to production units etc. (Cohen, 2020). Ultimately, it led to temporarily shut down for the organizations.

**H1: Several problems occurred due to Covid-19 which has negatively impacted the supply chain operations in automobile industry.**

Companies were facing the issue of labor shortage; employees were migrating to their home

town which was very tough to manage. Companies have adapted various measures like social distancing on the job and trying to control the infection inside the production plants. To run the manufacturing units with social distancing and less infection was the major challenge for the organization. Initially when the chances of infection were very high, employees were not turning in the organization. Those who were coming to the companies, they have been provided very limited load which ultimately reduced the company's productivity (Kumar et al., 2020).

In this condition where the chances of infection were very high, remote working options were provided to the employees. Employees and workers involve in the productions were suffered from mental stress as there was no communication between the members due to social distancing (Roy et al., 2020 and Govindan et al., 2019).

**H2: There is an impact of work from home and social distancing on supply chain operations.**

In the period of this pandemic, uncertainty is high in the external environment (Alicke & Strigle, 2020). The organization should be always ready to face these uncertain circumstances because it is found that the infection is related with the disruption in supply chain management activities (Williams et al., 2017). This the responsibility of the managers and the management to come up with sustainable solutions so that they can prevent themselves from this kind of volatile and uncertain environment. The organization can work on certain policies which will help in managing human resource management, supply chain operations, and other organizational activities. Managing these activities surely support the employees to perform better during Corona -19 (Lavrakas, 2008).

**H3: There is an impact of managing supply chain operations with the help of sustainable solutions on employees during Covid-19.**

From the year 2000, implementation of AI (Artificial intelligence) took place in various fields like engineering and science too. There are always some advantages and barriers too in the implementation of a technique and it has happened with AI also shown in literature review (Davenport, 2018). It is observed that without having proper AI strategy, it can't be successfully implemented. It also requires acquisition of talent and technology for implementation. Some example of AI failures is face recognition, Google translate, and handwrite recognition etc. (Schoemaker & Tetlock, 2017). As Gartner predicted that 50 percent of the global companies will transform their supply chain operations with the help of

AI by 2023 (Panetta, 2018). AI in supply chain management can be implemented in terms of optimization, simulation, prediction, and modelling (Choi et al., 2018). AI with the help of image recognition technology, can help in managing inventory in the warehouse (Umeda et al., 2017). To get the good results of using AI depends upon the right data source to train the model.

**H4: There is a significant impact of AI on supply chain operations in automobile industry during Covid-19.**

### **2.1 Summary of Literature Review**

It is observed in literature review that there was a shortage of raw material which has affected the supply chain operation of the organization. It is also seen that due to no transportation, raw materials like plastics, steel and other components required in automobile industry were not available on time which has ultimately increased the production time of automobiles in the organization. There was no possibility of the demand forecasting due to Covid-19 because of high uncertainty in the environment. Researcher has also observed in the literature review that most of the parts are manufactured in China and it was a big halt in the production due to which no regular supply of required raw material was not in India.

### **2.2 Research Gap**

It is seen in literature review that many studies were conducted in India and other countries to understand the effect of Covid-19 on industries like FMCG, Steel, and pharmacy etc. Among all these studies, no study is found which is conducted on Indian automobile industry. Researcher would like to take up this opportunity to conduct a study on analyze the impact of Covid-19 in the supply chain operations of automobile industry.

## **3. Research Methodology**

### **3.1 Nature of the Study**

To work on the fulfillment of the objectives, researcher has work on the qualitative and quantitative approach. This approach includes interaction and data collection from the department of supply chain operations like floor manager, warehouse manager, workers working on the production floor etc. Quantitative analysis is done on the data collected from automobile company from India. Qualitative analysis is done on the case study research to see the problems occurred in supply chain operations during Covid-19.

### **3.2 Methodology**

The complete process of data collection and case study took place in four cycles.

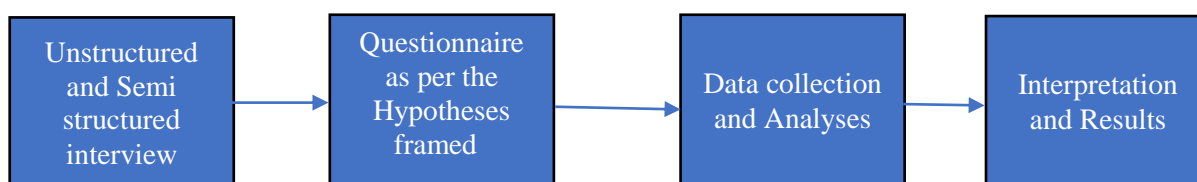
**Cycle 1:** Initially, Unstructured and semi-structured interview is conducted with the managers of the organization. It was very tough to correlate hypothesis with the unstructured interview as its generally starts with one or two questions and can have the connectivity with the literature. After that, semi structure interview was conducted with the managers and it was all open ended but all the research questions and research objectives were kept in mind. The interview was conducted with five mangers who were catering to the different departments like supply chain mangers, warehouse manager, floor manager, and with two senior managers of the unit. It was kept in mind that they should be having more than five years of experience in the same unit because then only they have been faced the Covid-19 scenario in the unit.

**Cycle 2:** Questionnaire is prepared on the basis of disruption ad problems faced by industries during Covid-19. The questionnaire is divided in to three subparts. First part was prepared in keeping in mind the impact of pandemic on the employees of the organization. Second part consist of the questions related to supply chain operations and third part was focusing on the actions taken by the organization during Covid-19. Fourth part of the questionnaire focuses on impact of AI on the supply chain operation in the organization.

**Cycle 3:** Case and collected data is analyzed to see the impact of Covid-19 on the supply chain operational activities and employees.

**Cycle 4:** Based on the analysis, results are discussed and the validity of hypotheses are checked. This research is able to see the impact of Covid-19 on supply chain operations and on employee too and the researcher hope to understand the results by the managers of other industries to implement changes in the organization after Covid-19.

**Figure 3.1: Framework of methodology used**



### **3.3 Sample Profile**

Non-random sampling (Convenient sampling) was used to collect information from the managers and the employees. Apart that representative sampling is used because there were many impossible in the organization but it was not possible to reach to many of them (Lavrakas, 2018 and Grafström&Schelin, 2014). Sample is selected from two groups, one from the managers and the other one from the employees. Sample size taken was 190 and

most of the employees were involved in floor operations, warehouse or working as a manager in the operation unit of the organization. Out of 190, 133 (70 percent) employees were from floor operations, 5 (3 percent) were managers, and 52 employees were from warehouse operations.

### **3.4 Statistical tools used**

Data collected from the questionnaire is analyzed on the Microsoft excel and SPSS. Data is collected on the nominal scale so it was very helpful in observing the variables in descriptive study. Data collected by questionnaire is analyzed to check the validity of the hypotheses. All four hypotheses are checked with the help of analysis done on excel and SPSS.

### **3.5 Data Collection tool: Questionnaire**

As the researcher has mentioned earlier that the data is collected through the questionnaire and the questionnaire is divided in to two parts. First two parts were asked from the employees and managers whereas third part is focusing more on the methods taken to manage Covid-19, was asked from the managers only. Data collection through questionnaire took almost one and half months.

### **3.6 Hypothesis testing**

**HypothesisH1: Several problems occurred due to Covid-19 which has negatively impacted the supply chain operations in automobile industry.**

- a. **Availability of raw material and other stock in the company:** As the company is reputed one and have a control in the market. Problems occurred in managing certain items imported from other nations but the firm was able to manage it and no disruption in managing the raw material and other stock took place in the company.
- b. **Impact on the presence of the labour in the organisation:** Apart managers, labour on floor and warehouse were affected because they were not working online. Mostly those who were working in production plant on floor and in warehouse were affected. Out of 133 employees on floor, 121 were affected and out of 42 employees in warehouse, 27 were affected. Due to isolation of 2 weeks and after availing sick leaves, there was a shortage of labour in the organisation.
- c. **Impact on the modes of transport in the organisation:** Due to pandemic, closure in transportation at national and international level was there. It was either very slow or no dealing was taking place to arrange raw material and other stuff from outside to the organisation. The impact was seen on the supply chain operation due to no availability

of transportation, no availability of drivers and no foreign trade as reported by 82 percent employees.

- d. Technological support to manage pandemic:** By keeping in mind the situation that the managers were suffering from Covid-19, work from home was allowed to them. They were managing the activities with technical support like cloud computing, robotics, and virtual augmented reality.

**Hypothesis H2: There is an impact of work from home and social distancing on supply chain operations.**

Awareness regarding taking precautions against covid-19 was properly given to the employees. They were getting information from external sources of information too to save themselves after following the Covid-19 protocols. Organization was taking care of the physical and mental well being of the employees as stated by 94 percent employees. Extra workload was there due to social distancing because everybody was not coming regularly. It was also the time when employees were availing sick leaves and were on isolation too. Responsibilities were increased and tools like automation, IoT, ERP, and big data analytics were used to manage supply chain related activities.

**H3: There is an impact of strategic decision taken by the management on the employees which affected supply chain operations during Covid-19.**

In the organization, there were two groups who were working to manage supply chain operations. One group was of employees and the other group is of managers. Those who were working on the floor, it was not possible for them to work from home. Due to no regular interaction between managers and employees, decisions were delayed and hampering the productivity. No lay off is done but due to migration of employees and no response from their side, productivity hampered a lot. All kinds of support whether financial or non-financial were given to the employees.

**H4: There is a significant impact of AI on supply chain operations in automobile industry during Covid-19.**

In this study, managers are asked about the implementation of AI and its impact on the supply chain operations of the organization. Machine learning, neural networking, and natural language processing were some AI methods used by the organization. For forecasting credit risk in terms of right supplier selection is done by machine learning as the risk during corona is increased (Soleimani, 2018 and Cavalcante et al., 2019). Intelligence system like chatbots



were created to interact with manufactures, suppliers, and customers (Lyutov et al., 2019). In warehouse, to reduce the threat of contamination, robotics was used, it was used for picking the containers and unloading the containers as well. In retail, Machine learning was used to analyze the data so that the right product and services can be suggested on time.

**Table 3.1: Application of AI in managing SCM**

S.No	Tools used	Application of tools in SCM
1.	Machine learning	In the selection of supplier (for the fulfilment of order on time). In Simulation and in 3D Designing.
2.	Natural Language Processing	Chatbots are used for providing assistance to customers and for operational procurement purposes.
3.	Expert System	For controlling the inventory
4.	Neural Networking	For demand forecasting
5.	Machine Learning	For suggesting product
6	Machine Learning	For payment management.

### **3.7 Results of Unstructured Interview**

During Covid-19, border closure and dependency for raw material on other nations led to many complications for the organization. Chip and semiconductor shortage led to halt production which has increased the delivery time for the vehicles to the customers. The whole world is facing issue and it's the right time to decrease our dependency on China and other countries. Supply chain operations were at stand still due to travel restriction and border closure. Possible re-routing options were needed and still the company is working on these options. Transportation strategies were worked out so that dual route transportation can be worked out and the transportation cost can be reduced. Digital technologies were adopted where with the help of virtual reality, customer without coming to the showroom, can finalize the product.

The company has mentioned certain factors where the risk is high as well as low. At a financial part, company was at a lower risk but due to not managing demand, face issue is sold and lacked in increasing profit numbers. Company was facing issues in managing supply, demand and manufacturing so it's at a high risk. Due to halt in the production in many parts of the Asia, supply erupted and that impacted to our plant too. Fear of infection has stopped the workers and employees to come to the manufacturing unit which has also

delayed production.

### **3.8 Practices adopted by the organization during Covid-19**

Union Ministry of Home Affairs (MHA) has issued guidelines for the manufacturing units and especially after the lockdown. Guidelines were different on a different level. Standard operating procedures (SOP) for opening manufacturing units and for the workers were mentioned by the Government of India (GoI). These precautions were done for the units which were closed during lockdown. Company has adopted various practices which are mentioned below:

#### **For manufacturing units**

- a. One week of trial is done with all the safety procedures to avoid any mishappening in the organization.
- b. Checking of all the equipment's were done with all the safety procedures.
- c. All storage facilities were checked like ventilation, and lightening.
- d. All the arrangements for handling any kind of emergency is done.

#### **For employees and workers**

- a. From entrance to exit, sanitization maintained after every 3 hrs especially in lunch areas and crowdly areas.
- b. Temperature of the employees checked at entrance and once more in a day.
- c. In case of fever, employees and workers are asked to take leave and isolate themselves.
- d. Mask was compulsory for everyone and they have been also provided mask and gloves during the working hours.
- e. All the guidelines for workers and employees who were travelling was followed.

## **4. Results**

Data collected and analyzed has shown that supply chain operation of the company suffered and it resulted in delayed production. Organization is able to understand that there should be less dependability on the other nations to manage raw material and other parts and should try to redesign the procedure. Company should look at some local resources to manage raw material and other parts to avoid delay in emergencies. Company has also seen that more contact and touch points should be increased to interact with the customers as physical interaction was not possible during corona. For managing activities during corona, company has planned changes at many ends like managers were working from home. Some technologies like IoT, automation, ERP, and virtual reality has been used to manage supply

chain operation activities.

#### **4.1 Managerial implications and recommendations**

It is observed that the company analyzed in this study was ready for uncertainty avoidance and have some emergency plans also to implement. Based on the results, it can be said that other automobile companies can also be prepared themselves with the help of AI solutions in long term. Based on the results, it is recommended that the company should implement the AI solutions widely in vehicle routing, fault detection and in customer clustering. It is also said by Gartner [22] that all the companies will transform their supply chain operations with the help of AI by 2023.

#### **4.2 Limitations**

This study is done in India and the environment which is referred in this is very different because this kind of environment is not faced before. This study is limited to one company and the data is collected from the managers and the employees of the same company only. This study may only be useful by other automobile companies when the same kind of situation occurred so this study can't be generalized. Additional limitations were also there like employees were not disclosing full information due to maintaining secrecy of the organization. There is a chance of misunderstanding the responses and wrong interpretation.

#### **4.3 Conclusions**

This research paper has specifically taken the condition of Covid-19 and its impact on supply chain operations of automobile company. Supply chain operations are important as it starts from the raw material providers to the customers. It connects many stakeholders like supplier, manufacturer, retailer, and customers. Hurdle at any level can disrupt the whole process and result in delayed delivery of the product to the customer. During Covid-19, disruption from managing raw material to final delivery of product to the customer happened many times. In this research, it is observed that with the help of AI solutions like machine learning, neural networking and expert system were used to manage the inventory and other supply chain related activities.

## **References**

1. Ivanov, D. Predicting the Impacts of Epidemic Outbreaks on Global Supply Chains: A Simulation-Based Analysis on the Coronavirus Outbreak (COVID-19/SARS-CoV-2) Case. *Transp. Res. Part E Logist. Transp. Rev.* 2020, 136, 101922. [CrossRef] [PubMed]
2. Kumar, A.; Luthra, S.; Mangla, S.K.; Kazanço ğlu, Y. COVID-19 Impact on Sustainable Production and Operations Management. *Sustain. Oper. Comput.* 2020, 1, 1–7. [CrossRef]
3. Ivanov, D. (2020b), “Viable supply chain model: integrating agility, resilience and sustainability perspectives—lessons from and thinking beyond the COVID-19 pandemic”, *Annals of Operations Research*, pp. 1-21.
4. Chowdhury, M.T., Sarkar, A., Paul, S.K. and Muktadir, M.A. (2020), “A case study on strategies to deal with the impacts of COVID-19 pandemic in the food and beverage industry”, *Operations Management Research*, doi: 10.1007/s12063-020-00166-9.
5. Betti, F. and Ni, J. (2020), “How China can rebuild global supply chain resilience after COVID-19”, *World Economic Forum*, available at: <https://www.weforum.org/>.
6. Ivanov, D., Dolgui, A. and Sokolov, B. (2019), “The impact of digital technology and Industry 4.0 on the ripple effect and supply chain risk analytics”, *International Journal of Production Research*, Vol. 57 No. 3, pp. 829-846.
7. Chen, Y. and Biswas, M.I. (2021), “Turning crisis into opportunities: how a firm can enrich its business operations using artificial intelligence and big data during COVID-19”, *Sustainability*, Vol. 13 No. 22, pp. 1-17.
8. Sombultawee, K.; Lenuwat, P.; Aleenajitpong, N.; Boon-itt, S. COVID-19 and Supply Chain Management: A Review with Bibliometric. *Sustainability* 2022, 14, 3538. [CrossRef]
9. Nayak, J.; Mishra, M.; Naik, B.; Swapnarekha, H.; Cengiz, K.; Shanmuganathan, V. An Impact Study of COVID-19 on Six Different Industries: Automobile, Energy and Power, Agriculture, Education, Travel and Tourism and Consumer Electronics. *Expert Syst.*
10. Eldem, B., Kluczek, A., & Bagiński, J. (2022). The COVID-19 Impact on Supply Chain Operations of Automotive Industry: A Case Study of Sustainability 4.0 Based on Sense–Adapt–Transform Framework. *Sustainability*, 14(10), 5855.

11. Sharma, S. D. (2022). India's Fight against the COVID-19 Pandemic: Lessons and the Way Forward. *India Quarterly*, 78(1), 9-27.
12. Cohen, M.J. Does the COVID-19 Outbreak Mark the Onset of a Sustainable Consumption Transition? *Sustain. Sci. Pract. Policy* 2020, 16, 1–3. [CrossRef]
13. Roy, S.; Das, M.; Ali, S.M.; Raihan, A.S.; Paul, S.K.; Kabir, G. Evaluating Strategies for Environmental Sustainability in a Supply Chain of an Emerging Economy. *J. Clean. Prod.* 2020, 262, 121389. [CrossRef]
14. Govindan, K.; Mina, H.; Alavi, B. A Decision Support System for Demand Management in Healthcare Supply Chains Considering the Epidemic Outbreaks: A Case Study of Coronavirus Disease 2019 (COVID-19). *Transp. Res. Part E Logist. Transp. Rev.* 2020, 138, 101967. [CrossRef]
15. Alicke, K.; Strigel, A. Supply Chain Risk Management Is Back 2020. Available online: <https://www.mckinsey.com/businessfunctions/operations/our-insights/supply-chain-risk-management-is-back> (accessed on 21 January 2022).
16. Williams, T.A.; Gruber, D.A.; Sutcliffe, K.M.; Shepherd, D.A.; Zhao, E.Y. Organizational Response to Adversity: Fusing Crisis Management and Resilience Research Streams. *Acad. Manag. Ann.* 2017, 11, 733–769. [CrossRef]
17. Lavrakas, P. *Encyclopedia of Survey Research Methods*; Sage Publications, Inc.: Thousand Oaks, CA, USA, 2008; ISBN 978-1-4129-1808-4.
18. Grafström, A.; Schelin, L. How to Select Representative Samples. *Scand. J. Stat.* 2014, 41, 277–290. [CrossRef]
19. Davenport, T. H. 2018. "From Analytics to Artificial Intelligence." *Journal of Business Analytics* 1 (2): 73–78. doi:10.1080/2573234X.2018.1543535.
20. Schoemaker, P. J., and P. E. Tetlock. 2017. "Building a More Intelligent Enterprise." *MIT Sloan Management Review* 58 (3): 28.
21. Panetta, K. 2018. "Gartner Predicts 2019 for Supply Chain Operations." *Smarter with Gartner*. Available at: <https://www.gartner.com/smarterwithgartner/gartner-predicts-2019-for-supply-chain-operations/>
22. Choi, T. M., S. W. Wallace, and Y. Wang. 2018. "Big Data Analytics in Operations Management." *Production and Operations Management* 27 (10): 1868–1883. doi:10.1111/poms.12838.

23. Umeda, Y., H. Muto, M. Tomita, K. Kondoh, T. Kominami, and Y. Hidaka. 2017. "Warehouse Product Inspection System Achieves Work Efficiency and Quality Improvements." *NEC Technical Journal* 12 (1): 40–44.
24. Cavalcante, I. M., E. M. Frazzon, F. A. Forcellini, and D. Ivanov. 2019. "A Supervised Machine Learning Approach to Data-Driven Simulation of Resilient Supplier Selection in Digital Manufacturing." *International Journal of Information Management* 49: 86–97. doi:10.1016/j.ijinfomgt. 2019.03.004
25. Soleimani, S. 2018. "A Perfect Triangle with: artificial Intelligence, Supply Chain Management, and Financial Technology." *Archives of Business Research* 6 (11): 5681. doi:10.14738/abr.611.5681.
26. Lyutov, A., Y. Uygun, and M. T. Hutt. 2019. € "Managing Workflow of Customer Requirements Using Machine Learning." *Computers in Industry* 109: 215–225. doi:10.1016/j.compind.2019.04.010.

## **Questionnaire used**

### **Appendix A**

Unstructured Interview (Case study purpose)

Q1. How Covid-19 has affected the supply chain operations of the company?

Q2: What challenged were faced and how the company was able to mitigate the challenges?

Q3. What policies and programs during Covid-19 were focused by the company to reduce the impact of Covid-19?

Questions related to supply chain operations based on the case study framed

Q1. What is your name and department?

Q2: What responsibility you were taking care of in the department during Covid-19?

Q3: What was the action plan of the company when they have come to know about the Covid-19 as a car manufacturer?

Q4: What kind of problems faced by the company during Covid-19?

Q5: How did you cope up with these problems and challenges?

Q6: How did you convey about the changes took place in the organization due to Covid-19 to the employees

Q7: What do you think about other firms in automobile industry also suffer from this pandemic?

Q8: What supply chain operations were crucial to manage during Covid-19?

Q9: What supply chain operations change took place before and after Covid-19?

Q10: Do you think you are ready to avoid any kind of uncertainty if occurred in future?

### **Appendix B**

#### **Part A: Impact on the employees**

**Name:**

**Department:**

Q1: Did you train your employees regarding the precautions taken during Covid-19(For managers only)

Yes

No

Q2: Do you think that your organization help you mentally and financially at the time of Covid-19?

Yes

No

Q3: Did you provided any kind of extra workload during the pandemic?

Yes

No

Q4: Is there any kind of responsibility increment or decrement took place?

Yes

No

Q5: What kind of technological change in managing supply chain operations took place?

AI

Big data analytics

IoT

Simulation

Cloud Computing'

ERP

Web 2.0

Automation

Natural Language Processing

Machine Learning

Neural Networking

Others

Q6: Did you feel safe coming to the organization?

Yes

No

Q7: Did you ever face threat to lose your job?

Yes

No

Q8: Did you follow social distancing properly and follow all the rules and regulations?

Yes

No

Q9: What kind of leave you are provided during pandemic?

Sick leave



Casual leave

Leave without pay

Leave with pay

**Part B: Impact on supply chain operations**

Q10. Is there any change in the production?

Significant increment

Slight increment

No change

Slight decrement

Significant decrement

Q11: What is the impact of pandemic on opening stock of the organization?

Significant increment

Slight increment

No change

Slight decrement

Significant decrement

Q12: What is the impact of pandemic on closing stock of the organization?

Significant increment

Slight increment

No change

Slight decrement

Significant decrement

Q13: Is the production stop due to no availability of raw material and spare parts in the organization?

Yes

No

Q14: Is the production stop due to no availability of labor in the organization?

Yes

No

Q15: Is the supply chain operation stop due to no availability of transport?

Yes

No

Q16: What is the change observed in demand during pandemic?

Significant increment

Slight increment

No change

Slight decrement

Significant decrement

Q17: Did you manage supply chain operations by working from home?

Yes

No

Q18: Did you get any technological support to manage supply chain operations?

Yes

No

**PART C: Policies taken to manage pandemic (From managers only)**

Q19: Did you provided work from home partially to your employees to manage supply chain operations?

Yes

No

Q20: What was your main concern for remote working of your employees?

Mental health

Lack of concentration

No physical communication

..... anything else

Q21: Did you hire new employees?

Yes

No

Q22: Did you ask the employees to leave the organization means layoff done ?

Yes

No

Q23: Did you get any financial/non-financial benefit from the government?

Yes

No

**PART D: Impact of AI on supply chain operations (From Managers)**

Q24: Which application of AI used in supply chain operations during Covid-19?

Ans.....

Q25: Where is the implementation of AI took place more in the organization?

- a. Logistics      b. Manufacturing      c. Customer      d. Retailer      e.
- Suppliers

f. Any other .....

Q26: What was the impact of AI in handling Logistics during Covid-19?

.....

Q27: What was the impact of AI in handling manufacturing during Covid-19?

.....

Q28: What was the impact of AI in handling customers during Covid-19?

.....

Q29: What was the impact of AI in handling suppliers during Covid-19?

.....

Q30: What was the impact of AI in handling retailers during Covid-19?