Major Research Project

Artificial Intelligence in Supply Chain

Submitted By:

ALKSHENDRA

2K19/DMBA/11

Under the Guidance of

Dr. Saurabh Agrawal

Assistant Professor

DELHI SCHOOL OF MANAGEMENT

Delhi Technological University

Bawana Road Delhi 110042

DELHI TECHNOLOGICAL UNIVERSITY

CERTIFICATION

This is to certify that the work titled '**Artificial Intelligence (AI) in Supply Chain** as part of the final year major Research Project submitted by Alkshendra in the 4th semester of MBA, Delhi School of Management, Delhi Technological University during January-May 2021 was conducted under my guidance and supervision.

This work is his original work to the best of my knowledge and has not been submitted anywhere else for the award/credit degree whatsoever.

The report is submitted to Delhi School of Management, Delhi Technological University in incomplete satisfaction of the prerequisite of the level of Master of Business Administration.

Mr. Saurabh Agrawal

Assistant Professor

Delhi School of

Management, Delhi

Technological University

DECLARATION

I hereby declare that the report titled '**Artificial Intelligence (AI) in Supply Chain**' as part of my final year Major Research Project submitted by me in the 4th semester for the grade/credit purpose for partial fulfillment of MBA at Delhi School of Management, Delhi Technological University during January-May 2021 under the guidance of Dr. Saurabh Agrawal is my original work and has not been submitted anywhere else.

This report has been composed by me in my own words and not replicated from somewhere else. Anything that shows up in this report which isn't my unique work has been properly and suitably alluded/refered to/recognized.

Alkshendra

2K19/DMBA/11

MBA (Operations & Marketing)

ACKNOWLEDGEMENT

I would like to take this opportunity to express my gratitude towards the people who supported and encouraged me to keep working in these tough times. I wish to express my deep regards to my guide on this project Mr. Saurabh Agrawal, Delhi School of Management, DTU for his enlightening guidance and encouragement to explore this topic.

I am thankful to him for constantly guiding me and helping me in understanding this topic in depth. This project wouldn't have been possible without his valuable guidance. Finally, I would like to express my heartful thank to my family members to corporate with me in these tough times and providing me with every possible resource needed to complete this report.

Alkshendra

2K19/DMBA/11

MBA (Operations & Marketing)

EXECUTIVE SUMMARY

This report is being created to analyze and understand the technological impact that has occurred in the Supply Chain due to Artificial Intelligence and machine learning. The objective of this study is to find out what all the effects has occurred in the logistics and supply chain how it is being changed and the future aspect of it because of Artificial Intelligence. It will help us understand how the dynamics of both Artificial Intelligence and the supply chain industry how the trends have shifted after these technologies and its shortcomings. Furfure, the study will also help in understanding how these technologies could help in situations such as the present pandemic.

All the major factors are analyzed thoroughly to see what all areas needs to be developed and what are the trends going on in different industries. The analysis is thoroughly examined by collecting data from various internet sources. Using these databases helped us examining the current performance of the supply chain industry which are using AI.

After collecting the data from these databases, the analysis was done to understand the impact of these factors. After this detailed analysis probable recommendations were suggested on how to improve the current situation in the economy. And what all steps can be taken without impacting the livelihood of any individual.

Table of Contents

Table of Figures

CHAPTER 1

INTRODUCTION

1.1 Background

In the hour of more prominent interest vulnerability, higher stock danger, and expanding cutthroat competition, Supply chain (SC) greatness relies regularly upon the association's capacity to coordinate and arrange the whole chain from start to finish cycles of precuring materials or parts, changing over them into finished goods, and delivering them to clients. Since such capacity can be upgraded by expanded perceivability across the entire from start to end Supply Chain measures, many driving edge associations have endeavored to enhance their data sources and share real time data with Supply Chain accomplices. Accordingly, Supply chain management (SCM) is turning out to be more data driven and its center has been coordinated toward the replacement of resources (e.g., inventory, warehouses, transportation equipment) with data.

The supply chain consists of four elements, each of which presents an opportunity to leverage new age technology:

- Integration
- Operations
- Purchasing
- Distribution

Seeing the extending significance of information to SC achievement, SC specialists have explored various ways to deal with all the more probable manage information and impact it to make better business decisions. One of those ways may join artificial insight (AI) that has been in presence for a significant long time, anyway has not been totally utilized in the space of Supply chain the load up (SCM). At the point when everything is said in done, AI is implied as the use of PCs for speculation, seeing models, taking in or understanding certain practices for a reality, getting and

holding data, and making various sorts of inference to deal with issues in unique conditions where ideal or exact plans are either unnecessarily expensive or difficult to convey.

The principal goals of AI are to see more about human insight and to plan PC frameworks to emulate human standards of conduct and make information applicable to critical thinking. Simulated intelligence ought to can learn and see new ideas, gain as a matter of fact ("on-their-own"), perform thinking, reach inferences, attribute meaning, and decipher images in setting.

With the immense improvement of digitization, information, progressed mechanics, correspondence development, and Artificial Intelligence (AI), the world is going through an age known as the "fourth current change", which has an undeniable segment that machines gain knowledge to make decisions instead of human brain. Artificial intelligence (ML) is one of these techniques, which stress with the development and utilization of PC estimations that "learn" from the experience.

Arthur Samuel was the first to coin the expression "AI" in 1959. He called attention to that ML was the investigation of calculations and numerical models that PC frameworks used to dynamically improve their exhibition on a particular assignment. Tom M. Mitchell's well-known definition has been fiercely cited: “A computer program is said to learn from experience E with respect to some class of tasks T and performance measure P if its performance at tasks in T, as Arthur Samuel was the first one to coin the term “Machine Learning” in 1959. He pointed out that ML was the study of algorithms and mathematical models that computer systems used to progressively improve their performance on a specific task. Tom M. Mitchell’s famous definition has been wildly quoted: “*A computer program is said to learn from experience E with respect to some class of tasks T and performance measure P if its performance at tasks in T, as measured by P, improves with experience E*.”

1.2 Objective of the study

The main objective of this study is to find out what are the ongoing trends in the supply chain management with respect to modern day technologies. How companies are incorporating these technologies. The research will help us to understand the use of new age tools and techniques of Artificial Intelligence and machine learning in modern days' supply chain. The idea is to see the challenges and benefits around using these modern technologies in the supply chain management and derive a result based on the research that how AI and ML can be incorporated with the traditional Supply Chain methods and tools. Some of the research areas include:

- Artificial Intelligence (AI) and Machine Learning (ML) in Supply Chain
- Ongoing trends and future aspects
- Benefits of AI in supply Chain
- Challenges of AI in supply Chain
- Why modern supply chain requires AI
- How AI can help in the optimization in supply chain
- Implementing AI integration in Supply Chain
- Infrastructure needed by different industries to implement this change
- How AI equipped Supply Chain could be beneficial during emergency (recent covid time).

1.3 Scope of the Research

The technological development in supply chain has vast scope of opportunities that is slowly growing in the whole world. Many companies are exploring this domain for its potential and cost effectiveness in turn to increase efficiency. This research aims to study the factors affecting the incorporation of AI technologies in the supply chain and barriers to these approaches.

1.4 Structure of the Research

Chapter 1 discusses the introduction, followed by chapter 2 that brings out a review of the existing literature about the trends and observation regarding the history of supply chain and its evolution over the years. Chapter 3 introduces the research methodology discussing the tool and techniques used. Chapter 4 brings out the analysis followed by chapter 5 recommendations and conclusion. Finally, chapter 6 presents the limitations and scope of future research.

CHAPTER 2
LITERATURE REVIEW

"***Supply Chain Management*** is the systemic, strategic coordination of the traditional business functions and the tactics across these business functions within a particular company and across businesses within the supply chain, for the purposes of improving the long-term performance of the individual companies and the supply chain as a whole."

"***Logistics*** is that part of the supply chain process that plans, implements and controls the efficient, effective forward and reverse flow and storage of goods, services and related information between the point of origin and the point of consumption, in order to meet customers' requirements"

If we consider the history of supply chain, in the late 1920s, with the introduction of mass production and industrialization it also laid the foundation of supply chain management. The first successful implementation of supply chain management is seen in the automobile industry which was implemented by Ford in United States of America.

The another most significant factor that contributed to the supply chain was railroad network before any modern-day transportation medium railways and ships were the only two modes of transportation. While the waterways were constrained only for transportation towards region were there was the connectivity for water transports. The mainland transportations were predominantly done through these railway networks. The late 1800s and early 1900s were the period of development of this network. It helped the supply chain and logistic to work efficiently in different terrains and area.

The 2nd world war was a significant event in the supply chain and logistics, as countries far away from each other's became allies and cross-border exchange of war equipment's and weaponry along with food supplies for soldiers are started being transported. This led to the improvement in the transportation of shipments, as better and efficient transportation of weaponry meant an upper hand over the enemies.

In the early stages of Supply Chain Management mechanical equipment's such as "Pallet" and "Pallet lifts" mechanization and warehousing space, its layout and racking were the focus area of the research. The "Unit Load" concept was developed during this era, it expresses that it is faster and prudent to move a ton of things all at once rather to move every single one of them separately". It helped to lower rate cost per unit handled.

The extension to mechanized equipment, warehousing spaces, and unit load concept was transportation management by using multi-purpose compartments along with boats, prepares, and trucks to move them. This set up for store network globalization.

In mid 1990s with growth of manufacturing in countries like China the term "Supply Chain" popularized. The export from China to U.S. went from $45billion per year to over $280 billion within a span of 7 years. Increase global trade showed the complexity of global networks and how critical logistics strategies could be. Hence the need of supply chain to be managed more efficient was required and supply chain management become a discipline in itself.

After the 1980s, computer technology has paced the logistics and supply chain utilization. The internet has skyrocketed and the changed the prescription of communication. The centralized planning with distributed collaboration came into picture an important development from distributed models.

The data computerization started to take place which streamline the logistics, this helped in many areas like more accurate forecasting, efficient warehouse storage, inventory management and trucking routes. The real time warehouse management system was introduced in the late 1980s. Before that logistics records were sent through paper and the data was vulnerable of getting lost in the process.

New software made easier to track the shipment, helped in route planning and mapping which making it easier to track cost and maximize profits. Enterprise Resource Planning (ERP) software came handy in performing such tasks.

RFID (Radio Frequency Identification) is an extremely low power data communication between RFID scanner and an RFID tag. The RFID tag consist of microchip and antenna, the tags are placed in any number of items from individual parts to shipping labels. The tags can print and wirelessly load information which can be for wide variety of tasks. The RFID are different from the conventional barcodes as the scanners don't need to be brought near the code unlike the barcodes, they can communicate with the radio frequency and don't need to see them individually.

The technology slashed the receiving time by checking inventory without opening every box to scan individual items and make it easy to track and move the goods in the warehouse. With the RFID technology, sharing and accessing data is easier. RFID tags also helps in organizations to quickly account for goods in transit and get data about the shipment which can be quickly shared with other supply chain partners.

Another technological revolution in the supply chain industry was the introduction of cloud technology, although cloud technology has been around for two decades but the supply chain incorporated it very recently, the cloud based SCM software paced the revenue of the industry by $19 billion. The cloud technology makes it possible to closely track a shipment throughout its

lifecycle. The cloud technology makes the business more scalable, cost containment, efficient, accessible, flexible and more responsive.

According to research, with a CAGR of 8.1%, the growth of Artificial Intelligence in the Supply Chain Market is predicted to reach USD 46.22 million by the year 2027. This forecast can be attributed to the rising demand for transparency and efficiency in the supply chain and logistics industry. Moreover, with the help of Artificial intelligence, data storage and management can be eased to perform effective data analysis for the organizations.

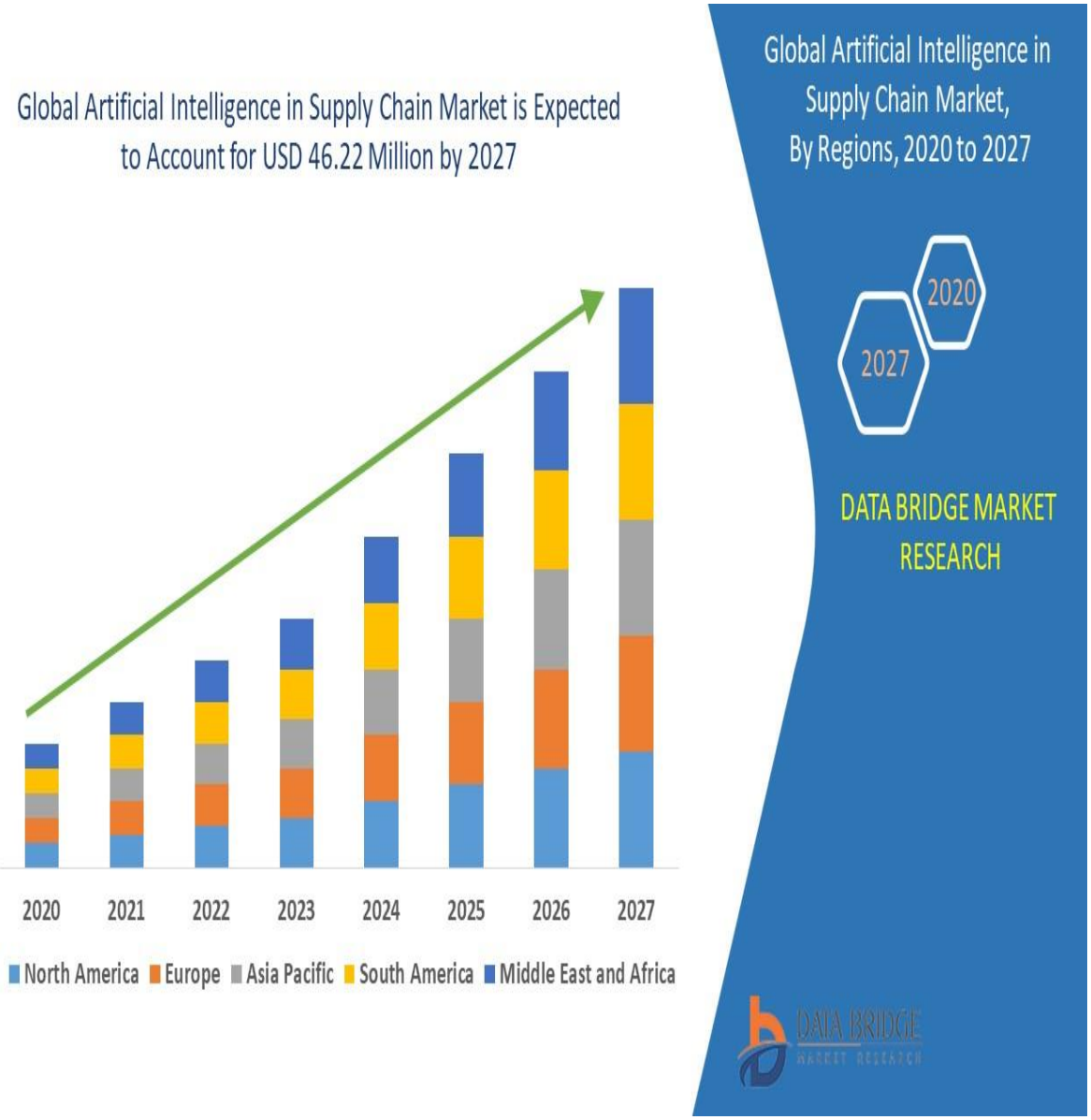

Figure 2.1: Prediction for the growth of AI in global SCM

CHAPTER 3

RESEARCH METHODOLOGY

3.1 Introduction

In this chapter we will be knowing about the methods and approaches we are going to take to complete our study on the topic in hand. This will focus on analyzing various research papers related to technological growth activities and other indicators in the same field to get a conclusive evidence and prepare a well-read study of the same. The objective here is to not just collect different information sources but display a well round picture of the scenario backed up with research driven examples and indicators to prove our conclusion.

3.2 The research in this study is qualitative

The qualitative research is the one in which involves collecting and analyzing non numerical data as per research requirements to find or build a strong argument or basis of the research. It is used to determine our assumptions and other parameters taken for the study are correct or not with the help of relevant research papers and secondary data. Here we didn't build any statistical model or collected any primary data. We're just focusing on the already existing research done in the past as the sources readily available on the internet and analyze the same to complete our study.

Advantages of using this type of research:

1. The data sources are readily available with no discrepancies or whatsoever. As all these sources are maintained by the regulatory authorities and other independent data agencies.
2. The conclusion can be easily drawn as research help suggesting the trend of all factors involving the use of technology in the supply chain industry.
3. Makes research work easy.
4. Descriptive analysis can be performed without any issues.

3.3 Research Technique

There are mainly 4 steps to complete this research work:

Problem: In the first step we will be defining our problem statement and what is the objective and background of this study is.

Data Collection: The next step here is to collect the relevant research work from reliable sources so that we can maintain the quality of the project work and interpret the right insights from the same.

Data Analysis: The third step is to analyze the collected research work and their finding what they tell about the present scenario and interpret it to the best of our knowledge.

Recommendations: The fourth and the final step is to give out some recommendations on the basis of our research work.

Conclusion

This chapter elaborates about this research methodology and the way the study has turned out in sense, how the data aka research papers/case studies/testimonials/reviews/ have aided in final completion of this report. Here we will give our concluding remarks to give our understanding of the research topic and finalize the report.

CHAPTER 4

CASE STUDY

4.1 Paper I-

A literature review on machine learning in supply chain management

Introduction

A successful supply chain (SC) has high logistics requirements such as reliability, flexibility and transparency. With increasing business, rise in the volume of data has led to the large data sets also known as big data; handling of which with conventional management tools is near impossible. With the advent of next generation artificial intelligence computer programs ease of doing work involving large datasets has increased over time. Development of machine learning (ML) based models for virtuous cycles of supply chain management (SCM) have proved to be advantageous for businesses in managing the task efficiently with minimal errors in the process. ML deals with the computer-aided modelling and realization of learning phenomena. It is a predictive analysis method which utilizes ultrasophisticated hardware tools like GPU to make SCM models based on the big data for efficient management of work. The SCM model has three main components i.e., supply chain design (SCD), supply chain planning (SCP) and supply chain execution (SCE). The SCD helps in location decisions with long-term planning, decisions such as buy or make, supplier relationships, capacity dimensioning, strategies in logistics and mundane tasks, etc. Cost optimization of logistics and production processes is another important task of SCD. Whereas, SCP mirrors the arranging of creation and coordination's assets to satisfy client orders. The undertakings for SCP incorporate the spaces of interest and organization arranging, which set the reason for obtainment, creation and dispersion arranging and empowering accessible to-guarantee/proficient to-guarantee checks. For the time being, obtainment arranging, booking and sequencing and momentary appropriation arranging support SCP. The SCE comprises cross-company processes such as SCM and supply chain control. The main objective of SCE is to support decision-making at the operational level. By utilizing different ML algorithms these SCM tasks can be completed in

much efficient manner. Different types of ML such as supervised, unsupervised and reinforcement learning can be utilized in SCM. The relationships between the customer and supplier are most important factors of SCD. The ML model provides a tool to predict plausible candidates for future customer-supplier relationships. SCP is another important task for SCM which can help in creating capital. Planning well in advance is accompanied by long-term orders, resulting in high storage costs and tied up capital. The ML algorithms are valuable to make precise demand forecast in advance. A huge improvement in figure quality could be accomplished and modern accomplices are currently ready to design significantly sooner. Conveyance dependability and item accessibility would thus be able to be altogether upgraded, which is upheld by a mechanized data stream of future prerequisites to modern accomplices. ML find its extensive application in SCE followed by SCP and SCD. A major lacuna is reported in applications of ML in SCM in the available literature. There is a dire need to cover the gaps in ML algorithms applications in SCM.

Inference

The present literature review summaries the utility of ML in predictive analysis of SCM and predictive model for smooth SCM functioning of a business. Further, it emphasises on how ML can be employed to different aspects of SCM and a smooth operation can be performed. The following inferences were made from the current literature review:

- Rapidly increasing businesses and consumer base is generating big data or large datasets which cannot be handled with simple linear regression models manually.
- A more sophisticated approach based on artificial intelligence based predictive modelling algorithms called machine learning (ML) is replacing the conventional model-based approach for big data management.
- ML is a sub-space of artificial intelligence and machine learning another method of programming. ML manages the computer supported demonstrating and acknowledgment of learning wonders. It is characterized as a cycle that utilizations experience to improve execution or make substantial expectations. The experience alludes to past data, which is given to the methodology from an electronic information assortment. ML includes the plan of successful and exact calculations. The three main types of ML universally known are:

supervised, unsupervised and reinforcement learning. Supervised Learning is an interaction wherein a computer program is prepared by utilizing known model information. Unaided learning depicts a framework that can find information. The technique distinguishes similitudes between the contributions to arrange contributions by basic examples. Though with support learning, the ideal arrangement is obscure to the framework toward the start of the learning stage and thusly should be resolved iteratively.

- An effective supply chain management is based on three main tasks i.e., supply chain design (SCD), supply chain planning (SCP) and supply chain execution (SCE). Each tasks have different components for managing the SCM with ease.
- The SCD manages long haul arranging as far as area choices, settle on or-purchase choices, supply connections, limit dimensioning, coordination's methodology and general errands.
- The SCP mirrors the arranging of creation and coordination's resources for fulfill customer orders. The endeavors for SCP join the spaces of interest and association organizing, which set the justification securing, creation and scattering orchestrating and engaging open to-ensure/fit to-ensure checks.
- The SCE comprises cross-company processes such as SCM and supply chain control. The main objective of SCE is to support decision-making at the operational level.
- ML can be employed to find new business partners or customers. It can also be used to improve customer-supplier relationships which is an important aspect of SCD.
- For SCP, an advance demand forecast is required for successful SCM. Delivery unwavering quality and item accessibility would thus be able to be altogether improved utilizing AI based ML, which is upheld by a robotized data stream of future prerequisites to modern accomplices.
- ML can also predict false positive RFID tags and manage goods transport which is another important aspect of SCE. In the area of SCP, ML topics address the task of demand planning and procurement planning.
- Operationally organized SCE, the writing tends to the spaces of Order Management, Supply Chain Event Management, Inventory, Production and Transport Management. All of these can efficiently be managed using ML algorithms.
- ML find its extensive application in SCE followed by SCP and SCD. It was shown that in the SCM task model a similar region might have distinctive ML techniques applied for a shared objective.

General infrastructure of AI and its uses in the industry:

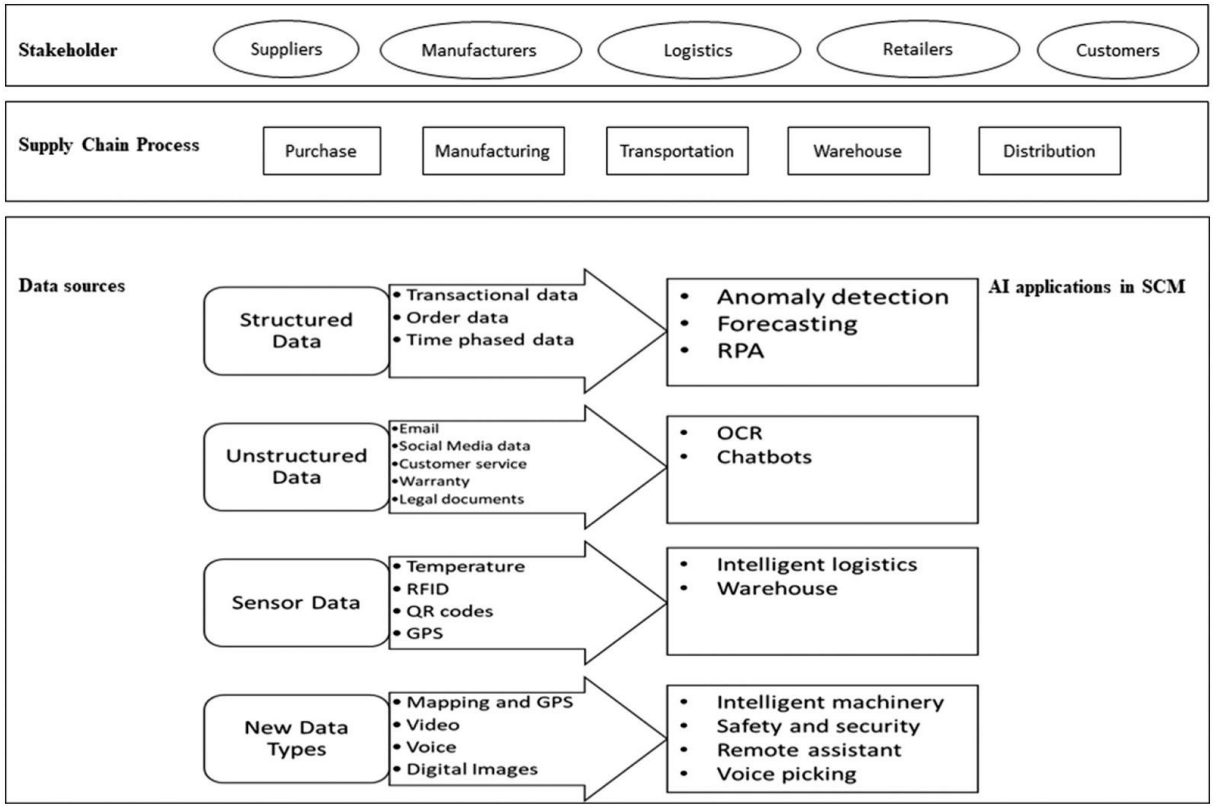

Figure 4.1: Links between different AI applications and their uses in the supply chain industry

The mechanical framework portrayed in Figure 1 can be considered as a finish of two huge parts: (I) Data Collection Infrastructure and (ii) Model Training Infrastructure. The previous for example The Data Collection Infrastructure is developed for the centralization of gathering information both constant and chronicled. The hotspots for the assortment of the information can be from Infrastructural frameworks, Internet of Things (IoT), and Industrial data frameworks, and so forth The Data assortment foundation is trailed by the Model Training Infrastructure which comprises of Machine learning, Cloud processing and enormous information investigation, and so forth The motivation behind the subsequent part is to handover decentralized and secured large information examination of the information gathered.

Conclusion

The research paper highlights the applications of ML in different tasks of a successful supply chain management by predicting the demands, customer-supplier relationships and cost and transport management for effective supply of goods to customer. However, there is still a huge research gap in applications of ML in SCM. A deep research with real world data is required to find out successful applications of ML in different tasks for effective SCM in different businesses.

4.2 Paper II-

A systematic review of the research trends of machine learning in supply chain management

Introduction

Uncertainties associated with decision making, information asymmetry in SCM and complexity associated with big data affect the SCM in many ways. ML can thus be used as an effective tool for smooth SCM process. ML truly establishes a genuine resource for SCM. In the first place, ML can depict the non-direct relationship while customary strategies are not, for the preparation model of ML better portrays how the yield changes with the info. Second, ML can manage unstructured informational indexes where conventional models come up short. Third, ML and its center builds are reasonable for a superior SCM execution expectation. Forward, with the assistance of visual example acknowledgment across a SC organization, ML can investigate a great deal of possible applications in upkeep of actual resources and actual assessment. The deficient utilization of ML in SC may be brought about by the helpless comprehension of how ML could be applied, the low acknowledgment in organization culture, and the powerlessness to get appropriate information. The helpless use of ML to SCM may be fundamentally because of the deficiency in comprehension of the most recent advancement in ML calculations, that is, in the information on scientific classifications or rules for SCM analysts and professionals in choosing the correct ML calculations for the privilege SCM. The present systematic literature review addressed the three important issues regarding the general research trends of ML applications in SCM, frequently used ML algorithms, and distribution of these algorithms in different SCM tasks.

Inference

- The literature survey revealed limited applications of ML in SCM. Fuzzy theory and soft computing tools were found to be two key search tools. The ML was found to be superior in generating production demand forecast in SCM. China topped the countries exploiting theoretical building of ML applications in SCM followed by countries like USA, Iran are Turkey, Korea, UK, Taiwan, India and Germany.
- The research design analysis of literature-based research revealed simulation data (50%) was the prime choice for ML based applications in SCM followed by chronicled information (30%) and the blend of the examination with a recorded information (9%).
- The staple and food enterprises overwhelm the ML applications in SCM, trailed by the car and design ventures.
- SCM is an earlier decision since sanitation ought to be observed and tried at each SC step. ML can be utilized for effectively following food items from ranch to customer to give straightforwardness. Additionally, more exact guaging with ML enhances evaluating and stock of food businesses.
- The leading research in ML based applications in SCM is from universities including Hong Kong Polytechnic University, Yonsei University, followed by Concordia University, Ferdowsi University of Mashhad, University of Florida, Purdue University, University of South Australia, National Institute of Technology, National Taipei University of Technology. Most research are done in Hong Kong universities and South Korea.
- Only 10 out of 32 regularly perceived ML calculations have been oftentimes applied in SCM. Some high level ML calculations were dismissed, for instance, profound learning calculation.
- Ten regularly utilized ML calculations included choice tree, arbitrary woodland, K-implies, K-closest neighbor, strategic relapse, innocent bayes classifier, neural organizations, support vector machine, troupe calculations, outrageous learning machine.
- The top ten calculations were dispersed in six unique assignments of SCM including request/deal assessment, acquisition and supply the board, creation, stock and capacity, inventory network improvement, and so on Neural organizations, group calculations, arbitrary woods, K-implies, K-closest neighbor, strategic relapse were usually utilized in these six assignments.
- The contemplates consolidating "large information" with SC ought to be done to make SCM research more commonsense later on. Different ML calculations ought to be applied into SCM research.
- In an unpredictable and speedy inventory climate, the ML applications would certainly be furnished with a brilliant future in production network the board.

- The considers joining "huge information" with SC ought to be done to make SCM research more pragmatic later on. Different ML calculations ought to be applied into SCM research.
- In an unpredictable and speedy stock climate, the ML applications would most likely be furnished with a splendid future in inventory network the executives.

Benefits of Machine Learning in the Supply Chain Industry

Difficulties in the coordination's and inventory network industry are happening because of an irregularity among request and asset accessibility, insufficient region planning and vehicle breakdown. AI imaginatively decides designs in inventory network information. It upgrades client encounters and changes coordination's the board measures. AI calculations can discover new examples in store network information without manual intercession.

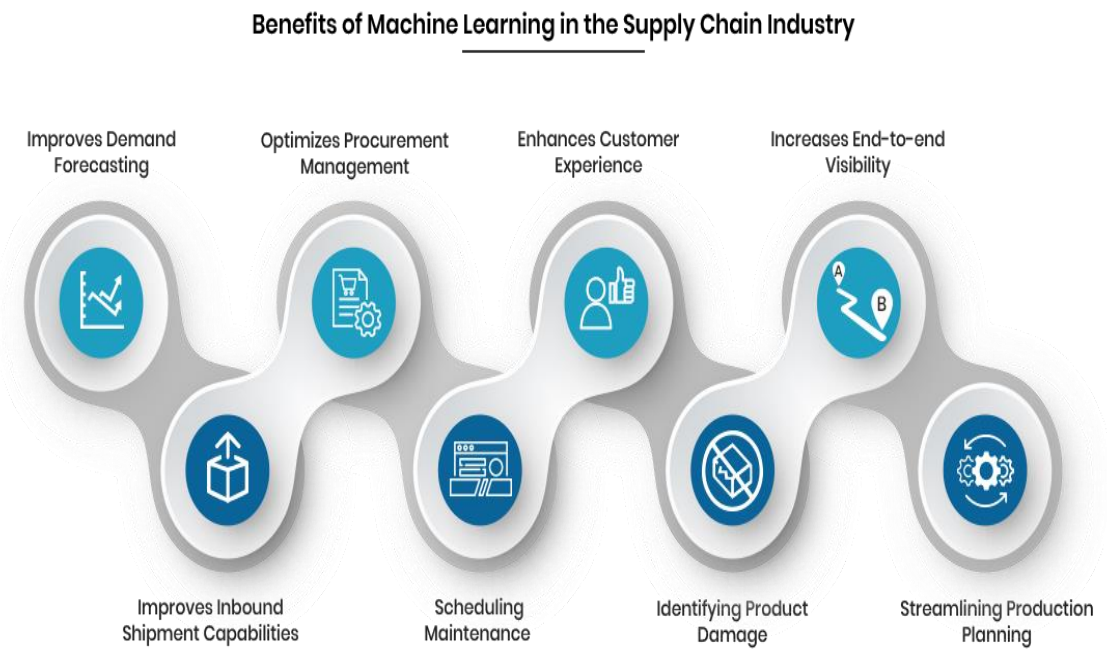

Figure 4.2: Benefits of Machine Learning in Supply Chain Industry

4.3 Paper 3-

Forecasting and planning during pandemic: COVID-19 growth rate, supply chain disruption and governmental decisions

Introduction

The current COVID-19 pandemic has influenced practically every one of the nations on the planet and set off the most serious downturn in almost a century. The remarkable disturbance in work and public activity to the entire population made this pandemic unique. This paper is written before the current 2nd wave through which whole world is being affected specially India. This pandemic and the global healthcare crisis have disrupted the supply chain quite significantly. People are hoarding and panic buying essential like food and medicines. The black marketing of many needful items has been seen all around the world. The supply and demand were further impacted by the travel restrictions and countries celling their borders in order to save them from this deadly disease. This has impacted the supply chain immensely and real time forecasting has become the need of the hour. The current vaccine situation in India is living example of how important forecasting is in these tough times, for effective government decision making, for managing supplies and imposing decisions of lockdown and reopening of curfews. The limited amount of data and multidimensional problems make it even worse to counter these problems as such an event is very new to our generation. With diverse demography and geographical region of different countries it is quite difficult to figure out an effective method for forecasting. Decision scientists and operational researchers have been using time series and machine learning techniques so far to address the problem of forecasting. To narrow down the best technique for real time and short-term forecasting this research paper evaluates 52-time arrangement, epidemiological, AI and profound learning procedures. The information from different arrangement of nations like UK, USA, India, Germany and Singapore has been taken for evaluation.

Inference

The research paper tries to figure out the best possible method for short-term real time forecasting technique through quantitative research method. The data collected from various countries during the first wave of the current pandemic. The researchers used 52 different forecasting techniques for their evaluation. The researches took the help of machine learning forecasting methods such as Random Forest, Ridge regression, Support Vector Machines etc. to reach to the conclusion.

- Forecasting strategies for pandemic improvement can be apportioned into time-plan strategies, compartmental epidemiological models, expert based models, metapopulation models, and approaches in metrology.

- A late expansion to this not insignificant rundown is AI (ML) and profound learning (DL) strategies. In 2010, Soebiyanto, Adimi and Kiang proposed the utilization of ARIMA models for one-stride ahead guaging of flu week after week cases.

- In Nearest Neighbor approach, researchers used the clustering technique for countries with same socioeconomic, climate, and Covid 19 related factors after using applying the Partial Curves (PC) and Nearest Neighbor (NN) Forecasting technique.

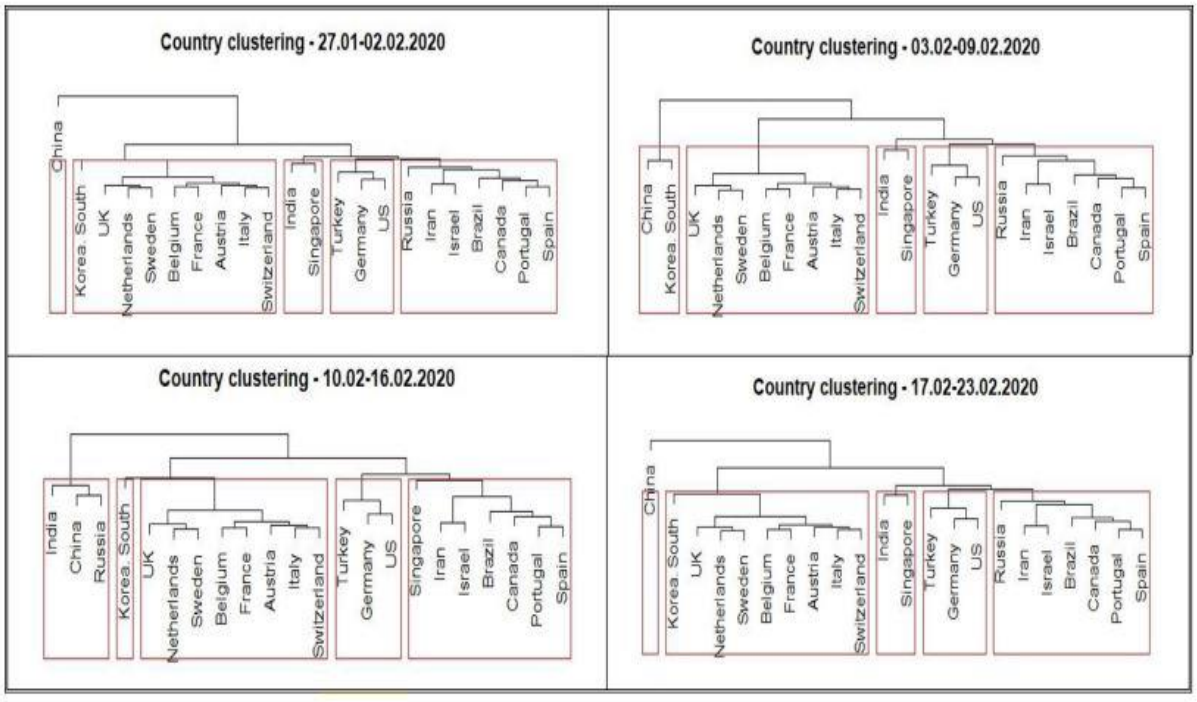

Figure 4.3: Clustering of countries using different methods

- The Country level forecasting they produced the forecasts for the growth rates at various stages of the pandemic for 46 times for daily data and 6 times for weekly data at the peak of pandemic in the month of January 2020.

- In the multivariant forecasting method the death and recovery rates were take as independents and Mean Absolute Scaled Error and Symmetric Mean Absolute Percentage Error was evaluated for each iteration.

Relative median errors across all weeks, from the average of the top-3 performing methods for each country.[2]

Country	Weekly		Daily		Top-3 models
	RelMdMASE	RelMdSMAPE	RelMdMASE	RelMdSMAPE	*(Weekly forecasts)*
Germany	0.1758	0.2264	0.2573	0.2672	Naive-d 0.5; Naive-d 0.4; Naive
India	0.1484	0.1252	0.2357	0.2727	CPC-NN3uw; PC-NN5; CPC-NN3ew
Singapore	0.1260	0.1290	0.1292	0.1363	PC-NN5 PC-NNall; PC-NN3ew
United Kingdom	0.2674	0.2792	0.2221	0.2584	Naïve; PC-NNall; CPC-NNall
USA	0.1907	0.2254	0.3032	0.2877	PC-NN3uw; PC-NN3ew; CPC-NN3uw

Figure 4.4: Relative Median Error of different countries

- The PC-NN/CPC-NN was used for countries like USA and India. Naïve method was for small countries with less population size like Germany.

- This paper shows that various strategies perform better in various nations. For instance, for Germany Naïve and two variations of Naïve with float are the top-performing models; while for the USA the two variations of PC–NN and CPC–NN are the top-performing ones.

- The increase in demand due to announcement of lockdown led to panic buying and people starting hooding groceries and other essential items and the demand supply got disrupted.

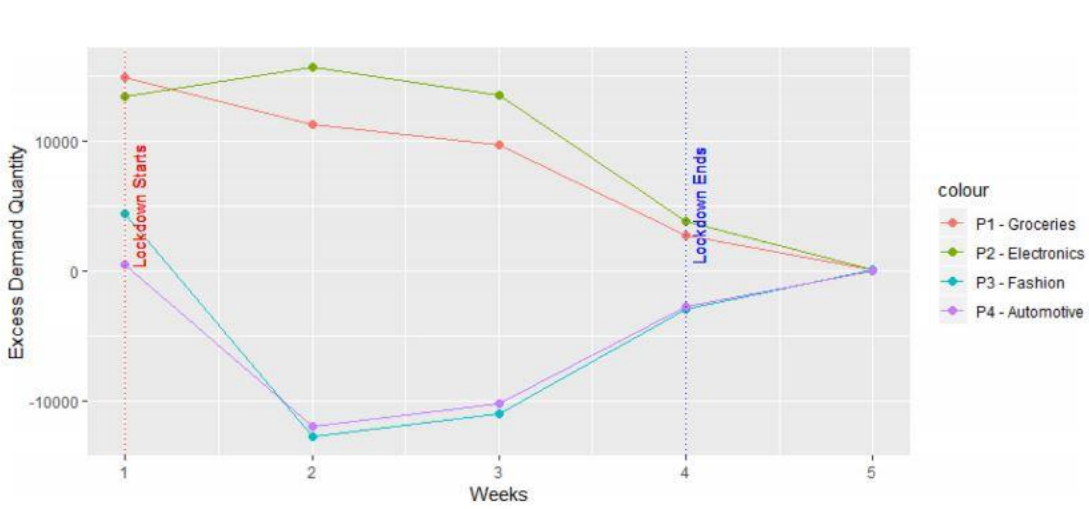

Figure 4.5: Excess demand due to COVID 19 in different product categories

- Different countries showed different trends and impact of lockdown on demand of food and other supplies, making it even harder to predict or forecast. These are the areas where technologies can be very helpful.

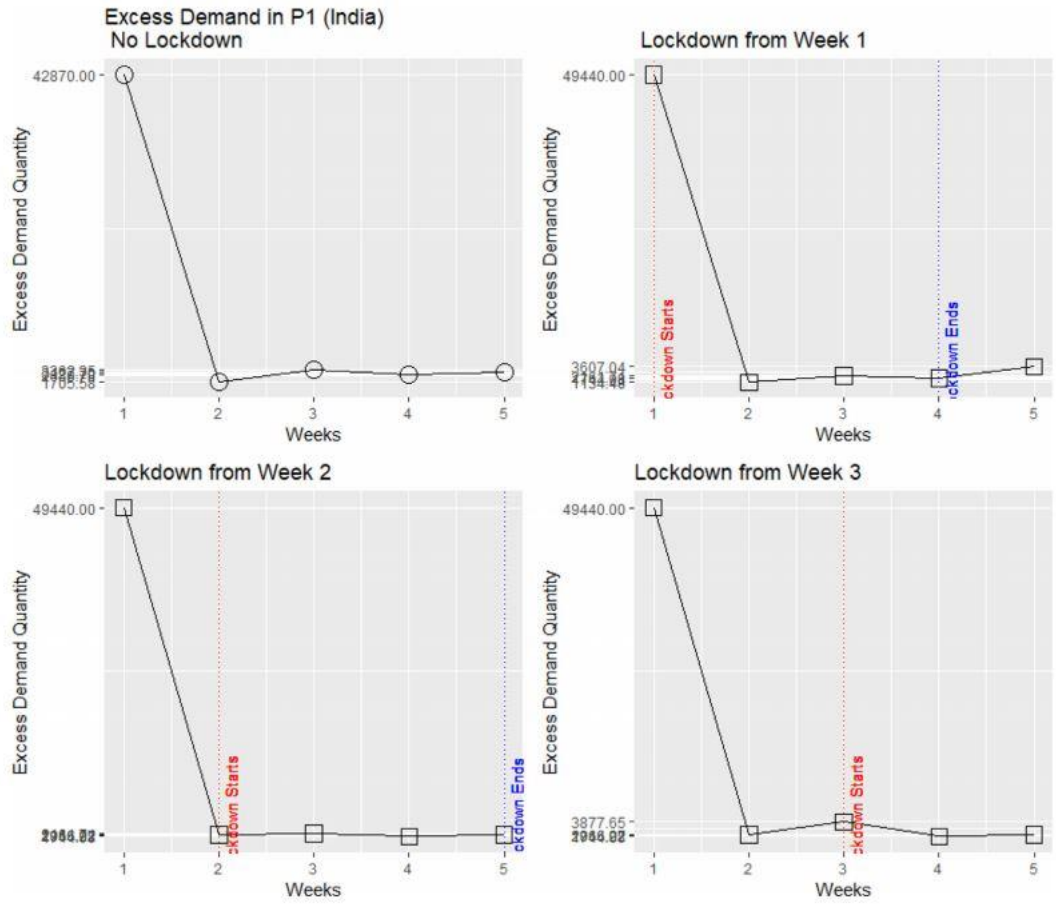

Figure 4.6: The impact of Lockdown decisions in excess demand for Groceries in India.

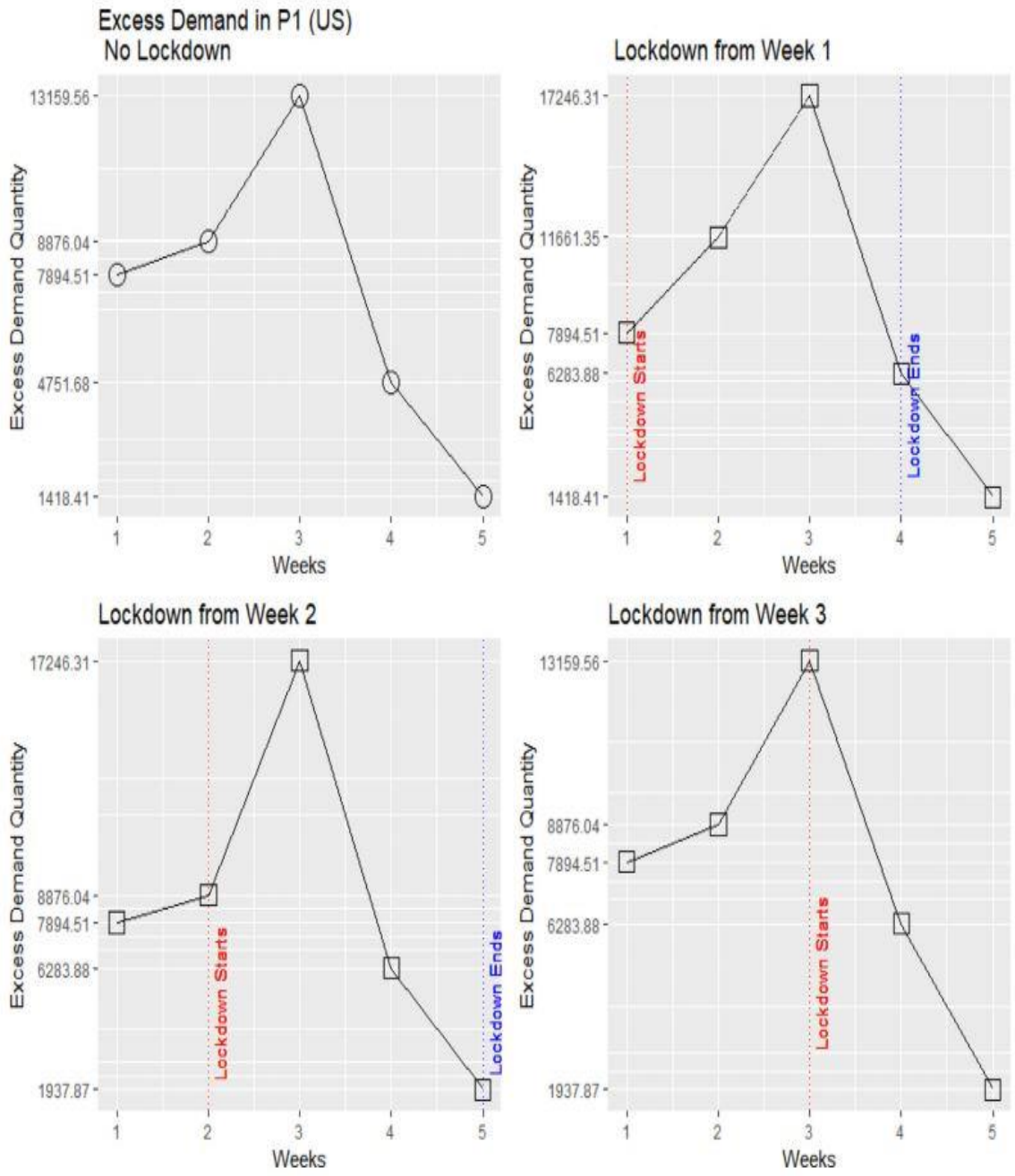

Figure 4.7: The impact of Lockdown decisions in excess demand for Groceries in US.

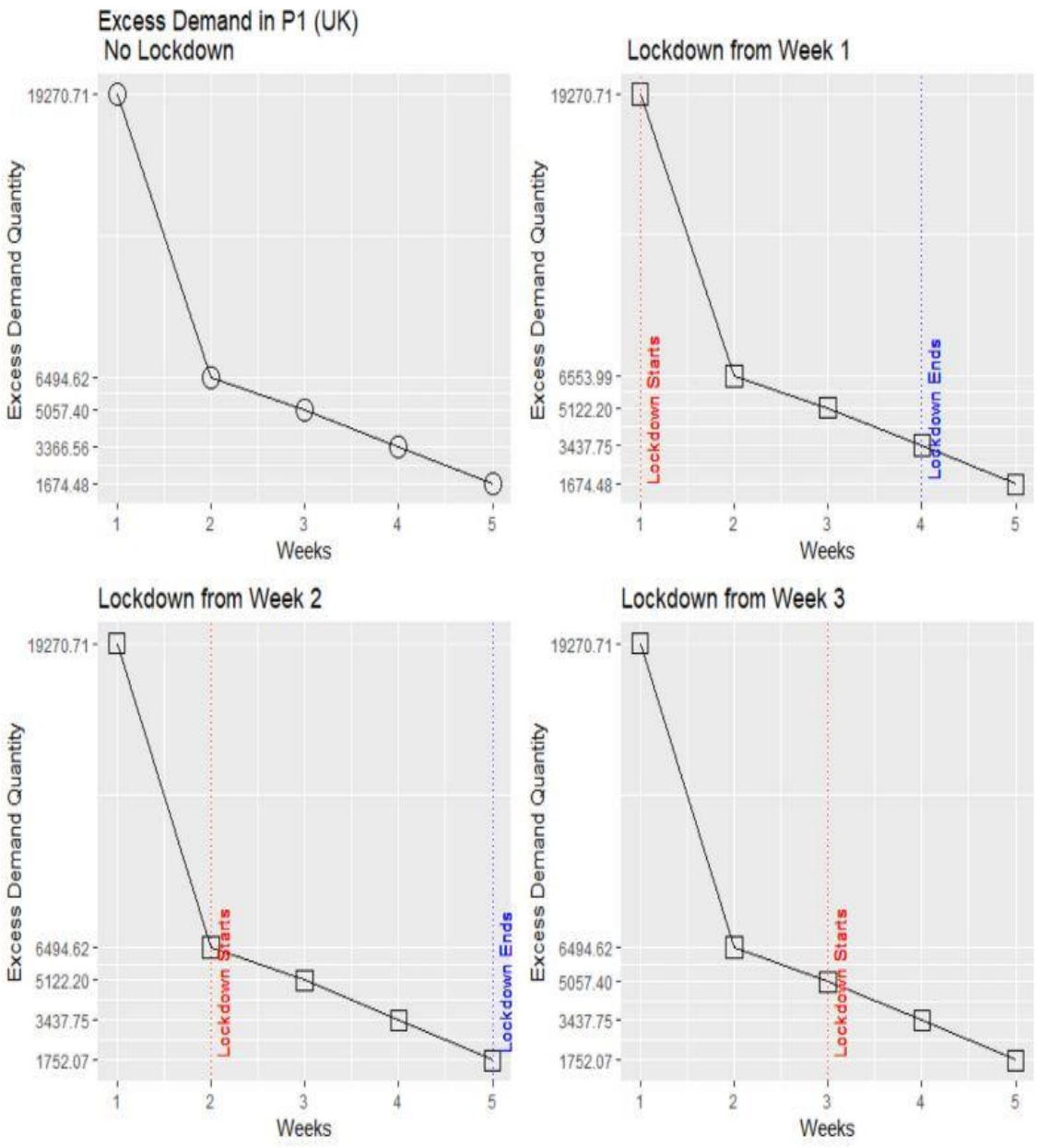

Figure 4.8: The impact of Lockdown decisions in excess demand for Groceries in Singapore

Let us first comprehend the working of a straightforward AI based determining model. Straightforward AI models portray the connection between free factors and ward variable as a condition. For instance, let us take a gander at test deals information for an attire store:

Item No.	Price	Colour	Promotion	Previous Month Sales	Sales
H1	1000	Red	Yes	25	28
H2	800	Green	No	40	25
H3	1200	Black	Yes	50	125
H4	600	Red	Yes	10	20
H5	1500	Blue	No	30	45

Figure 4.9: Sample Date to feed in Machine Learning Algorithm

Simplistic version of the kind of algorithms that are being deployed in supply chain is as follows:

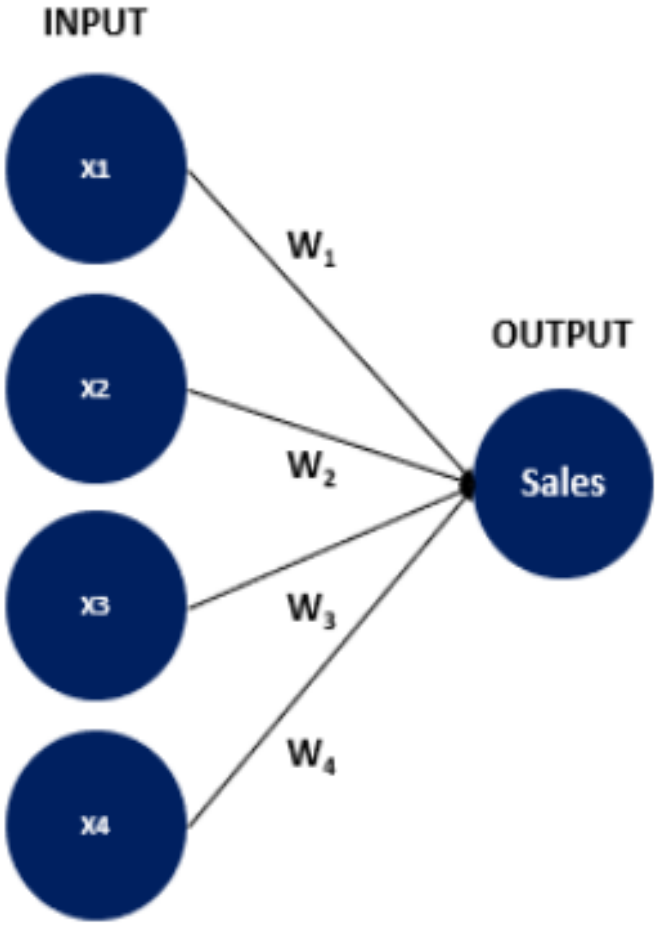

Figure 4.10: Simple Algorithm Structure

Artificial Neural Networks are propelled by the working of the human mind and dominate at perceiving complex non-linear examples in assessing the interest of an item in assembling frameworks. There is a Hidden layer between the info and yield layers which can show complex connections and interdependencies between drivers of demand. The picture beneath exhibits something similar.

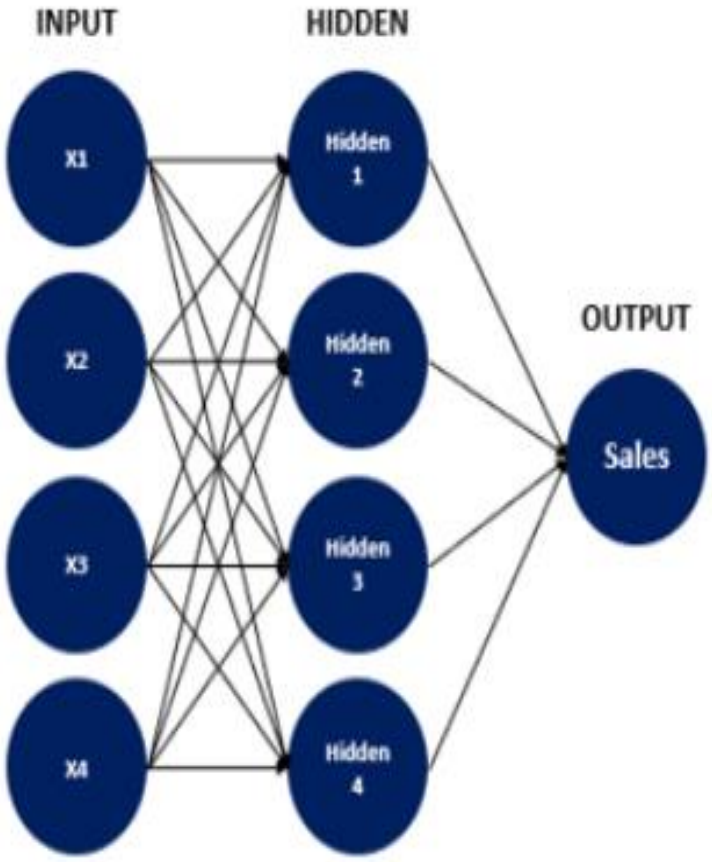

Figure 4.11: ANN Algorithm Structure

Deep learning procedures are an augmentation of the above idea – they utilize various secret layers and are subsequently, ready to identify considerably more convoluted examples. They are being utilized to settle probably the most troublesome Artificial Intelligence issues, for example, Voice acknowledgment and Virtual Personal Assistants. The picture below demonstrates the same.

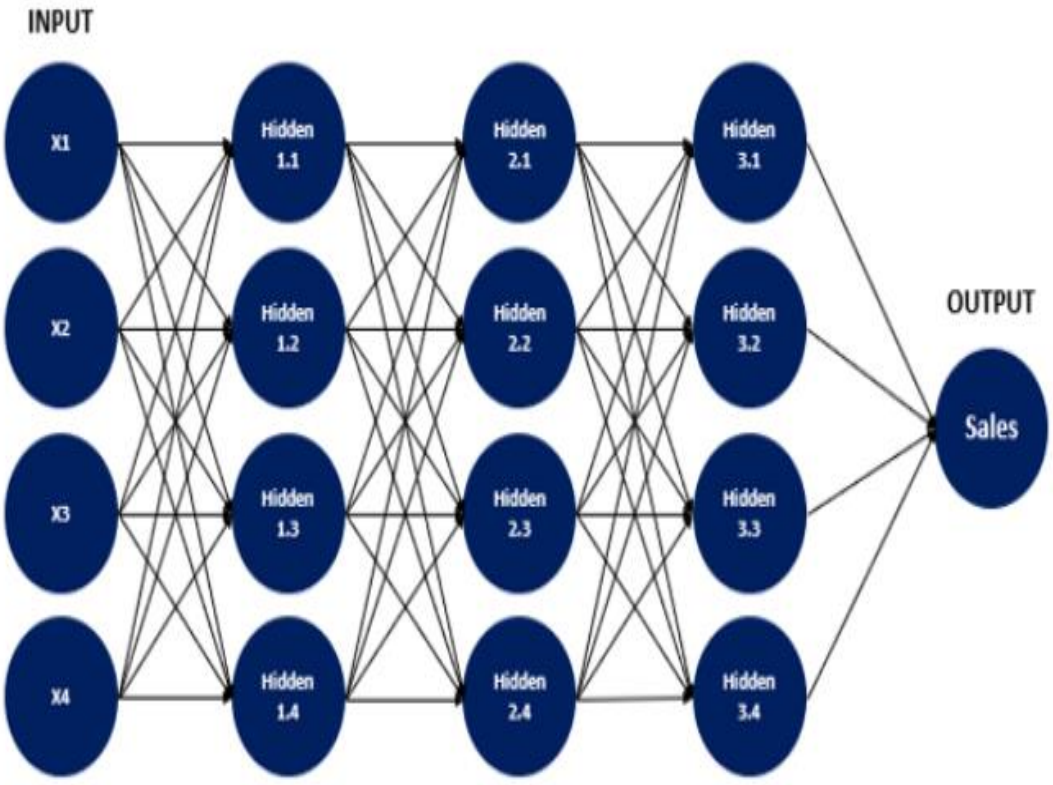

Figure 4.12: Complex ML Algorithm Structure

Machine Learning algorithms were redone and thoroughly tried prior to sending them for business execution. The gauges alongside Monte Carlo Risk Modeling were utilized to set the ideal stock levels for everything at the provincial level just as plant level. Hazard Modeling permitted us to figure the ideal stock level which adjusted the expenses of overloading (stock expenses) and expenses of understocking (lost deals).

Apart from decrease in stock expenses, Demand determining additionally helped in improving creation proficiency.

4.4 Paper 4-

Breaking through the bottleneck using artificial intelligence

Introduction

The research paper is the focuses on the weak spots in the mid-sized manufacturing company and how technology can be helpful in overcoming these shortcomings especially new age artificial intelligence. The study is done through simulation of data from a manufacturing company. The main area of concern of this research paper is how to reduce the order lead time by taking autonomous decisions for production planning. The biggest problem in these new technologies is that there is no infrastructure and resources in mid or small size industries. The paper suggests that there should be more useful utilization of man-made reasoning, for example, backing of people in dynamic cycles in regular activities as self-learning. A study by Accenture shows that manufacturing sector is the one of the sectors which would profit by AI advances in the coming years. Unlike nowadays where AI solutions has been successfully incorporated in autonomous unmanned vehicles, speech recognitions, video games, medical diagnosis, industries like manufacturing are lagging behind in such technologies. In manufacturing industry, the decision making is complex and at the same time very crucial to address such complexity it makes the ML and AI technologies indispensable for Smart Supply Chain. The current RFID technology is taking the supply chain industry by storm. The RFID has made the warehousing more transparent and easier to manage. Early researchers were also concerned about on the security aspect of these technologies in order to connect the supply chain partners in order to provide valuable support for practitioners.

AI Practices in manufacturing Industry:

Manufacturing tops in volume of information made

The manufacturing sector has high expectations for AI. As indicated by Deloitte's study on AI selection in assembling, 93% of organizations trust AI will be a vital innovation to drive development and advancement in the area. China's exhibition in AI appropriation is extraordinary. The market size of AI in the assembling area is relied upon to surpass $2 billion (US) by 2025, posting normal yearly development of in excess of 40% compared to 2019. The ascent of AI appropriation in China's assembling area has been supported by great arrangements, abundant assets, and the potential for AI execution.

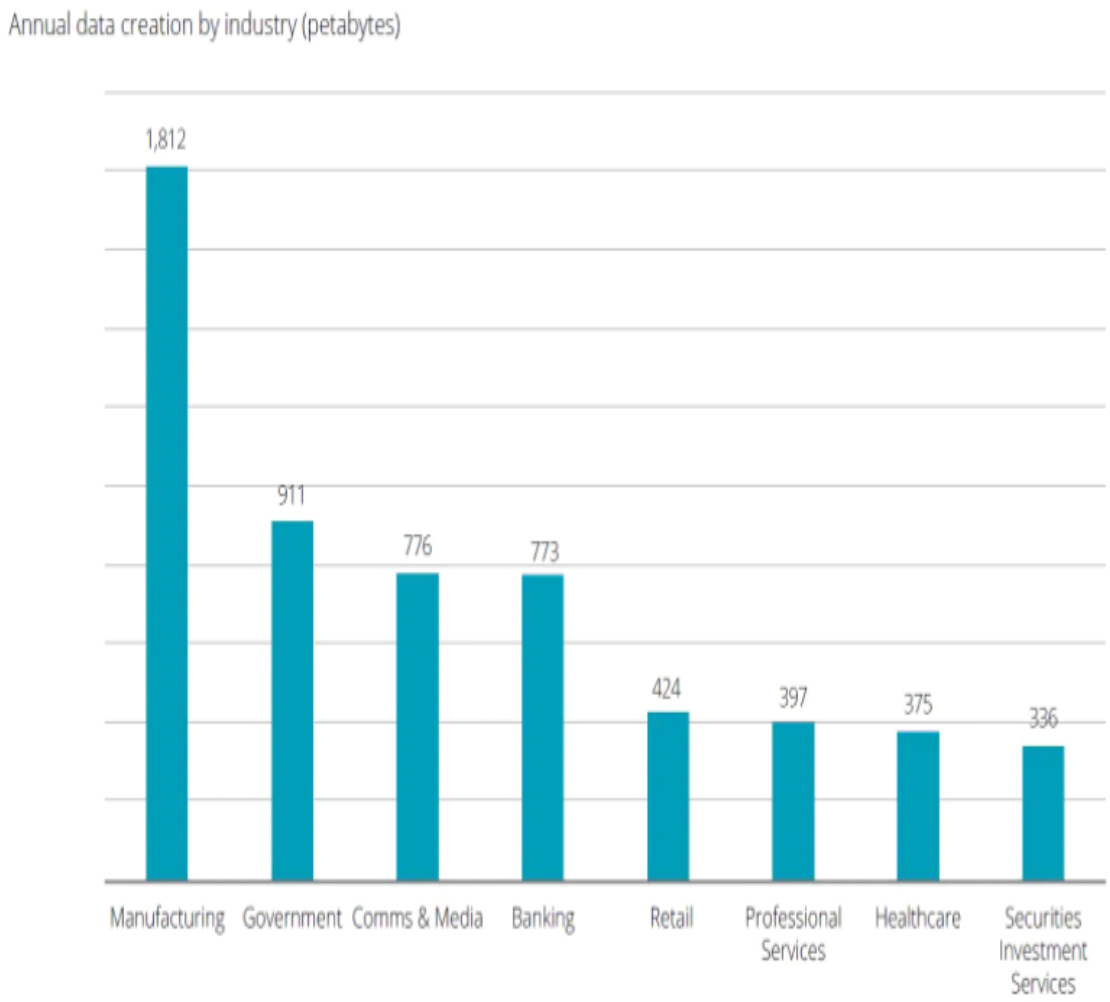

Figure 4.13: Annual Data creating by Industry wise(petabytes)

AI has made or will make a practical and visible impact in Manufacturing Industry

Seeing innovation patterns (below in the graph), more organizations will put resources into half breed innovation frameworks to improve creation, expenses, stock, or quality control, to anticipate deals and costs, or perform prescient support. Organizations are less energetic about putting resources into innovation utilized for a solitary reason, like visual reconnaissance, robot restriction and master frameworks.

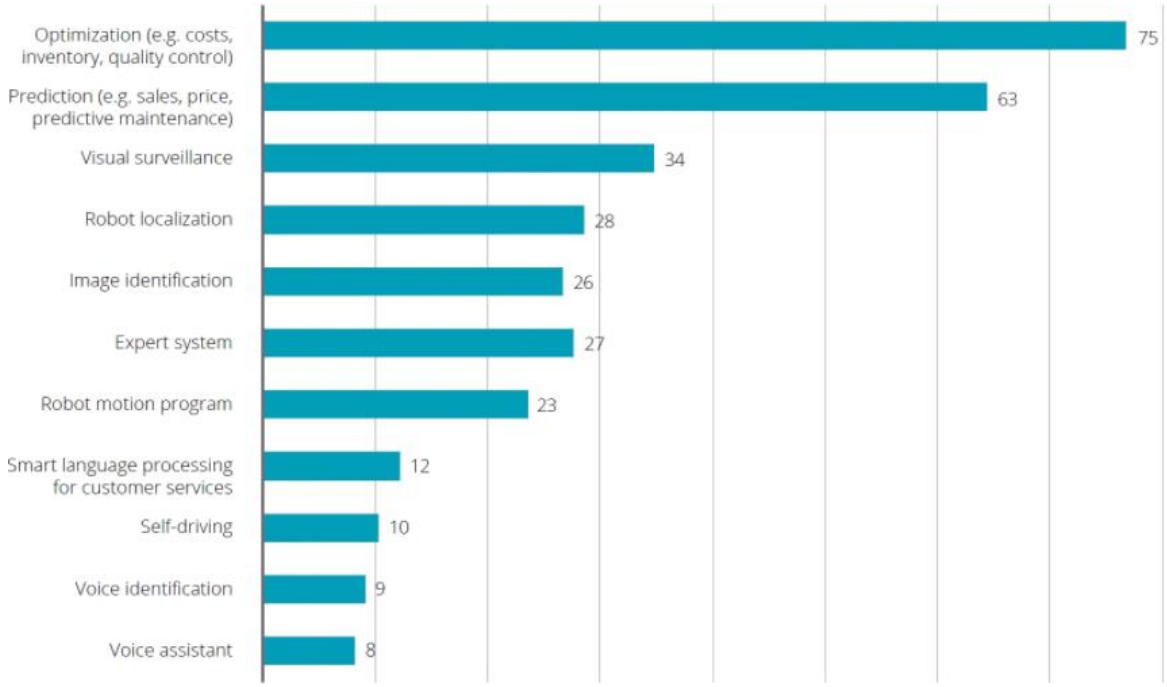

Figure 4.14: AI adoption in manufacturing by Deloitte Survey

Inference

This paper is exploratory research where the author is trying and testing various technologies based on AI and ML to incorporate it into Supply Chain based on the works of various other researches. Such as paper published in 2016 and 2018 which suggested that the rise of complexity and decline of the possible level of agility of the supply chain by Gaiannakis and Louis were taken as a research constraint which seeing the implications of AI in SCM theory.

- AI based Assembly to order supply chain in project phase is created by the author which has three main components.

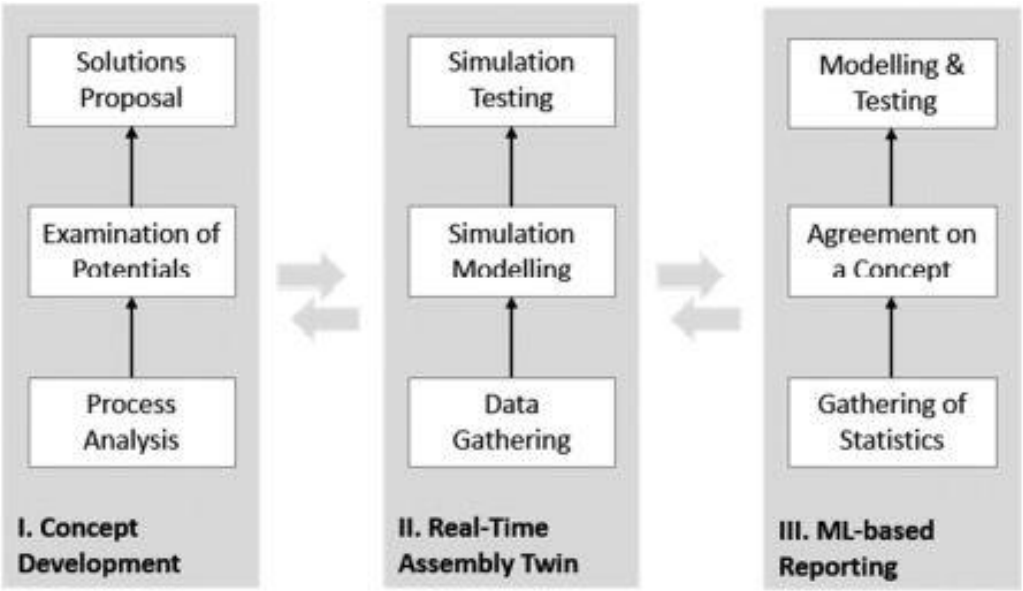

Figure 4.15: Project Phase AI based model

- In request to make the venture sensible the AI based model is partitioned into three phases: Modeling of Real-Time gathering twin and AI based revealing along with the concept development.

- Concept development which analysis the process, examine the potentials and propose the solution.

- According to the researchers the planning process is the main source of bottlenecks within the supply chain.

- As the planning process of different departments are done differently there is lack of communication and transparency, this leads to unnecessary extended order lead time.

- AI technology is capable of for real time decision making for synchronizing all planning process along the supply chain and shortening the order lead time.

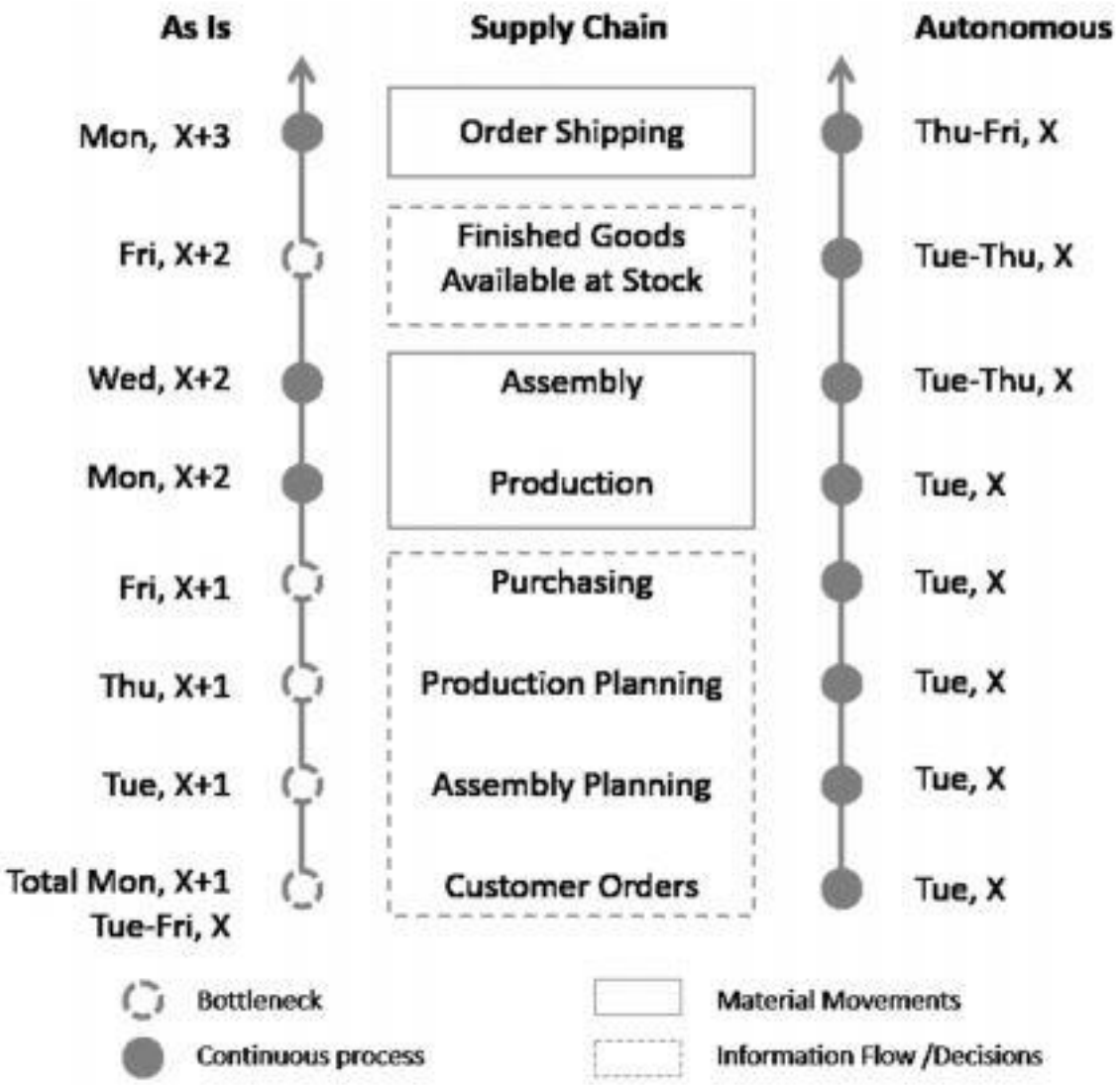

Figure 4.16: Bottleneck order lead time

- The time utilization is arranging is because of absence of programming support, conflicting data and inaccessible authentic information in the assembling business. Information coordinating in various offices are tedious and lead to failure.

- Real-Time Assembly Twin was made and tried to help organizers and laborers in the get together region. Furthermore, it gives data on the current status of orders to different offices, like warehousing and in-house transportation.

- Quality Assurance utilizing AI in Supply Chain Management: Quality affirmation is the support of an ideal degree of value in an assistance or item in production network the board. Sequential construction systems are information driven, interconnected and self-ruling organizations. These sequential construction systems work dependent on a bunch of boundaries and calculations that give rules to create the most ideal finished results. Simulated intelligence frameworks can distinguish the distinctions from the standard yields by utilizing machine vision innovation since most deformities are apparent. At the point when a final result is lower quality than anticipated, AI frameworks trigger an alarm to clients so they can respond to adapt.

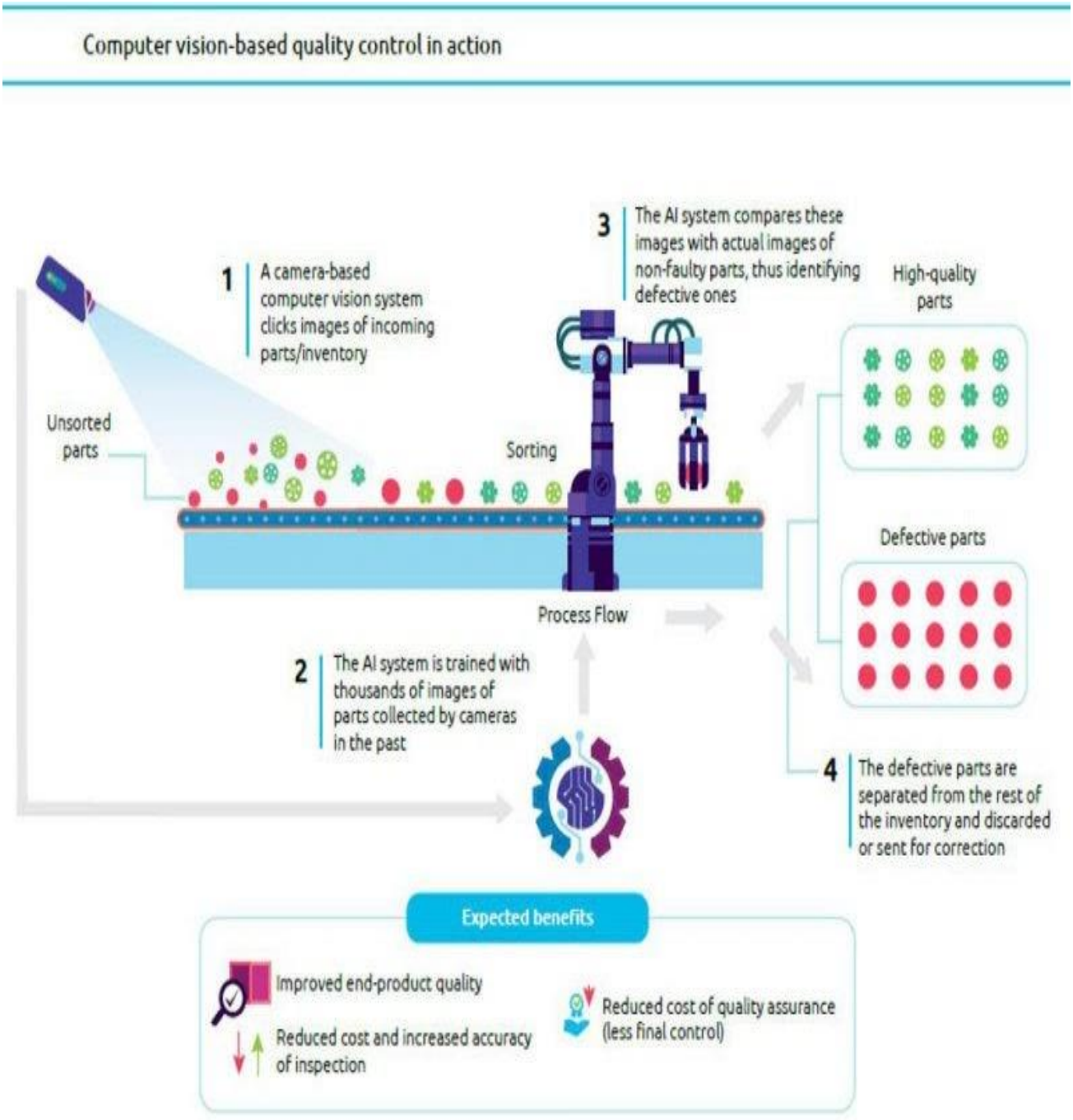

Figure 4.17: AI technology with action-based approach towards detecting high quality and defective parts

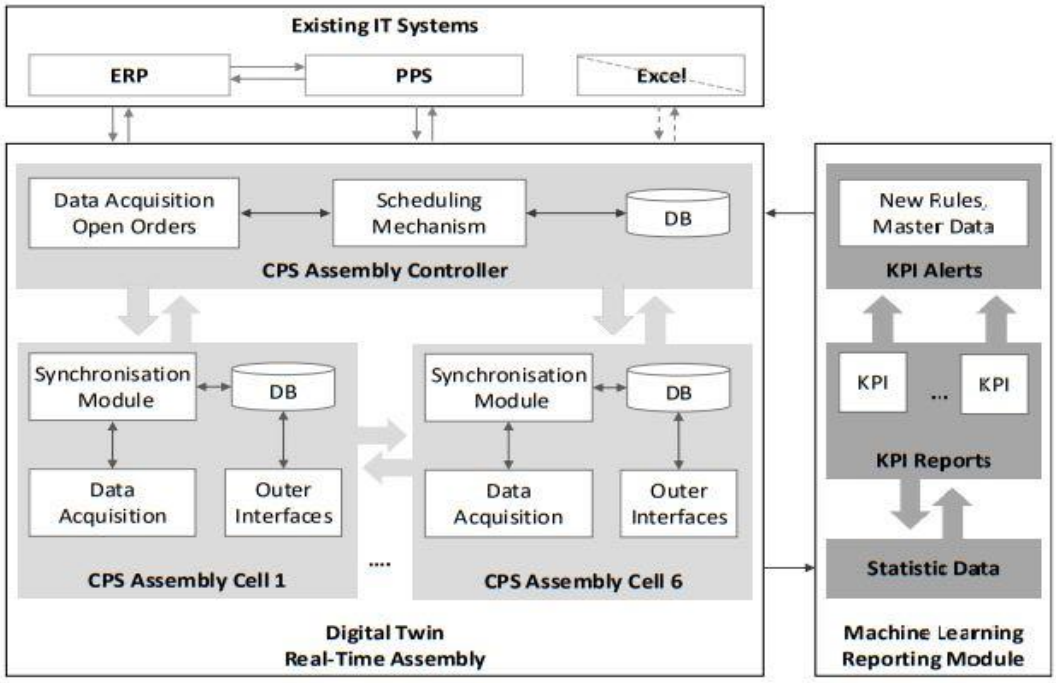

Figure 4.18: AI based solution for Bottleneck

CHAPATER 5

CONCLUSION

5.1 Introduction

In this chapter we will conclude our study and display our findings of the case along with possible solutions to the unstructured problems faced in the case. At the end we will also highlight the limitation that this study has.

5.2 Conclusion

The 1st research paper highlights the applications of ML in different tasks of a successful supply chain management by predicting the demands, customer-supplier relationships and cost and transport management for effective supply of goods to customer. However, there is still a huge research gap in applications of ML in SCM. A deep research with real world data is required to find out successful applications of ML in different tasks for effective SCM in different businesses.

The 2nd research paper present systematic literature review addressed the three issues related to most often ML algorithms which are in use in SCM, general trend of applications of ML in SCM, and parts of SCM in which these ML algorithms are distributed. Total 10 ML algorithms were found used in SCM most frequently; the use of these algorithms was found to be unevenly distributed across the SCM activities most frequently reported in the literature. Further studies are required to establish a successful SCM model for different business in future. New research is expected to bore down into the interpretability of ML calculations for dynamic settings to be tried in future.

The 3rd research paper suggests that as numerous approach choices are taken week by week, a week after week recurrence and anticipating skyline turns out to be vital for arranging. One key conclusion from research is that all countries do not have same level of errors and for some it is easier to forecast than others. On the basis of the research could be concluded that forecasting at level of countries could lead to effective local guidance and decision making. Such research can be quite significant in situations like todays.

The 4th research paper highlights the use of AI based planning system and implication of AI based tools in the manufacturing industry in order to reduce the lead time and better functionality of a mid-size industry. Although the results are quite promising but the implication is rather hard as the AI

solutions for industries in the research is limited and future research and developments needed to be done to overcome the issues.

From the analysis of all the research paper, data and trends it is evident that Artificial Intelligence and machine learning is next thing forward when it comes to supply chain management. The total Machine learning algorithms which are available out of there only 10 percent are being used in this field. It is also quite evident that there is very less exploration made in this field as compared to field such as automobile and robotics.

5.3 Limitations

This study has some limitations which are mentioned as follows:

- Data taken is restricted to the year for which the data was publicly available in case of the 3rd research paper as the pandemic is still not over.
- Inferences and conclusions drawn are from a broader aspect.
- There are various data sources that are used to complete this study, so if data discrepancies exist then kindly avoid it.
- The research part is an analysis of the secondary data available publicly on the internet, so conclusions or inferences drawn have a limited scope.
- The views which are depicted here in the study are taken from various researchers and then compiled in a more detailed way to complete this study.
- This study is done in a limited duration with the limited information available.

All these limitations were deliberately put in order to stick to scope and reduce the complexity. Although all these limitations can be overcome when available with required resources such as man power, time and technology but for the current study this all has been avoided to complete this research study with stipulated time and with available resources.

REFERENCES & BIBLOGRAPHY

- Petri Helo and Yuqiuge Hao (2021), “Artificial intelligence in operations management and supply chain management: an exploratory case study”, *Production Planning & Control - The Management of Operations*, ISSN: (Print) (Online) Journal homepage: https://www.tandfonline.com/loi/tppc20

- Y, Kajikawa Y, Mori J (2016) “Extraction of business relationships in supply networks using statistical learning theory” Heliyon

- Du Ni1,Zhi Xiao1,Ming K. Lim, “(2019), “A systematic review of the research trends of machine learning in supply chain management”, International Journal of Machine Learning and Cybernetics (2020)

- Julia Feldt Henning Kontny and Axel Wagenitz (2018), “Breaking Through the Bottlenecks Using Artificial Intelligence” University of the West of Scotland, Paisley HAW Hamburg Fraunhofer IML Dortmund

- https://research.aimultiple.com/manufacturing-ai/#:~:text=AI%20technologies%20can%20reduce%20operation,better%20forecasts%2C%20reduce%20inventory%20costs.

- https://www2.deloitte.com/cn/en/pages/consumer-industrial-products/articles/ai-manufacturing-application-survey.html

- https://erpsolutionsoodles.medium.com/benefits-of-using-machine-learning-in-supply-chain-63c661d1f0e8

- https://www.neenopal.com/MachineLearning.html

- https://throughput.world/\

- https://flashglobal.com/7-reasons-why-a-major-carrier-might-not-be-best-for-your-spare-parts-logistics-needs/

- https://www.duprelogistics.com/the-impact-of-technology-on-supply-chain-management/

- https://www.tandfonline.com/doi/full/10.1080/09537287.2021.1882690

- https://www.forbes.com/sites/williamarruda/2020/05/07/