

Impact of Artificial Intelligence on demand Forecasting in Supply chain Management during COVID-19

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ABSTRACT

COVID -19 has brought in lot of damage to the supply chain as companies have not been able to respond to rapidly increasing consumer demand, limited products supplied and changes in workplace rules .The war against COVID-19 has made us to come with innovative solutions. The application of AI in supply chain related task holds high potential for boosting top line and bottom line value. Companies today at even at the enterprise level have started implementing AI tech into every day supply chain tasks. It's a lousy time for companies to start looking, but AI can help them to enable their efforts. If more Industry can adopt technology in their operation, Supply chain could become a green industry in no time. AI in these uncertain times will help to accurately forecast the demand and will help to meet those demands. What this pandemic has shown us is that integration of Artificial intelligence and supply chain management applications helps automate decision-making, Improve efficiencies and better utilization of human resources.

Keywords

Artificial Intelligence ;Forecast; Consumer Demand ;COVID-19; Supply chain ;Innovative solutions

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Introduction

Artificial intelligence is making machine human intelligent. AI is something, which is going to shape the next Century. Artificial intelligence is going to make a significant impact on lives of people and the world around them under the age of 50. If India wants the current century to be an Indian century then it needs to start investing in Artificial Intelligence.

AI is been used today in almost every industry today such as Agriculture, Healthcare ,Finance, Transportation, Hotel, Aviation etc. but It hasn't given much focus on Supply chain Management which is a bit surprising as SCM is an important part of every company. from Businesses are showing great interest in AI applications from its benefits to fully leveraging vast amount of data collected by industrial logistics, Warehousing and transportation systems.

World has changed after corona, more sensitive, more demanding, Less lead times(Speed to Market), high mix low volumes(Fashion Demand), Online purchase increased rather than store direct sales, now too much big challenges for the companies to survive with least wastages Highly multi skilled manpower, high Robotic and artificial intelligence usage. (Industry 4.0) and Strong Supply chain Management.

COVID -19 has posed a huge challenge in supply chain operation as well across the industries. Integrating from demand and supply planning to operations execution with Distribution in seamless manner is a critical requirement.

Now what are the potential areas requiring attention?

- There will be more demand post COVID than pre COVID era. Capturing real time data using Artificial intelligence to assess better product forecast will help in better demand planning.
- How to make optimum use of resources

- Use of Artificial Intelligence can help in Data Analytics & Prediction in many operations from Product Forecasting to Transportation Planning.

If everything goes according to the plan and falls into place Artificial Intelligence will surely change the Supply chain in coming few years if not in near future.

Artificial Intelligence has capability to solve some of the biggest problems in supply chain management. This can be done pairing of Machine Learning and predictive Analytics .Artificial Intelligence based transformation dives deep into problems than any other search functions

Artificial Intelligence based models can provide you real time visibility into your supply chain with Predictive Analytics in place. It helps you to forecast hurdles and efficiently allocate resources before the supply chain kicks off.

Companies, which have been using traditional and rudimentary methods like the Excel, are fighting for their survival in the market. As we know that not every modeling technique which is computerized can account for accurate forecasting for changes in supply and demand which we are seeing in these unprecedented times. Even Companies like Proctor and Gamble, which is the largest manufacturer of Toilet paper in the country, and possess highly sophisticated supply chains in their armory have struggled.

Global Disruptions caused in supply chain due to COVID-19 in these unseen times have forced Companies to start tweaking and changing their models to reflect on new priorities and constraints as you are dealing with a situation in which Information is changing constantly with time, Artificial Intelligence model can be of great help. One of the great features of Artificial Intelligence model is that it very quickly crunch those numbers and can very quickly estimate about the forecasting patterns and what it resembles.

Literature review

Technologies have had a huge role to play in supply chain management in recent years and one of them is Artificial Intelligence. According to Soleimani, S. (2018) various methodologies of AI that are used is Machine learning, Neural network, Expert system, Robotics etc. Artificial Intelligence is used for various purposes in Supply chain management such as optimization, prediction, simulation, and modeling and for various decision purposes. So AI can benefit everyone in the supply chain from supplier to Manufacturer to distributor and consumer.

A Research conducted by Abdalnaser S. H. Al-MSloun (2020) suggested that around 85% of supply chain problems could be solved by using Artificial intelligence, which is a significant amount. Artificial Intelligence is a lot more effective in forecasting and demand planning which boosts the use of AI in this field. It also states a possibility of providing innovation in logistics services and could provide improvement in business strategy by 30%.

What Anirut kantasa-ard*. Abdelghani Bekrar.* (2019) said that Forecasting in current scenario is a bit difficult i.e. can be unrealistic due to the complexity of supply chains between the manufacturers and consumers. Research done by Robert J (2020) suggests that not only having a bare minimum amount of safety stock will help companies during these times but also having transparency and visibility in your supply chain. Success of the business in COVID-19 era does not depend upon the kind of assets you have but depends upon how agile, flexible your business model is, and how quickly it can adapt to the situation.

Studies by Salah Bouktif, Ali Fiaz, Ali Ouni and Mohamed Adel Serhani (2020) mention that various statistical models which are traditional in nature such as moving average, Auto regressive, and Auto regressive moving average (ARIMA) have had a lot of application in Industries due to their Time series prediction capabilities. In these, the basic assumptions made to implement these models are because time series are considered stationary and linear and are based on statistical distribution. However, there are various other models, which are different from statistical models i.e. an alternative to the statistical model and have the capability to address non-linearity in time series data. The most commonly used among them are artificial neural networks, which have the ability to model the most complex and nonlinear relationship.

Mahya Seyedan and Fereshteh Mafakheri (2020) say that predictive analytics could play a huge part in Supply chain management especially in trend analysis, demand forecasting and customer behavior analysis. Wide varieties of statistical techniques have been used till date in Supply chain Management for time series analysis and demand forecasting. The advancement in technologies these days have led to arriving at a more precise prediction that reflects customer needs in a better way, improves efficiency of supply chain, supports supply chain risk assessment and helps in facilitating assessment of supply chain performance. The amount of data available today's global supply chain makes the use of big data analytics and machine learning approaches a necessity for demand forecasting and incorporating block chain technologies for better tracking of supply chain.

Research conducted by Abdalnaser S. H. Al-MSloun (2020) says that Logistics, one of the links in Supply chain which is used to control the storage and movement of goods from one point to another. AI can be used by logistics industry to ensure there is no delay in delivery during anytime and to maintain proper condition of goods during the delivery and hence it will boost the overall efficiency of logistics industry.

Dianjun Fanga, Weibing Weng* (2011) say that currently used traditional forecasting methods are not capable of providing satisfied results. There has been a huge difference observed in forecasting results and actual sales done. The annual forecasting errors have been around 5% and monthly forecasting error has been more than 10%. There are many factors which lead to these forecasting errors, one of them being demand of retailers are quite amplified and delayed because retailers often are afraid of being stocked out, especially with the bestselling brands and products.

Model and Method/Methodology

In this section, we will be getting to know about the different methods, which could be employed for demand prediction and optimization.

Artificial Intelligence model for prediction and forecasting

Artificial Intelligence has proved to be helpful in improving demand planning, reducing forecast errors and delivering shipments on time by applying its application in predictive techniques. They have proved to be a lethal weapon for the future.

Predictive analytics across sales

This kind of analytics allows the companies across Industries to determine a lot of things which could be the way for the future such as demand for their products or services, also helps to understand the likely changes in consumer behavior based on seasonal changes and also guidance on what are the key elements that drives sales.

To make demand forecasting solution we make use of machine Learning algorithm which are combined with historical data and new data from various resources such as Enterprise resource management system, Customer relationship management system, Point of sales, Customer engagement through company websites, digital media and social media platform.

Now after attaining data from all the sources we can perform data cleansing process which will help to identify variables which impact the business process like cost, sales, demand and many others. The cleansed data obtained is combined with the Machine learning algorithm to build the predictive models which enables the company to get outcomes and tap opportunities within. But this predictive model which makes use of machine learning is quite different from traditional models used for this purpose because of the it enables to compare the predictions obtained with the actuals and helps in building the model of the future with improved forecast accuracy.

For this predictive modeling to work the company needs to link the data with ground realities.

Discerning the demand

Sensing the demand of the market is another application of artificial intelligence, which could help in letting know the consumer behavior while purchasing by capturing fluctuation in real time data, and makes the organization aware about the market demand. By having these demand solution in perspective will help the Industries across sectors to optimize their supply chain in a much better way due to higher demand and forecast accuracy. This a very critical demand forecasting method in the industries which has a very fast changing market.

Take the apparel industry for an example, what is trending today might not be trending tomorrow due to various reasons like it's not trending today and hence it is shown in consumer behavior maybe through purchasing or an interaction on social media or may be a survey conducted across platforms.

In demand discerning, the data is collected from various sources such point of sale systems and warehouses and is backed by data collected through customer engagement on various platforms, latest trending and many more. Demand discerning allows to capture demands which are trending on a short term basis and the various factors which cause fluctuations in it thus helping companies to build an effective data driven supply chain.

Time series forecasting:

This could be defined as one of the key areas in Artificial intelligence. This becomes vital because supply chain witnesses a lot of prediction problem on daily basis, which involves time, based component with it. Enterprises have been using this model to attain vast improvements in various areas such as demand planning, forecast error rates, on time shipments and cost reductions.

Machine learning models is based on finding anomalies, patterns and predictive insights based on the large data sets provided to them. With the addition of time component comes the a lot additional information too which makes this particular prediction a lot more difficult compared to others. These kind of models are designed mostly on account of seasonality, randomness, trends and advantages.

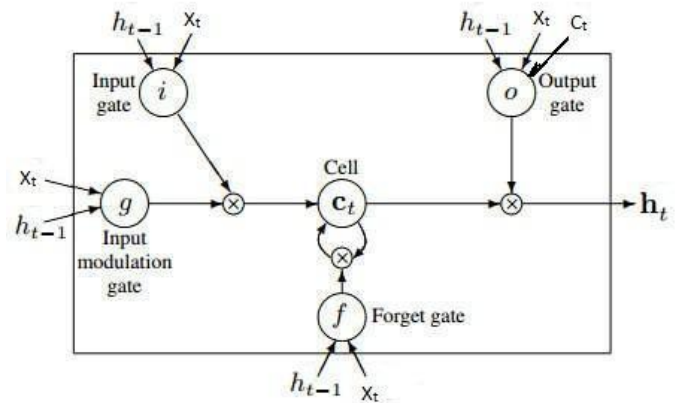
LSTM Model

Long-term short memory are networks, which can be applied to time series forecasting. Different types of LSTM models can be applied to particular Time series forecasting. LSTM models always has had an edge over other conventional models like RNN in many way due to their property of remembering the patterns for long duration of time.

Architecture of LSTM

The functioning of LSTM is built around facts, events and other evidences. A typical LSTM will consist of a different memory of blocks called cells. The cells or the memory

block is responsible for remembering things and transfer it to the next cell or memory block. This memory cell is composed of four main elements: The input gate, an output gate, the forget gate and a neuron. The gates present helps to serve the interaction between the memory cell and it's environment.



Forget Gate

This performs the work of removing information from the memory block. It removes information of less importance or the Information, which is no more required by LSTM to understand the nature of things with the help of a multiplication filter. It proves to be helpful in optimizing the performance of a LSTM network. It accepts two inputs h_{t-1} and x_t .

Here h_{t-1} is the output from the previous cell or even might be a hidden state from previous cell while x_t is input at that point of time. The inputs present are multiplied by a weighted matrix and we add a bias to it. After this we add a sigmoid function to the value obtained. The sigmoid function produces output with values ranging from 0 to 1 in form of a vector, equivalent to numbers in the cell state. The main responsibility of the sigmoid function is to decide on which values one should keep and which one should it discard. For example if we have 0 as an output for a specific value in the cell it means that forget gate wants the cell to forget that particular details out rightly. Vice versa if 1 is provided as an output this denotes forget gate instructs the cell to keep the particular bit of details with itself. The vector output obtained is multiplied with the sigmoid function

Input gate

This gate has the responsibility of adding information to the cell. The addition of information is done in three steps:

1. Uses the Sigmoid function to regulate values, which are to be added. This is very similar to the forget gate used and is and basically acts as a filter for all the information used
2. We need to create a vector with all possible values that can be added to the cell state. This can be done using the tanh function, which has an output ranging from 1 to -1.
3. Multiply the values obtained from the sigmoid gate to the created vector using the tanh function and then we need to add this cell state via adding it.

This three step process ensures that all the information contained in the cell is useful and not redundant.

Output gate

It performs the job of collecting useful information from the current cell and providing the output is done with the help of output gate.

The function of output gate also has three main steps to it.

1. Create a vector and apply tan function to the cell state, which scales up the value in the range of -1 to +1
2. Building a filter using the values h_{t-1} to x_t , so as to regulate the values which are needed as output. The filter, which is been designed, makes use of sigmoid function in it.
3. Firstly, The value of the filter made is multiplied to the vector and then it is sent as an output and also kept in a hidden manner in the next cell

Results and Findings

We have opted for LSTM models for forecasting and prediction purpose compared to ARIMA model, LM FNN, K-NN regression MLP FNN, Support vector regression.

When one has enough amount of data and abundant of learning set available we can use LSTM as it works better compared to ARIMA which needs a series of parameters that is determined with the help of data but LSTM is quite different as it does not require any such parameters. ARIMA performs well only when stationary time series provided, whereas LSTM can do it when time series is not stationary i.e. when there is change in seasonality, trends etc. With enough data available, you will get an RNN or LSTM, which matches the nonlinearities of your real data well, which in turn makes its predictions much more accurate than the ARIMA model

Since LSTM units have memory cell it can maintain information in memory for long periods of time and so we prefer it compared to RNN. Standard RNNs (Recurrent Neural Networks) suffer from vanishing and exploding gradient problems which the LSTM doesn't.

LSTM models are provided with loops in them and hence have power to contain the information for a longer period of time when compared to any traditional model.

Conclusion and Limitation

In this paper how Artificial Intelligence can help in Prediction and forecasting is studied. Here we have studied new models based on Neural networks instead of a traditional or regression model to have the best forecasting results with us.

Artificial Intelligence and Machine Learning are products of Science. The idea that machine could even perform Human tasks is thousand years old but Artificial Intelligence and Machine Learning have made it possible. This paper shows that there is an urgency in today's world due to the unprecedented times we are living in and amidst chaos to look for new technologies and models, which could provide results with better accuracy and efficiency.

In real production environment there is a need to go for forecasting application to provide prediction results within milliseconds and in some cases even microseconds. Therefore short term prediction with the help of machine learning models is demand of the situation and is practically required too as it provides great advantage in fast

forecasting. In addition, the LSTM model makes use of Machine learning algorithm so the model is able to perform task parallel while the algorithm is being conducted so the processing time will be even shorter than expected in production environment and hence guarantees time efficiency.

This work lets you know about the Machine Learning and deep Learning techniques such as LSTM that can be applied in day to day supply chain for forecasting purposes.

One thing, which led to the popularity of LSTM, is its ability to deal with Vanishing gradient problems. But what remains to be seen is that it can't remove it completely. It happens because data has to move from one cell to another, as it needs to be evaluated. Adding new gates such as forget gate has moreover increased the complexity of the cell.

They also need time and a lot resources for training purposes so that they can be ready to fight real-world challenges. Technically speaking they require a high bandwidth because of presence of linear layers in the cell, which is usually not provided. Hence the, LSTMs may not be able to provide the efficiency which it should.

LSTMs are very much vulnerable to overfitting and it's not easy to control this issue by applying dropout Algorithm. Dropout is defined as a regularization technique or method which is applied for neural network models where probabilistically exclusion of input and recurrent connections to LSTM units takes place from activation and weighted update in a network.

Future scope of study

The main challenges with supply chain is the demand variability, lack of quantitative analysis and lack of tools to analyze the data. So in the future more detailed research needs to be done on how to deal with these challenges.

Artificial Intelligence is considered as the future in supply chains because of the availability of the major concrete tools like Machine learning and deep learning which can help in forecasting the inventory with demand and supply. Artificial Intelligence has the ability to revolutionize the agility and optimization of supply chain decision making. A lot of companies across industries have used various technologies to stream line their supply chain process but Artificial Intelligence can greatly contribute to improve it by many folds. Future is going to be such that there are going to be time constraints in all the sectors and getting humans to the tedious job of collecting and analyzing data is not going to prove efficient which Artificial intelligence will be able to without any errors.

The work carried out in this research paper is highly factual in nature. The model presented here is useful when we have good quality data present with us. The success of any forecasting model depends upon the quality of data, which was made available to it.

Traditional time series model has paved the way for new multivariate models such as Machine Learning model which has the capability to incorporate a lot of variables with a high accuracy but this doesn't mean the traditional models are not valid in any way because they competent the machine learning model so the presence of both is equally important. So the future is more likely to combine the all the models ever developed.

As data is the new oil and success of organization depends upon use of Industry 4.0 technologies, Future work consist of offering greater importance to decision making in supply chains with the help of Artificial Intelligence Algorithm by discovering patterns in data provided to them.

Appendix A. Supply chain management

Supply chain Management is defined as wide range of activities required to produce a product a from it's raw material to the consumer in the most economical way possible. It also covers integrated planning and executes the process in a way that optimizes flow of materials, information and capital.

Supply chain management has many benefits such as better efficiencies, higher accuracy, lower costs, higher profits. It also enables organization to manage the demand in much better way, have right amount of inventory at your disposal and also enables you to handle the disruption caused in the chain.

SCM starts with what discerning what products consumer wants to how to deliver it to the customer in a safe and proper way . Hence, it has a greater impact on both the enterprise and customer.

Appendix B. Machine Learning

While Artificial Intelligence May be defined as one of the Broader science of copying human abilities in a machine, Machine learning is a subset of Artificial Intelligence on how to act like humans or how to be human intelligent. Popularity of machine learning has grown over the years because of the importance of data than ever before.

To create good machine learning systems one needs to have a better capabilities to prepare data, sound knowledge of advanced algorithms, Automotive and iteration process, Scalable and ensemble modeling. It is been immensely used by many Institution and organization such as Financial services ,Government, Healthcare industry, Retail ,Oil and Gas ,Transportation and many more which suggests that Machine learning has been changing the way Organization works.

Various popular Machine learning methods are Reinforcement learning, Transfer learning, Ensemble methods, Dimensionality reduction where transfer learning is the most widely used method. The main aim of machine learning is to make to understand the structure of the data but the real test of a machine-learning model happens on the validation error on the new data.

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