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RESEARCH PAPER

A Machine Learning Method to improve Supplier Delivery Appointments in Supply Chain Industries: A Case Study

Anitha Palakshappa[1], Sumana Maradithaya[1], Charunayana V[1]

[1]Ramaiah Institute of Technology (RIT) / visvesvaraya Technological University, Bangalore, Índia.

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ABSTRACT

Goal: The paper aims at the customization of supplier schedules upon the priority of key articles. It aims at the prediction of an appointment to a supplier based on the key aspects. The objective of this study is to investigate whether the machine learning algorithms can be used to predict the delivery dates of the products based on the trained data.

Design/Methodology/Approach: The prediction method uses a machine learning approach. Prediction algorithms namely, Logistic Regression (LR), K-Nearest Neighbour (KNN), and Random Forest (RF) are used for forecasting. The appointment is assigned to a supplier based on the delivery date of a previous supplier order. If a supplier requests a prior date, then the average sales and opening stock of the products is verified and the prior date of n-3 will be assigned ('n' represents the assigned days of delivery).

Results: Clustering is used to visualize the group of products based on the days of delivery and quantity ordered. This helps in creating the floor space for the on-time delivery of fast-moving products and reducing the manual process for the reordering team. The present work can be used for the procurement of key articles for the fulfillment of customer demands. The combination of K-Means with prediction and classification is giving lesser expected delivery date using RF compared to LR and KNN method.

Limitations: The limitation of the current work is that it is applicable for small scale industries in the developing countries. Also deployment of the application in agricultural sectors allow for greater transparency and accountability in the supply chain.

Practical Implications: Further, the work will also provide recommendations for retail companies looking to implement machine learning algorithms in their supply chain management.

Originality/ Value: The case study developed a model for Retail industries to manage the supplier delivery appointments.

Keywords: Appointments; Clustering; Customer Satisfaction; Prediction; Supplier Schedulin.

1 INTRODUCTION

Retail industries are facing problems in managing unplanned appointments of suppliers in accepting orders. This problem leads to unproductive work in managing the paper calendar and phone calls in a retail store. Small-scale supply chain industries were contacted to analyze their perception of supplier delivery appointments. The availability of floor space, the availability of products, and the delivery date of the items are the key aspects of the supply chain. The date and time agreed between supplier and retail store buyer for the arrival of goods at a particular

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destination are termed delivery appointments in supply chain industries. There are different types of appointments scheduled in the supply chain - transportation/logistics appointments, supplier appointments, and s

hipping. According to the survey with the supply chain team, retail industries are facing a lot of challenges with supplier appointments. For example, more than a thousand suppliers are present in any of the medium-scale retail stores supplying ordered products with prior appointments. The problem is that all the suppliers taken prior appointment are unable to supply the goods in time or some suppliers supply the goods before the appointment, which leads to customer dissatisfaction, and unloading issues. Some problems for not supplying the goods in time may be challenges in transportation or shortage in raw materials or may be inadequate work force. The Supply chain needs to align these suppliers for supplying the goods in a stipulated time. This process is labor-intensive in many Indian retail industries. Order deliveries in a retail store are a combination of goods from the warehouse and goods delivered directly to stores from the supplier. Because of the limited floor space and lack of receiving points in stores, operations need to be managed for both planned and unplanned cases. A major challenge in retail stores is the alignment of supplier orders in the store. Scheduling supplier order is a major issue in many industries. Figure 1 shows a common example of an appointment schedule:

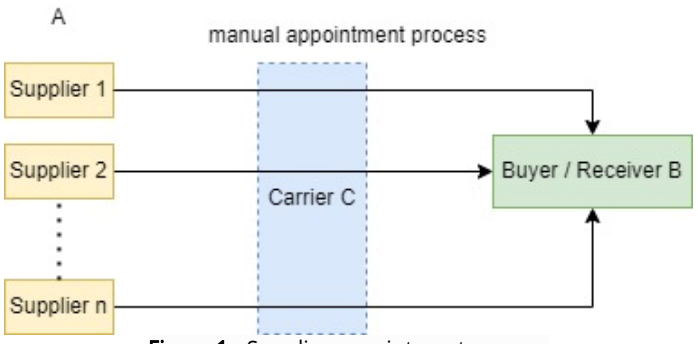

Figure 1 - Supplier appointment process

From figure 1, the supplier needs to supply the goods to buyer B through carrier C. Either the supplier calls to a carrier for an appointment or the carrier communicates with the supplier continuously for delivery timings and drop-off location. There may be hundreds or thousands of suppliers across the industry communicating daily day in and day out movements. This impacts the man-hours required every day for chasing the appointments.

The objective of the work is to overcome the manual appointments using machine learning algorithms and to meet the green supply chain to some extent (RezaHoseini et al., 2021). The work contributes to supply chain industries in reducing the manual process of supplier delivery appointments. The goal of any retail sector is the timely supply of the goods from suppliers and explicitly meeting the demands of the customers. This can be achieved if there is proper planning in the section of goods ordering and receiving. This can be either in warehouses or sometimes directly in stores. Traditional resource allocation was using a manual approach, which is entirely based on paperwork by maintaining some registry entries. Nowadays, many B2B industries have automated in order to reduce their carbon footprints. But some of the works are still using manual updates.

This work is useful in prioritizing and supplying the key article (palakshappa et al., 2021). Articles are classified as high sales, average sales, and low sales. High sale articles are called Key articles. The current experiment can be used for giving appointments to suppliers based on the priority of article sales (palakshappa et al., 2021).

Many industries are applying their maximum share of the operational costs for the purpose of handling and storing the goods either in distribution centers or in stores (Vieira et al., 2017). This is due to the dynamic nature of demand and supply of goods. To perfectly manage the supply and demand, parameters like reliable transportation and early response via automation are necessary (Vieira et al., 2017). The restructuring of logistics space has attracted the attention of many researchers from academia and the public sector. It influences greatly metropolitan areas, where the population is more and land availability is minimum or cost for land utilization is more. The emergence of e-commerce has contributed to improving logistics facilities and trying to fill the gap between supply and demand (Xiao et al., 2021).

Replenishment teams are responsible to verify the number of goods available and ordering new goods by giving delivery dates either early or late based on the availability. To achieve on-time delivery, the important thing is proper sequencing and tracking of appointments. Though some

industries are using automated applications for supplier order scheduling, there will be always 10 to 20% manual intervention. To achieve success in managing the procurement, on-time delivery relies on the performance of the suppliers (Saputro et al., 2021). Suppliers need to be selected appropriately to deliver goods with the right quality at the right time. Providing appointments to the supplier is a manual process in many Indian Retail Industries. Following are the steps explaining the problems faced by supply chain industries due to manual appointments.

1. Unloading time
2. Non-availability of floor space
3. Parking Issues
4. Shortage of man power for unloading the goods
5. Congestion in goods receiving area.

According to the above list, if the supplier does not provide the delivery of goods during the allotted dates, the problems like congestion in the receiving area, manpower issues, unloading time, floor space, and also parking space for the vehicles, which leads to challenges in stock replenishment, availability issues and indirectly affects customer satisfaction (Abdelhadi et al., 2024).

The paper is organized as: Literature Review is discussed in section 2, Methodology is explained in section 3, Implementation and results are presented in section 4, followed by conclusion and future enhancement.

2 LITERATURE REVIEW

As the globe is moving towards digital technologies over the years, and also industry 4.0 are considered to be a way of future for supply chain management (Reza et al., 2021), initiation of online applications is required. Out of many prominent technologies like blockchain, Analytics, IoT, and cloud computing, Artificial Intelligence has the capability of imitating humans (Reza et al., 2021). It is popular for adopting the processes in various areas including the supply chain (Reza et al., 2021). The literature reveals a framework for designing warehouse operations, mainly on supply and demand strategy, distribution strategies, and their characteristics (Vieira et al., 2017). Many design considerations for an order-picking system are available, which includes strategies and policies for order picking, routing pattern, and also decision making. Designing a warehouse includes the number of stock-keeping units (SKUs), count of pallet locations, number of cases per pallet and output requirements (Thomas et al., 2015). So supply, orders, and costs are the main criteria to be paid attention in designing the operations for distribution centers or warehouses (Thomas et al., 2015).

Maintenance of a warehouse or store is systematically based on the space organization. The author explained the development of new multi-story buildings, major types of land usage efforts, and reorganization and renovation of existing facilities to fill the gap between the supply and demand of products (Xiao et al., 2021). To maintain on-time delivery, the replenishment team needs to commit to the delivery of purchase order items on time (Sarvestani et al., 2019). Implementation of new technologies is not possible in many countries due to lack of population, so only fewer users can make use of technology (Stieninger et al., 2021). The author explained the selection of suppliers on several criteria like the reliability of suppliers, pricing for products, delivery timeliness, quality of products, and their position in the market (Shendryk et al., 2019). Appropriate selection of suppliers upon the key article sales helps the firm to maintain and manage efficiently the customers and supply of goods (palakshappa et al., 2021).

New technologies in retail industries benefit both businesses and consumers, which is indirectly profitable for businesses (Saputro et al., 2021). Implementation of internet of things in the retail sectors can improve the overall performance of supplier integration with respect to response times (Abdelhadi et al., 2024). As part of survey it is identified that, the customer, suppliers and also technology are responsible for adopting to supply chain uncertainties in manufacturing sectors (Hatani et al., 2024). The importance of supplier relationship management like supplier selection, evaluation and collaboration is causing impact on improvement of supply chain performance (Emon et al., 2024). The machine learning algorithms are used for analysing the delivery performance of various products in the retail sector. The delivery dates are predicted earlier using various ML algorithms and prediction errors can be reduced (Rokoss et al., 2024).

Patent survey: Appointment Scheduling (google patents)

The invention is on implementing a method that allocates or schedules an appointment on the basis of supply and demand. According to the invention, a customer can schedule an appointment using different devices like the telephone, email and message. This invention is based on the suppliers like doctors, mechanics, providers and beauticians. If the supplier is not available, then the alternative system has to suggest an alternative appointment time. Also if a customer is not

satisfied with the allotted time, then the customer can contact other suppliers with the same procedure.

Supply scheduling:

Upon receiving the customer requirement file, which includes the current requirement items listed and each item is associated with supply dates. The customer needs to mention in the file – the quantities of items required when the items need to be supplied. This helps suppliers to manufacture the required goods from different sources to meet the demands of the customers.

3 METHODOLOGY

Step 1: Retail store team communicates with the supplier for the purchase order upon key article sales and customer requests.

Step 2: The supplier will fetch the purchase order details through login to the application.

Step 3: Supplier checks for stock availability.

Step 4: Also Supplier checks the delivery date mentioned. The delivery date is predicted using 3 algorithms as shown in Figure 2. Prediction is calculated using average sales, previous two delivery transactions of the same supplier, and opening stock. The following equation gives the average sales value:

Average sales (avg) = S/N ----(1)

Where, S = Previous 90 days of sales except non-sale day

N = Total number of days, including non-sale day.

Step 5: If the supplier requests a prior appointment, then check the availability and floor space using the following method: a standard value like 3 days prior to the assigned date, the calculation is as below:

i. Calculate for each article, Number of days require to sell the articles = opening stock (os) / average sales(avg).

ii. After calculating for all the articles using the above formula in a particular purchase order, check whether 50% or more articles are able to get over within the requested prior date. If it is greater than or equal to 50%, then provide a new appointment date. According to this work, the prior appointment has been set to 3 days before the actual date provided. This method helps to check the space availability and reduces congestion in the goods receiving area.

Step 6: Supplier will provide delivery of products upon the value obtained in Result.

Step 7: Agglomerative and K-Means clustering is implemented, based on the order quantity. Clustering is based on Order of Quantity and days of delivery. Also, clustering is shown supplier-wise and month-wise.

3.1 Mathematical equations for the proposed method:

Let n represents the number of days given for delivery of items, and n-3 represent prior appointment days. That is if n=20 days, then 17 days are given for prior delivery of items.

a. Let a1,a2.....am represents m number of articles. For each article, calculate days (d1,d2...dm) require for selling as shown below:

d1= (os/avg)

Similarly, calculate for all articles. Arrange the results of d1,d2....dm in ascending order and apply median Med[d] to identify the middle value using the below formula:

$$Med(d) = \begin{cases} d\left[\frac{m}{2}\right], & if\ m\ is\ even \\ d\frac{\left[\frac{m-1}{2}\right]+d\left[\frac{m+1}{2}\right]}{2}, & if\ m\ is\ odd \end{cases} \quad \text{------(2)}$$

b. Using equation 2, check the prior appointment given for the supplier or not using the below formula

$$\text{Result} = \begin{cases} Med(d) \geq n-3, & prior\ appointment\ is\ given \\ Med(d) < n-3, & prior\ appointment\ is\ not\ given \end{cases}$$

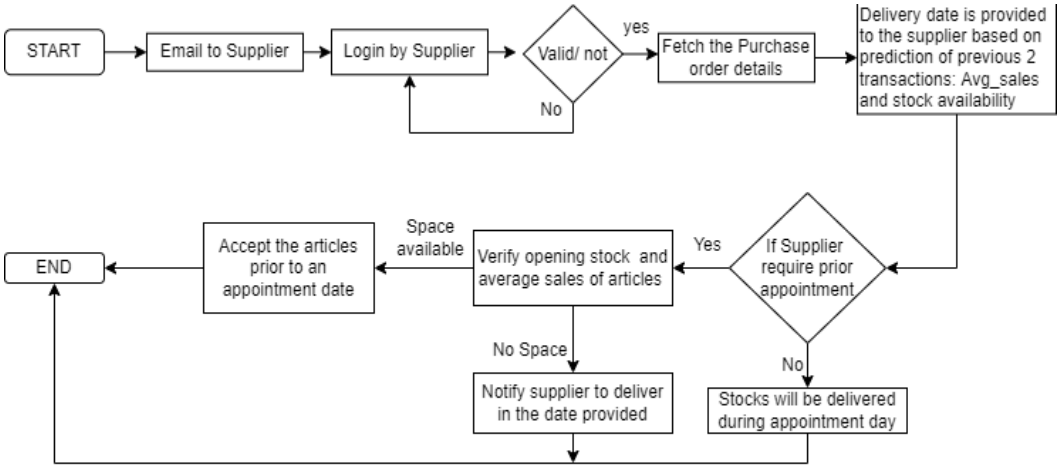

Figure 2 - Process of supplier appointment

Figure 2 and 3 give an overview of the concepts explained in steps 1 to 8. Fig 2 explains the procedure for supplier login to the application, checking the delivery date for purchase order and about prior appointments.

Fig 3 gives the prediction and clustering methods applied in the work. Independent variables considered in the prediction algorithms are average sales, order quantity and opening stock. The dependent variable is the delivery date. According to the prediction, the delivery date is predicted based on the independent variables. The prediction and classification algorithms used in the implementation are discussed below.

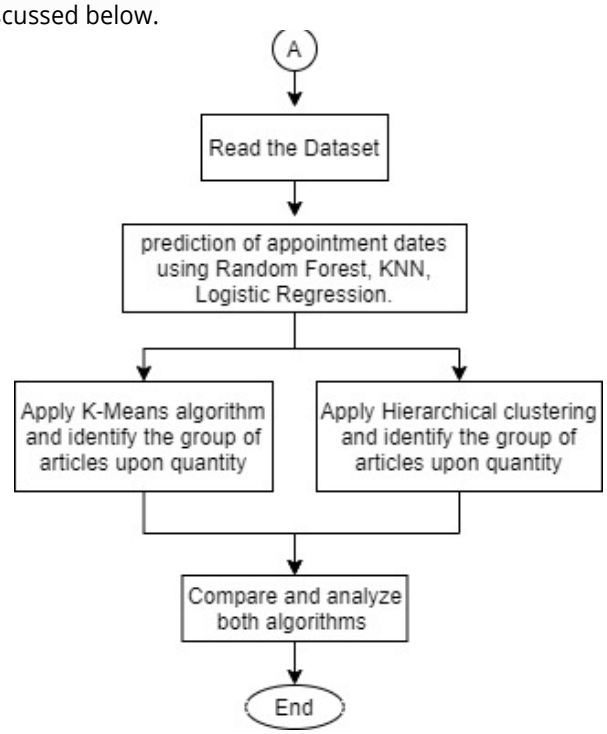

Figure 3 - Prediction and clustering process

Random Forest (RF) Algorithm: It is an example of a Supervised Algorithm, which can be used for both classification and Regression analysis. The algorithm works on creating multiple decision trees on the dataset, then predicts the value from each tree, and finally selects the optimum value based upon the majority. Fig 4 provides the working of the algorithm. According to the diagram, the dataset is divided into 80 and 20 for training and testing.

For solving regression problems, Random forest uses mean squared error (MSE) for identifying the branching of data from each node in a decision tree. The formula of MSE is shown below:

$$MSE = 1/N \sum_{i=1}^{N} (fi - yi)2$$

Wha N represents a number of data points, fi gives the value obtained from the experiment and yi is the actual value obtained from each data point i.

The formula helps to calculate the distance of each node from the predicted value.

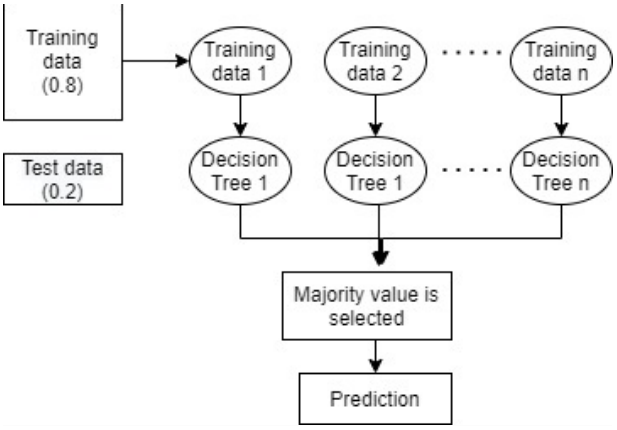

Figure 4 - Random Forest algorithm

Logistic Regression (LR): It is one of the simple and commonly used classification algorithms. Compare to Linear Regression, Logistic regression is categorical (Target variable) in nature. It works by predicting the occurrence probability of an event using the logit function. One of the properties of logistic regression is the dependent variable following the Bernoulli distribution.

K-Nearest Neighbour Algorithm: It is a non-parametric model compared to Logistic Regression. The algorithm works by calculating a distance (Euclidean, Manhattan and any other) from a new data point to all other points in training data. Then selects the k-nearest point (k-any integer) after sorting the distances in ascending order. Finally, assign the data point to the class, where a similar type of point is presented.

4 IMPLEMENTATION WITH RESULTS

Table 1 gives the description of the dataset used. It includes three months' supplier purchase order data- November, December and January. In November and December, delivery date values are present. Based on that prediction for January month is conducted.

Table 1 - Attributes of Dataset

Sl No	Attribute Name	Type	Description
1	Month	String	3 letter corresponds to month Nov and Dec
2	Store	Nominal	Name of the store, in which items need to be delivered.
3	Supplier Number	Numeric	4-digit unique number assigned for a supplier
4	Order Number	Numeric	5-digit bill number in a purchase order
5	Order_date	Numeric	Date of raising the purchase order
6	Delivery_date	Numeric	Date of delivery of items during Nov and Dec
7	Article_Number	Numeric	5 digit number assigned for each article
8	Order_Quantity	Numeric	Quantity of items ordered in kilograms
9	Average_Sales	Floating type	Correspond to previous 3 months average sales excluding the non-sale day
10	Opening_stock	Numeric	Opening stock of the articles

The experiment is executed for one of the supplier numbers. The following execution results are based on the same supplier. Figure 5 gives the predicted score by varying estimators using

Random Forest, KNN, and Logistic Regression. According to the table, all three algorithms' prediction score is lesser if we increase the number of estimator. But very less variation is seen in KNN/Logistic Regression compared to Random Forest.

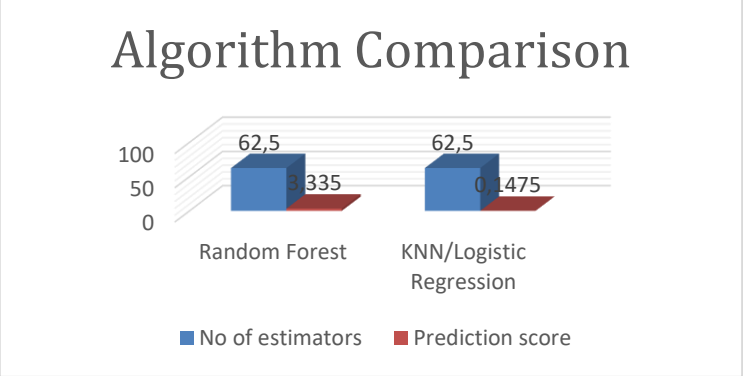

Figure 5 - Predicted score of algorithms

The experiment is carried out using a combination of prediction and clustering algorithms. The work is carried out with a combination of the following:

1. Random Forest predictor with K-means and Agglomerative clustering
2. KNN algorithm with K-Means and Agglomerative.
3. Logistic Regression along with agglomerative and k-means methods by taking different estimators.

Agglomerative: According to the results in tables 3 and 4, the order number or bill number is consolidated, that is all articles are not shown. Because for each order, the common delivery date is assigned. Also, 50 and 4 in the table represent the estimator value and cluster number. When comparing the results, we observe variations in predictions across RF, KNN, and LR when combined with clustering methods. Supplier selection can be executed using any of these algorithms; however, retailers should select the algorithm that best suits their prediction time frame requirements.

Table 3 - Results using RF, KNN, LR with K-means

Order Number	Ord Date	RF(50)&k-means(4)		KNN(50) & K-Means(4)		LR(50) & K-Means(4)	
		Predicted Delivery Date	Action	Predicted Delivery Date	Action	Predicted Delivery Date	Action
48607	14-12-2020	29/12/2020	No prior date available Request Prior Date	30/12/2020	No prior date available Request Prior Date	30/12/2020	No prior date available Request Prior Date
48993	14-12-2020	26/12/2020	23/12/2020 Request Prior Date	01/01/2021	29/12/2020 Request Prior Date	31/12/2020	28/12/2020 Request Prior Date
55157	21-12-2020	02/01/2021	30/12/2020 Request Prior Date	04/01/2021	01/01/2021 Request Prior Date	07/01/2021	04/01/2021 Request Prior Date
55475	21-12-2020	04/01/2021	01/01/2021 Request Prior Date	05/01/2021	02/01/2021 Request Prior Date	07/01/2021	04/01/2021 Request Prior Date

Table 4 - Results using RF, KNN, LR with Agglomerative

Order Number	Ord Date	RF(100)&Agglomerative (4)		KNN(50) & Agglomerative (4)		LR(50) & Agglomerative (4)	
		Predicted Delivery Date	Action	Predicted Delivery Date	Action	Predicted Delivery Date	Action
48607	14-12-2020	30/12/2020	No prior date available Request Prior Date	30/12/2020	No prior date available Request Prior Date	30/12/2020	No prior date available Request Prior Date
48993	14-12-2020	26/12/2020	23/12/2020 Request Prior Date	01/01/2021	29/12/2020 Request Prior Date	31/12/2020	28/12/2020 Request Prior Date
55157	21-12-2020	02/01/2021	30/12/2020 Request Prior Date	04/01/2021	01/01/2021 Request Prior Date	07/01/2021	04/01/2021 Request Prior Date
55475	21-12-2020	05/01/2021	02/01/2021 Request Prior Date	05/01/2021	02/01/2021 Request Prior Date	07/01/2021	04/01/2021 Request Prior Date

Figure 6 shows the clustering of delivery days versus quantity of items month-wise and supplier-wise. Based on the cluster organization, stores can check the quantities of items delivered on a particular day. Also, the quantity of items delivered is based on the supplier side.

Figure 6 can be used to analyse the 2 important things:

a. Overall quantities of order in a particular month and it's days of delivery.
b. Also supplier-wise, the data can be analysed.

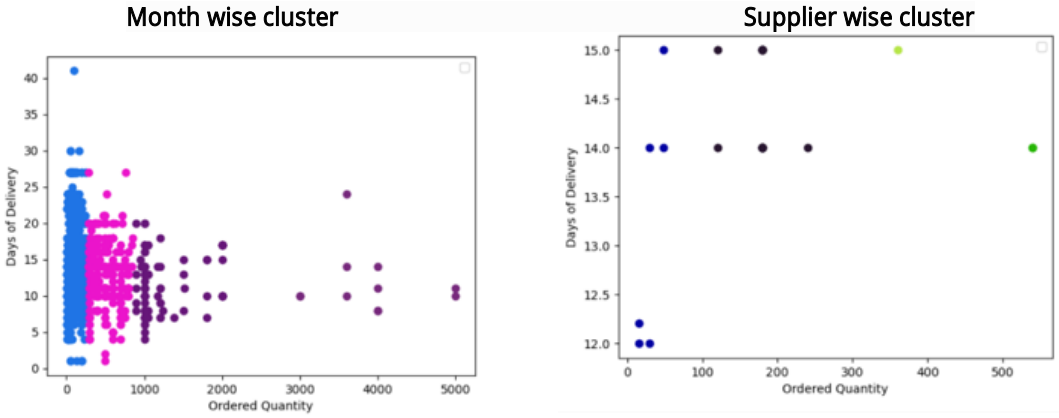

Figure 6 - Month and supplier-wise clustering using ordered quantity v/s days of delivery

K-Means Algorithms: Aim of K-means clustering is to partition the objects with an input parameter k. It divides the objects into a cluster in such a way that intra-cluster distance must be low and inter-cluster distance is high.

Agglomerative clustering: This method places each object in a cluster of its own. Then clusters are combined using the Euclidean distance formula. That is objects in two clusters are merged if they are forming a minimum distance between those objects. The process is repeated until all the objects in different clusters are combined into a single cluster.

5 CONCLUSION

The proposed work gives an overview of the supplier appointment process. Many retail industries are using manual appointment methods for supplying their ordered goods. The experiment helps in reducing the issues in appointment follow-up, and availability issues, and also brings efficiency to greenhouse management. Comparison of algorithms are done for calculation of predicted days of product delivery and prior date. As per the results in table 3 and 4, the RF with clustering algorithm is giving less number of days for prediction date of delivery compared to KNN

and LR algorithms. The experiment compares the prediction and classification algorithms like Random Forest, KNN and LR for the dataset. Clustering is used to visualize the articles days of delivery based on the order quantity. In this work, a prior appointment of three days is given based on the average sales and opening stock. The outcome of the work can be utilized by retail industries in scheduling supplier appointments. Further, this work can be extended to vary the prior date drawn on supplier requests or based on retail store time frame requirements.

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