PREDICTING LOGISTIC DELIVERY DELAYS USING MACHINE LEARNING

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ABSTRACT

In a competitive business environment focusing on the supply chain is crucial. A supply chain comprises of a network of suppliers, manufacturers, warehouses, and stores. Logistics management is integral to the supply chain. It involves the movement, storage, and control of goods, ensuring timely delivery. Logistics being a vital aspect of supply chain management, aids efficient resource use and leverages strengths in the market. The Global Logistics Sector is valued at 300 billion USD, with India attributing 10-15% of product cost to logistics. Amidst growth, logistics faces challenges, notably delivery delays. This report proposes a machine learning-based AI prototype to predict the possibility of a potential delay. The knowledge of potential delays can help businesses in strategic planning and minimizing losses.

1.0 INTRODUCTION

Logistics is the management of supply and transportation to deliver the goods on time and in good shape. handling of operations is a part of the logistics industry, and the need to perform efficient and cheap operations is of utmost importance in the modern competitive world. Even though delivering packages on time and in good condition has always been crucial to the supply chain, it has become even more mission-critical in recent years. This has happened as omnichannel commerce has become more prevalent, allowing customers to order customised products from their mobile devices and have them delivered the same day to their homes or stores. Suppliers, manufacturers, distributors, and retailers have all had to enhance their logistics procedures to outsmart the competition and meet the requirements of the fast-paced world of logistics. To better understand the supply chain, they have also had to streamline their operations and integrate all the processes and operations. However, as time passes, the evolutionary changes in technology, customer demand, and ever-changing legislation create more hurdles for even the largest logistics organizations. Some of the challenges that the industry faces are:

- **Transportation challenges:** Transportation by road is the primary mode of freight cargo transportation in India. Nearly 60% cargo moves by road. Owing to over-saturated rail networks and high rail tariffs, a mere 32% cargo moves by rail. Although majority of the supply chain moves by road, it is not without a fair number of hiccups. Road transportation proves to be quite inefficient because of poor road infrastructure, multiple checkpoints, and congestion.

- **Bulk order intensity ratio:** Keeping up with bulk order timelines is a herculean task for transportation companies. Every Indian Transportation Company in the Logistic Sector has faced the exhausting issue of keeping up with the supply-chain timeline in the event of receiving bulk load of orders. In the instance of high volume of orders received, it often gets difficult to prioritize and juggle orders and deliveries on an extremely tight timeline.
- **Hike in fuel costs:** Fuel cost is one of the biggest challenges faced by the transportation companies in the Indian logistic sector. The inflation in fuel prices results in increase of transportation costs to the shippers. Rise in fuel prices constantly increase the surcharges added to freight rates. This naturally cuts down the revenue and earnings of truckers, as fuel prices increase.
- **Unforeseen delays:** The varied terrain and diverse travel and weather conditions in India, create an unreliability in the transportation industry, owing to the high probability of unforeseen conditions. Even when the packaging and drops are conducted on schedule, the transportation industry is often challenged by delays. Mainly because India is a huge country, covering different terrains, subject to different conditions. Also, roads are terrible in the remote, internal parts of the country and Ghats are prone to accidents and landslides.
- **Poor warehousing conditions:** Another major challenge is storage. The unfortunate plight of pitiable warehousing facilities in India is no secret. Cargos incur immense damage owing to pest-infested warehouses, damage due to leakages, lack of proper storage space, and much more. This is most predominant in case of low margin goods and cargo. Also, the Governments use the big warehouses to store grains, leaving very little space for cargo storage
- **Overstressed delivery staff:** Overstressed delivery staff is a grave challenge faced by the supply chain of the Indian logistic sector. Every transportation company in India faces the problem of employing and retaining their delivery staff. The industry faces a shortage of delivery personnel, leading to the workloads of multiple time-bound deliveries being placed on the current workers. This obviously leads to them getting burnt out and discouraged with the pressure and with overwork.

Our cause of concern in this report would be around the problem of delays in logistic delivery. Below are the major causes of delays in logistic delivery:

1. **Traffic congestion:** Traffic jams are one of the most intuitive reasons for a delay in a delivery. This problem is specific to shipments that are sent via roadways.
2. **Weather:** Unfavorable weather conditions such as heavy rains, thunderstorms, hailstorm can not only delay logistic deliveries, but can also damage the products that are being shipped.
3. **Lost shipment:** Lost shipments are a common cause of logistics delays. Shipments can be misplaced or go missing. This can lead to disruptions in the supply chain.
4. **Incorrect shipping details:** Wrong delivery address, wrong contact details etc., can cause transportation to get misrouted and cause delays.
5. **Equipment malfunction or breakdown at the shipping company:** Lack of maintenance, or unidentified problems within the equipment parts can cause machinery to break down at the wrong time and therefore cause delays.

6. **Poor Inventory management and failure to predict market behavior:** Both of these problems are related. When firms are not able to predict the demand in the upcoming months, they are not able to adjust the supply accordingly. As a result, inventories either get understocked or overstocked. When inventories are understocked, businesses have to work on tight deadlines to fulfill unexpected high demand levels. Deliveries get delayed as a result.

According to an article titled "Delays to Delights: Transforming E-commerce with Logistics Scheduling" (2022) by Express Mobility News, "*In the contemporary business landscape, brands face immense pressure to deliver products swiftly, as 80% of customers expect same-day shipping. To add to this challenge, 61% of shoppers desire even faster delivery times, ideally within 1-3 hours of placing an order. Nearly all e-commerce platforms provide speedy delivery options to keep up with such high expectations. Nevertheless, unanticipated delays occasionally occur, but failing to notify consumers can prove to be a costly affair. In fact, research suggests that 69.7% of dissatisfied customers are less likely to shop with a retailer again, creating a detrimental impact on both the retailer and its logistics partner*.", which shows how crucial timely deliveries are for businesses. Reducing logistic delays has also been one of the main concerns of the government. Policies such as PM Gatishakti National Master Plan, National Logistics Policy, Investments in trade-related infrastructure, Logistics Data Bank project, Sagarmala and Bharatmala projects are also dedicated to reduce logistic delays.

Among the reasons for logistic delay that were listed above, points 2 to 6 consist of problems that are preventable, in the sense that the shipment company can always use predictive analytics or dynamic supply chain management systems that can make the businesses more efficient in their routine processes such that it becomes immune to logistic delivery delays. The possibility of a delay can be controlled as a result. But the first two points consists of problems that are completely outside the control of the shipment company. Moreover, the actual on road possibility of a delay cannot actually be prevented because these factors are outside the control of the business. Therefore, the knowledge of the probability of delay caused by certain kinds of uncontrollable factors can help businesses do the following:

- **Strategic Planning:** This includes optimizing shipping routes, adjusting shipment schedules and mitigating the impact of potential delays on overall logistics operations.
- **Risk Management:** Access to predicted delay information stakeholders to proactively manage risks associated with delays, such as re-routing shipments, adjusting inventory levels, and optimizing resources to minimize the impact of delays on their operations.
- **Operational Adjustments:** This proactive approach can help in reducing operational disruptions and maintaining supply chain efficiency.

So, the objective of the AI prototype will be to calculate the probability of logistics delays which occur due to factors outside the control of the business.

2.0 NEEDS ASSESSMENT

2.1 Current usage of AI in logistics

The evolution of predictive analytics in transportation and logistics has been marked by technological advancements, ushering in more sophisticated tools such as real-time predictive analytics and machine learning. Initially, early developments in this field were centred on improving route optimization and delivery times through the application of predictive analytics to determine the most efficient routes and minimize delays. Subsequent advancements, fuelled by artificial intelligence (AI) and machine learning, have enabled accurate demand forecasting, optimized route planning, and enhanced overall supply chain management. Real-time predictive analytics, utilizing algorithms and machine learning models, facilitates swift decision-making, allowing companies to adjust inventory and transportation plans in response to dynamic changes in demand and traffic patterns. Successful implementations of predictive analytics in transportation and logistics include real-time demand forecasting, route optimization, and predictive maintenance, resulting in reduced stockouts, improved on-time delivery rates, and minimized downtime.

2.2 Challenges to the usage of AI

The integration of predictive analytics in transportation and logistics faces several challenges, including the necessity of ensuring data quality, the high cost of implementing predictive analytics frameworks, and the demand for expertise coupled with substantial amounts of high-quality data. Despite these challenges, the potential benefits, such as improved efficiency, cost reduction, and enhanced customer satisfaction, are significant. The future of predictive analytics in the transportation and logistics industry is promising, with ongoing technological advancements and data availability leading to more accurate predictions and improved decision-making. The growth of IoT further contributes to opportunities for real-time data collection from various sources in the logistics chain, aiding in the creation of more precise predictive models. Advanced analytics techniques, particularly machine learning, are increasingly employed to enhance the accuracy of predictive models and automate decision-making, especially in the context of autonomous vehicles. However, the adoption of predictive analytics also faces broader challenges, including the need for a Chief Digital Officer to guide digital transformation, issues related to data quality and standardization, and the barriers of cost and resource constraints, particularly for smaller businesses. The shortage of technical expertise and the cost of hiring and training skilled personnel remain significant obstacles to the widespread implementation of AI technology in the logistics industry.

2.3 The problem in focus

From the preceding paragraphs what we can infer is that AI has certainly been able to reduce delays that occur due to preventable reasons. Traffic congestion is also something that AI has been able to predict quite well. But the focus of our discussion is the prevention of unforeseen delays which are a result of factors that are often outside the control of the business. Additionally, there are more factors that determine the fate of logistics delivery apart from the traffic and weather conditions. So, ideally our prototype must address the following needs:

- The prototype should make real time predictions, i.e., it must use real time data concerning traffic congestions and weather conditions so that dynamic route optimization is possible.
- It should take into account the infrastructural conditions of the target location.
- It should take into account the terrain related conditions.

- It should take into account the current condition of the shipping vehicle in order to predict the possibility of a break down.
- It should take into account the type and size of the shipment that is being prepared for shipment.

3.0 EXTERNAL SEARCH

The most important task is to gather a list of factors that are responsible for unforeseen logistic delivery delays. Some literature review would be helpful here:

Traffic

- The paper "Assessment of Urban Freight Transport and Logistics in India: Challenges and Opportunities" (Kumar & Tiwari, 2015) identifies traffic congestion as a major challenge facing urban freight transport and logistics in India. This congestion leads to delays in logistic deliveries, which have several negative consequences.
- The paper "Analysis of Road Freight Transportation Efficiency in India: A Focus on Traffic Congestion and Infrastructure Deficiencies" (Mitra et al., 2021) also identified traffic congestion as a cause for delay in deliveries.
- The FICCI report "Logistics Sector in India: Challenges and Opportunities" (2022) discusses traffic congestion and delays as one of the key challenges facing the sector. The report acknowledges that traffic congestion significantly impacts logistics efficiency, leading to increased travel times and delays.

Weather

India's vast and diverse geography makes it highly susceptible to a variety of weather extremes, which can significantly impact its roadway logistics network.

- Monsoon Rains: The annual monsoon season brings heavy rainfall, particularly in the eastern and western regions, leading to roads become flooded and impassable, causing delays and cancellations of deliveries. Slopes become unstable and prone to landslides, blocking highways and isolating communities. Delays in delivery of essential goods, increased transportation costs, and disruptions in supply chains.
- Fog: Dense fog, especially during winter months in northern India, creates low visibility conditions that. Drivers are forced to reduce speed, leading to congestion and longer travel times. Limited visibility increases the chances of accidents, further impacting traffic flow. The result is delay in deliveries, disruptions in passenger transportation, and potential safety hazards.
- Extreme Heat: Scorching temperatures during summer months can damage roads: Asphalt melts and cracks, leading to road closures and repairs. It can also cause tire blowouts: Overheated tires are more prone to failures, resulting in vehicle breakdowns and delays.

- Dust Storms: Dust storms, particularly in the desert regions, are characterized by reduced visibility. Dust clouds obscure vision, making driving hazardous and leading to accidents. Wind and dust can create dangerous conditions, forcing authorities to close highways for safety reasons. This results in delays in deliveries, disruption in passenger transportation, and potential health risks due to dust inhalation.

Terrain

India's diverse and challenging terrain poses significant obstacles to efficient logistics, contributing to delays and disruptions in the delivery of goods.

- Mountainous Regions: India's mountainous terrain poses logistical challenges due to high altitude, narrow roads, and landslide risks. This leads to increased transportation costs, longer delivery times, and limitations on transported goods.
- Desert Regions: India's desert terrain presents logistical difficulties due to sand dunes, limited infrastructure, and dust storms, leading to high maintenance costs, weather-dependent transportation, and challenges in ensuring timely deliveries.
- Coastal Regions: India's coastal terrain is susceptible to floods, erosion, and monsoonal rains, causing infrastructure damage, temporary road closures, and port congestion. This results in increased transportation costs, potential damage to goods, and delays in international trade.
- Forest Regions: India's forested terrain poses logistical challenges due to dense vegetation, limited infrastructure, and wildlife movements. This leads to increased transportation costs, difficulties delivering goods to remote areas, and potential safety concerns for drivers.
- Riverine Areas: India's riverine terrain presents logistical challenges due to reliance on bridges and ferries, seasonal water level variations, and flooding risks. This results in increased travel time, potential delays, and safety concerns associated with river crossings.

Condition of shipping vehicle

- Vehicle Breakdowns: Poorly maintained vehicles are more prone to breakdowns due to engine issues, tire blowouts, and other mechanical failures. This can lead to delays in delivery schedules and disrupt the entire supply chain.
- Reduced Efficiency: Unmaintained vehicles often suffer from reduced fuel efficiency, leading to increased operating costs and longer travel times.
- Safety Hazards: Vehicles in poor condition pose a safety risk to drivers and other road users. Worn-out brakes, faulty lights, and malfunctioning steering systems can increase the risk of accidents, causing delays and potential injuries.

- Cargo Damage: Unmaintained vehicles with damaged cargo compartments can expose goods to harsh weather conditions, dust, and moisture, leading to damage and spoilage.

Type of product

The type of product being transported also influences the possibility of a delivery delay. Consider the following products:

- Pharmaceuticals: Strict regulations concerning temperature control, storage conditions, and documentation make pharmaceutical transportation complex and prone to delays due to compliance issues. Therefore, the possibility of potential delays due to regulatory compliance checks, risk of product degradation due to temperature deviations, is quite high.
- Hazardous Materials: Hazardous materials require specialized packaging, labeling, and transportation procedures as per safety regulations. Delays can occur during inspections, documentation checks, and route planning. This increases transportation costs, creates potential delays due to safety checks and limited availability of specialized vehicles, and potential environmental risks in case of accidents.
- High-Value Goods: High-value products like jewelry and electronics require heightened security measures during transportation, potentially leading to delays in security checks and customs clearance. This increases transportation costs due to security protocols, potential delays due to security checks and customs clearance, and risk of theft or damage.
- Bulk Goods: Large quantities of bulk goods like grains, fertilizers, and coal require specialized transportation infrastructure and handling equipment. Delays can occur due to limitations in loading, unloading, and transportation capacity. There is also increase in transportation costs, potential delays due to infrastructure limitations and availability of specialized vehicles, and dependence on weather conditions.

Infrastructure

The condition of the infrastructure influences the possibility of a delay in the following way:

- Road Network Deficiencies: Many roads in India, particularly in rural areas, are narrow and lack proper lane markings and shoulders. This limited capacity leads to congestion, especially for large trucks, significantly increasing travel times and delivery delays. Furthermore, the poor quality of many roads, characterized by potholes, cracks, and uneven surfaces, slows down traffic flow, increases wear and tear on vehicles, and contributes to accidents and breakdowns, further impacting logistics efficiency. Additionally, missing links in the road network force vehicles to take longer detours, adding unnecessary time and cost to deliveries.
- Inadequate Logistics Infrastructure: The lack of designated parking and staging areas for trucks forces drivers to park haphazardly along roadsides, contributing to congestion and hindering traffic flow. Additionally, insufficient warehousing facilities near major transportation hubs create logistical challenges and delays in cargo handling and distribution. Limited multimodal connectivity, including poor

integration between road, rail, and waterways, restricts the efficiency of intermodal transportation and adds time to cargo movement, ultimately impacting delivery times.

- Administrative and Regulatory Bottlenecks: Complex and lengthy customs clearance processes at ports and border crossings significantly delay the movement of goods, causing frustration and incurring additional costs for businesses. Furthermore, the presence of multiple checkpoints along highways for toll collection and permits forces drivers to wait in long queues, adding unnecessary delays and reducing productivity. Finally, the lack of transparency and information availability regarding real-time traffic conditions and infrastructure limitations makes it difficult for logistics companies to plan routes efficiently and anticipate potential delays, further contributing to inefficiencies and disruptions.

3.1 APPLICABLE CONSTRAINTS

The biggest challenge that this project faces is the problem of collecting data for creating the machine learning model. Various machine learning models on the internet have indeed tried to predict the possibility of delays, but the variables that those models consisted were not the ones that we have mentioned in this report. Existing machine learning models contain only some of the variables that we require for our case. Also, most of the variables in our case are qualitative, with a large number of ordered categories. Therefore, separate research would have to be conducted to assign dummies to the variables in a way that the order of the categories is preserved. Moreover, in order to rank the infrastructural situation of a particular location we will have to rely on government reports and these reports often cover only a limited number of locations.

3.2 APPLICABLE PATENTS

The following patents can be applicable

Patent Title	Assignees	Patent Number	Description
Method and System for Predicting Delivery Delays	Amazon Technologies, Inc.	US 11,327,584 B2	Predicts delivery delays based on historical data and real-time factors
System and Method for Dynamically Predicting Delivery Time	FedEx Corporation	US 11,144,305 B2	Dynamically predicts delivery times based on real-time and historical data

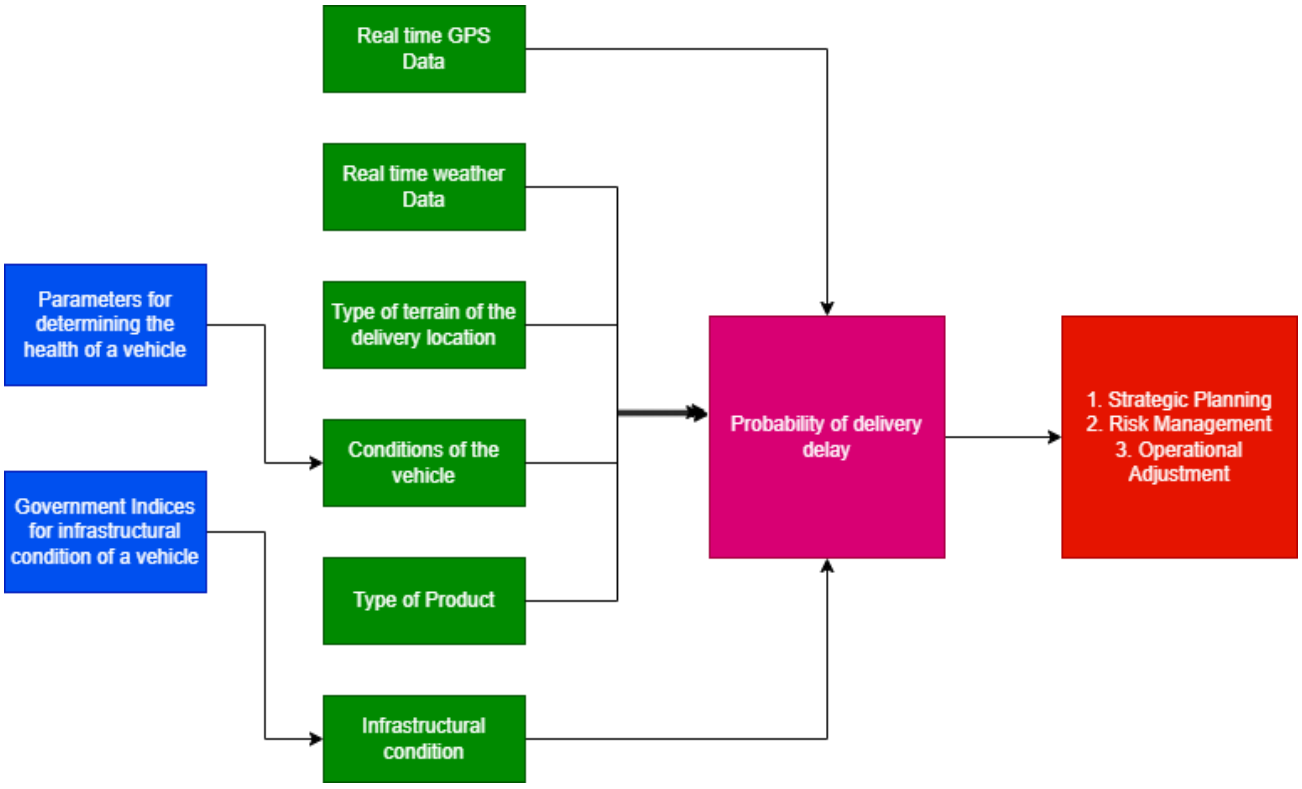
Method and Apparatus for Predicting Delivery Time and Route for Goods Delivery System	Alibaba Group Holding Limited	US 11,098,311 B2	Predicts delivery time and route considering factors like weather and traffic
Predicting Delivery Delays Based on Vehicle Location and Route Data	Google LLC	US 10,900,703 B2	Predicts delays based on vehicle location, route data, and unexpected events
Traffic Prediction-Based Delivery Route Optimization and Recommendation System	JD.com, Inc.	US 10,842,356 B2	Optimizes and recommends delivery routes based on traffic prediction
System and Method for Predicting Transportation Delays	United Parcel Service of America, Inc.	US 10,509,763 B2	Predicts delays based on historical data, weather forecasts, and real-time traffic
Method and System for Predicting and Preventing Delivery Delays	Uber Technologies, Inc.	US 10,475,281 B2	Predicts and prevents delays by analyzing various factors
Machine Learning System for Predicting Delivery Delays and Optimizing Delivery Routes	Google LLC	US 10,217,022 B2	Uses machine learning to predict delays and optimize routes
Method and System for Predicting and	Oracle International Corporation	US 9,983,977 B2	Predicts and mitigates delays using sensor data,

Mitigating Logistics Delays			GPS data, and weather data
Predictive System and Method for Delivery Route Optimization and Delay Estimation	Deutsche Telekom AG	US 9,864,985 B2	Optimizes routes and estimates delays based on real-time and historical data

4.0 BUSINESS OPPORTUNITY

Given the extent of losses that unforeseen delays can create in the smooth functioning of a business, the knowledge of a potential delay is highly valuable. The predictive analytics tools that are currently in the market provide prescriptive solutions, and the chances of an unforeseen delay generally remains unknown. Additionally, predictive analytics tools take into consideration variables like traffic situation and weather conditions only. Other significant variables that bring unexpected delays are generally not a part of those predictions. We therefore have an opportunity to offer a dynamic and real time data-based AI tool which can predict the probability of delays once the shipping vehicle is on the road.

5.0 FINAL PRODUCT PROTOTYPE



The diagram above explains how the model would work. It picks up data regarding two things:

1. The Parameters that determine the health of a vehicle. This could be a separate classification model itself, or we could also use some kind of grade to classify the health of the vehicle and directly feed into the main model.
2. The government indices for quantifying the infrastructural quality of the location.

These parameter values are fed into the main machine learning algorithm which calculates the probability of a delivery delay using the following variables:

1. Real time GPS data (for determining the traffic congestion)
2. Real time weather data
3. Type of terrain of the delivery location
4. Condition of the vehicle (From the previous layer)
5. Type of product that is being shipped.
6. Infrastructural condition of the location of delivery.

Using the specified classification algorithm, the probability of a delivery delay will be calculated. The probability can then be used for strategic planning, risk management and operational management by the business.

This entire prediction model will be used in the form of an integrated software or application.

5.1 PROTOTYPE DEVELOPMENT

We will be using some artificial data to develop a machine learning algorithm to demonstrate the working of the product. What should be noted is, that the data we are using is artificial, because the actual data for our use case is not available online. The real data will have to be collected through a ground survey which is beyond the scope of the current report. But, as long as our artificial data exhibits the patterns that our preceding discussion assert, it is safe to use it as a rough estimate for the actual prototype. The data that we will be using has 2000 rows and 8 columns. The variables are as follow:

VARIABLE	DESCRIPTION
Real time GPS Data	Inputs ‘Congested’, ‘Non-Congested’ by using Real Time GPS Data. For simplicity, we are assuming we have a separate model which helps us decide if the traffic is congested or not.
Real time weather data	Inputs ‘Sunny’, ‘Cloudy’ and ‘Rainy’ as weather forecasts.
Condition of the vehicle	Gives a rating out of 5 to the condition of the vehicle. Higher the rating, better the condition of the vehicle.
Type of Product	The type of product that we are transporting
Delivery Location	The delivery location

Infrastructural rating	Using government report, assigning a rating to the location's overall infrastructural rating.
Type of terrain of delivery location	The topography of the delivery location
Delivery Delay?	A "N" if the delivery was not a delay. A "Y" if the delivery was a delay.

Now let us have a look at the data:

	Real time GPS Data	Real time weather data	Condition of the vehicle	Type of Product	Delivery Location	Infrastructural rating	Type of terrain of delivery location	Delivery Delay?
0	Not Congested	Sunny	4	Liquid	Bengaluru	66.70	Flat To Undulating Plains	N
1	Not Congested	Sunny	4	Loose Or Bulk Cargo	Pune	66.27	Hilly Terrain	N
2	Not Congested	Sunny	4	General Cargo	Ahmedabad	64.87	Flat To Undulating Plains	N
3	Not Congested	Sunny	4	Liquid	Chennai	62.61	Coastal Plains	N
4	Not Congested	Sunny	4	Loose Or Bulk Cargo	Surat	61.73	Coastal Plains	N
...	...	...	...	...	...	...	...	...
1995	Congested	Rainy	1	Liquid	Ranchi	50.31	Hilly Terrain	Y
1996	Congested	Rainy	1	Loose Or Bulk Cargo	Belagavi	50.28	Flat To Undulating Plains	Y
1997	Congested	Rainy	1	General Cargo	Udaipur	50.25	Hilly Terrain	Y
1998	Not Congested	Rainy	1	Condition Products (Perishable, Requiring Vent...	Bengaluru	66.70	Flat To Undulating Plains	Y
1999	Not Congested	Rainy	1	Valuable Goods	Vasai Virar	51.26	Flat To Undulating Plains	Y

5.1.1. PREPROCESSING:

1. Most of the data is categorical. We will be assigning dummies to them.
2. The delivery location is not necessary, because the information associated with a delivery location is automatically represented by the infrastructural rating.
3. The only variables that will not be assigned dummies would be the condition of the vehicle and the infrastructural rating.

5.1.2. BUILDING THE MODEL:

We would be using k-fold cross validation on the following classification algorithms:

1. Logistic Regression
2. Random forest
3. XGBoost

The codes look as follow:

Logistic Regression:

```
In [136]: from sklearn.linear_model import LogisticRegression

In [137]: model = LogisticRegression()

In [138]: print(cross_val_score(model, X, y, cv = 10, scoring = 'accuracy').mean())
```

The mean accuracy for the model comes out to be 95.2%

Random Forest:

```
In [141]: from sklearn.ensemble import RandomForestClassifier

In [142]: rfc = RandomForestClassifier()

In [143]: print(cross_val_score(rfc, X, y, cv=10, scoring = 'accuracy').mean())
```

The mean accuracy comes out to be 94.9%

XGBoost:

```
In [149]: import xgboost as xgb
          from xgboost import XGBClassifier

In [150]: xgb = XGBClassifier()

In [151]: print(cross_val_score(xgb, X, y, cv=10, scoring = 'accuracy').mean())
```

The mean accuracy comes out to be 95.45%

So, we can use XGBoost Classifier as an algorithm for the case.

****The complete detailed code can be found on the given link:**

https://github.com/Msaad16/Feynn-Labs-Internship-Projects/tree/main

5.2 DEVELOPING THE FINANCIAL EQUATION FOR THE PRODUCT

There are two aspects to our product – the sales and the cost, and this would ultimately allow us to determine the profit generation capacity of the product. For the development of this project there are going to be large number of initial investments. Apart from that there might also be periodical costs on collecting new data to keep the model updated. The costs would be as follows:

1. **Establishing systems to integrate real time GPS data and real time weather data.** Given that we have existing technologies to serve these purposes, the costs generated will not be too large. **Let these be denoted by "G".**
2. Determining infrastructural indices for different delivery locations is also a cost consuming research project. The current indices that we used rate the location on an overall basis – it includes not just roads but health, sanitation etc. It is not known what weights are assigned to which parameter. **We need to make the infrastructural score very transport specific, and that requires on ground research. So, we can denote this cost as I** (Where I: Initial large cost that would be needed for researching the infrastructural capacity of given locations.)
3. **Experiment cost** would be substantial as well, because we do not have any existing dataset for our use case. So, what would be needed is that data is recorded for different deliveries so that a training set can be created for generating a machine learning model. Let this cost be denoted by "E"

4. **Operational costs:** There are also recurring costs in the development of the product:
    a. **Maintenance of database for customizing the product over time. Let this cost be 'd'.** Since data grows over time, the maintenance cost would grow as well. So let this cost be a function of time t i.e. d(t).
    b. Apart from that, the transportation facilities evolve, improve and depreciate over time. So, **regular surveys would have to be made to update the infrastructural scores of each location. Let this be denoted by 'u'**. We are assuming that this cost is unchanging.
    c. There will also be **costs of updating the machine learning model** in the form of research and development. Let this cost be r. For simplicity we will assume this to be constant as well.
5. So, the final cost which is a function of t becomes:

$$C(t) = G + I + E + d(t) + u + r$$

The second aspect of the financial equation is the sales aspect. The product will be sold on a yearly subscription basis and regular updates would be sent year on year. The users would not be charged for the updates, but yearly subscription cost would change according to the cost of updates that were made that year. Let us assume that the subscription fee is denoted by:

$$S + s\,(t, u, r)$$

Where s (t, u, r) is the marginal increase in subscription fee to counter inflation, to keep up with the cost of updating the infrastructural ratings and improving the existing model.

Note that s (t, u, r) is not actually a function of t, and not u and r because they are assumed to be constant here. We have added them to give the user and intuition that the increase in subscription has to be matched with the increase in u and r. Also, it is not necessary that u and r be constant. They might also be variable. In that case they would assume their separate functional forms.

Assuming that the **number of users is 'n'** and they are also growing as a function of time, the total revenue becomes:

$$R = n(t) * (S + s\,(t, u, r)$$

So, the profit function becomes:

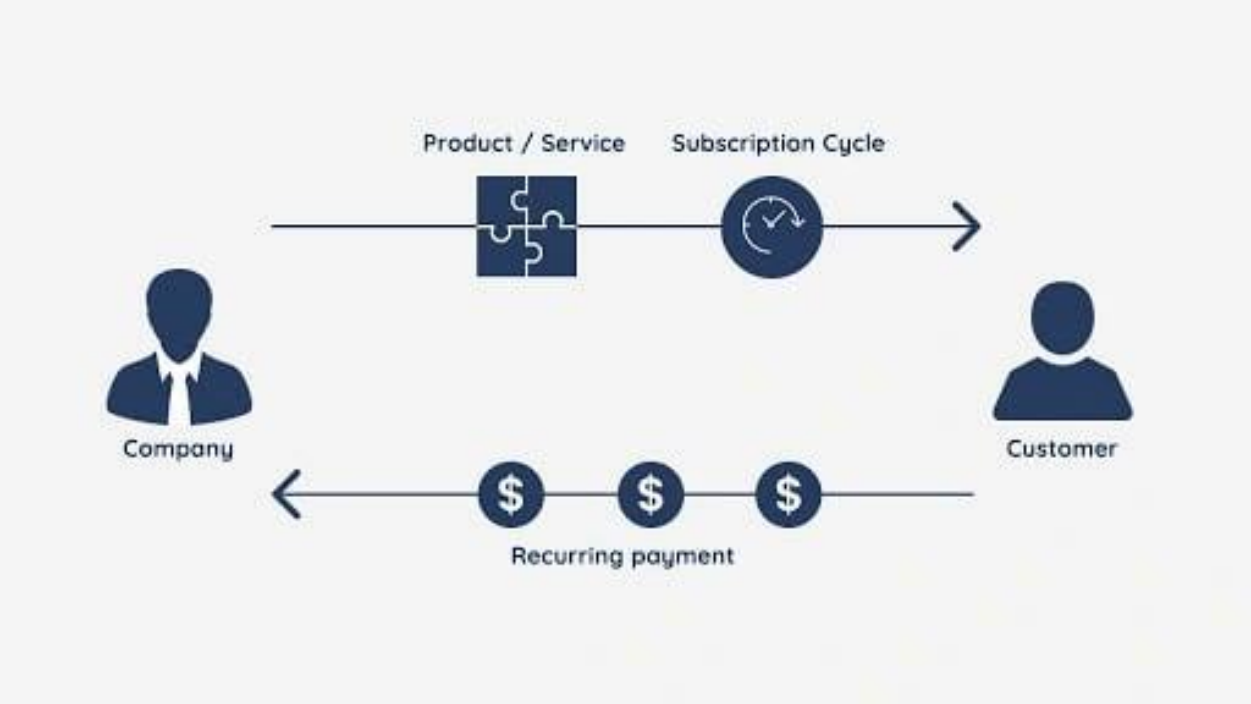
$$P(t) = [G + I + E + d(t) + u + r] - [\,n(t) * (S + s\,(t, u, r))]$$

Now, the shape of P(t) depends completely on the shape of the function d(t) and s (t, u, r). Additionally, if we had not assumed u and r to be constant, that would affect the shape of the profit curve as well.

5.3 THE BUSINESS MODEL

Quite obviously this is going to be a subscription-based business model. Subscription-based business models strive to attract clients in the hopes of luring them into long-time, loyal patrons. This is done by offering a product that requires ongoing payment, usually in return

for a fixed duration of benefit. These models are largely offered by digital companies for access to software. The subscription-based model can be understood with this diagram:



5.4 Team required to develop the prediction tool:

1. Supply chain expert/ Domain Expert
2. Machine learning engineer/Data scientist
3. Software or application developer for integrating real time data.
4. Automotives Expert/ Engineer

CONCLUSION

The world is evolving at a faster speed than ever. AI and Machine learning have placed their feet in supply chain management as well. We are living in an age where everyone wants their products and shipments delivered quick. The companies that do not adapt their supply chains to deliver the service that customers desire would surely be eliminated from the market. Delays in deliveries, can therefore, be not tolerated at all. Companies need to prevent delays not at just their own end, but they must also ensure that they at least minimize the losses that they can incur due to factors that exist outside of their control. The knowledge of the delay becomes really valuable in such a case.

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