Predicting Footfall Using Machine Learning Techniques

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Prototype Selection

Abstract

The capacity to produce accurate estimates on the number of consumers is a need for successful resource planning and utilisation in a variety of businesses. Additionally, it adds to societal problems on a worldwide scale such food waste. Tourism is a field that focuses mainly on short-term forecasting, and the research that is currently available indicates that calendar and weather data are the most crucial sources for precise prediction. We gathered and made available a dataset with visitor counts from four different companies over ten years that served as a good representation of the Swiss tourism industry, coupled with close to a thousand attributes that included weather, calendar, event, and lag information.

Every day, millions of people visit the leisure sector, and each one comes with their own set of expectations. Meeting those expectations is essential to luring clients back, and more and more leisure operators are looking to sophisticated analytics tools for guidance on how to do so.

Problem Statement

Assist the leisure industry, including restaurants, accurately anticipate visitor numbers and assess how weather, significant sporting and public events, or other external variables may have an impact. By focusing discounts and promotions on the times when they are most needed to increase traffic, a better understanding of visitor numbers throughout the year may also be used for marketing.

Market/Customer/Business Need Assessment

Here are some procedures to take while conducting a market, customer, and company requirements assessment in order to boost a restaurant's revenue by anticipating the number of customers:

Market Assessment:

- Examine historical data to comprehend visitor count trends, including seasonal patterns and week/day/month peak times.
- Examine regional festivities, events, and holidays that may affect the number of people that visit your business.

- Compile information on neighbourhood rivals' customer traffic patterns to spot chances to draw in more customers.

Customer assessment:

- Create customer personas using past data and customer feedback to better understand the wants and needs of your customers.
- Create a survey or other feedback mechanism to gather information on how the weather affects consumer behaviour, including willingness to eat outdoors, menu preferences, and visit scheduling.
- Collect real-time information on consumer preferences and feedback relating to weather conditions via social media and other internet channels.

Business Evaluation:

- Develop a predictive model for the flow of customers into your restaurant using historical data and weather predictions.
- Assess the capacity and staffing requirements of your restaurant to make sure you can handle increasing demand during peak times.
- Create a marketing strategy to advertise your business when the weather is good and use weather information to inform decisions about hiring, menu selection, and promotions.

Target Specifications and Characterization

It's crucial to create a target specification that explains your objectives and the methods you'll employ to attain them in order to boost restaurant revenue by forecasting customer volume and the impact of weather.

1. Revenue Goals: Be clear about your financial objectives and the timetable for accomplishing them. For instance, you might wish to raise sales by 10% in the upcoming six months.
2. Visitor Count Goals: Describe your visitor count targets and the time frame for accomplishing them in the second section. For instance, during the summer, you might want to boost the number of visitors by 20%.
3. Weather Metrics: List the weather factors, such as temperature, precipitation, and wind, that may affect the number of customers at your restaurant. Determine the measurements' cutoff points that will cause adjustments to the menu or other aspects of your restaurant's operations.
4. Marketing Strategies: Decide which marketing tactics, such as targeted advertising, social media promotions, or email marketing campaigns, can

help you meet your income and visitor volume targets. Indicate the spending limit and materials required to carry out these plans.

5. Operations Strategies: Choose the operational approaches that will enable you to satisfy higher demand during peak times, such as optimising staffing levels, modifying menu options, or increasing seating capacity. Indicate the spending limit and materials required to carry out these plans.
6. Data and Analytics: Describe the data and analytics tools you'll use to track your progress towards your objectives and make data-driven decisions about your marketing and operational strategies in point six.

External Search(Information and Data Analysis)

The sources we have used as reference for analyzing the need of such a system, have mentioned below:
https://select-statistics.co.uk/business/leisure/
https://www.scitepress.org/Papers/2021/103230/103230.pdf

Benchmarking

There are already a lot of applications on the market, like the Eat app, that anticipate restaurant sales using their own method of forecasting sales. It generally integrates POS with table management systems like Eat App.

Applicable Patents

The invention offers systems, programmes, and methods for predicting the likelihood of specific weather-related phenomena over the short period. Any identifiable geographic area for which a sufficient number of data points are available can be used with these embodiments. A data collection containing n observations of m parameters, where the parameters may be statistically associated, is used in the creative approach.
https://patents.google.com/patent/US7069258B1/en

Applicable Regulations(Government and Environmental)

Restaurant and eatery FSSAI rules

Food should never be handled with bare hands and should always be served with the proper utensils. Food that is kept at room temperature needs to be eaten within 4 hours. Cold food should be kept below 5 degrees Celsius, and hot food should be maintained above 60 degrees Celsius.

Applicable Constraints

- **Data Availability:** The quality and quantity of data that are available for analysis will determine the accuracy and dependability of the revenue prediction model. To train the model, historical visitor counts, sales figures, and weather data will be needed. Data accessibility may also be constrained by difficulties with privacy, laws, or technology.
- **Accuracy:** For use in realistic circumstances, the revenue prediction model must be extremely accurate. If the prediction is inaccurate, the restaurant could suffer large financial losses, and the algorithm might not even be employed at all. To confirm the model's accuracy, real-world data should be used to validate it.
- **Ethical Considerations:** All data collection and analysis must be done in an ethical manner and with the visitors' permission. Concerns over privacy must be addressed, and the restaurant must take action to guarantee that the information is retained safely and is not abused. The restaurant should be able to explain how the forecast was produced, and the model itself should be transparent.
- **Weather Data Availability:** The availability of weather data could also be a problem, particularly for small eateries that might not have access to real-time weather information. In such circumstances, the restaurant might have to rely on past weather data or meteorological information from outside sources.
- **Scalability:** The model must be scalable so that it can manage massive volumes of data and make predictions in real-time. The model should be able to adjust to the shifting environment as the number of visitors rises and deliver precise forecasts in a timely manner.
- **Cost:** The expense of creating and putting the revenue prediction model in place should be affordable and be within the restaurant's spending plan. This may entail locating affordable data sources, utilising free and open-source software, and optimising the model to cut down on computing costs.

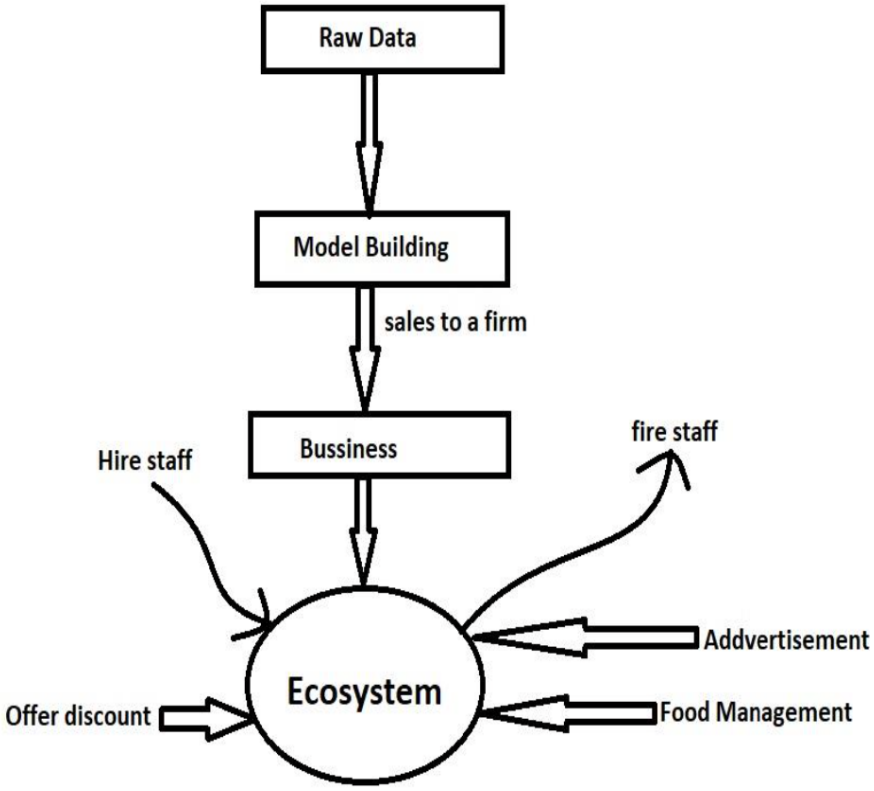
Concept Generation

1. Data gathering: Compile historical information on restaurant sales, local holiday information, meteorological data (temperature, precipitation, etc.), and important sporting events.
2. Pre-processing: Cleanse the data, deals with missing values, and transforms categorical data into numerical data.
3. Feature Engineering: Extract features from the data that have been collected that can be used to forecast restaurant sales. For instance, we

can extract information about the day of the week, the time of day, the weather, and whether a major sporting event or a holiday is taking place.

4. Model Selection: To anticipate restaurant sales, use the best machine learning model. Decision trees, neural networks, and linear regression are a few common models.
5. Model Training: Using the pre-processed data, train the chosen model.
6. Model Evaluation: Assess the Results Using measures like Mean Squared Error (MSE), Root Mean Squared Error (RMSE), and R-squared, the trained model is evaluated.
7. Model Deployment: Apply the learned model to new data to create predictions.

Prototype Development



Product Information:

The initial task is creating the model, after which the business firm receives it. It will make use of it to manage their workforce, meals, offer-making, and advertising efficiently.
Data source: historical information The XGBRegressor algorithm

Feasibility:

Due to its capacity to improve processes, cut costs, and lower human error, machine learning (ML) has established a firm foothold across a variety of industries. The power of AI and ML has already been utilised by several eateries 1. With the help of machine learning, you will be able to forecast sales based on the current weather and previous sales performance, allowing you to make the necessary adjustments. You can refer to prior data and learn about the menu items that did best as well as the current weather conditions by using an ML-powered forecasting tool. It also informs you whether you should anticipate a rise or fall in consumer volume 1. This can assist restaurant managers in improving business operations and making well-informed judgments.

Viability:

The Impact of the Climate-

Forbes' study findings indicate that the weather directly affects how customers feel about their dining experiences. Even with the best cuisine and service, unfavourable weather might still lead to negative ratings.
With the help of machine learning, you will be able to forecast sales based on the current weather and previous sales performance, allowing you to make the necessary adjustments. Let's say that last year, you sold more soup-based items on wet days. You can refer to prior data and learn about the menu items that did best as well as the current weather conditions by using an ML-powered forecasting tool. It also informs you whether a rise or fall in consumer volume is anticipated.

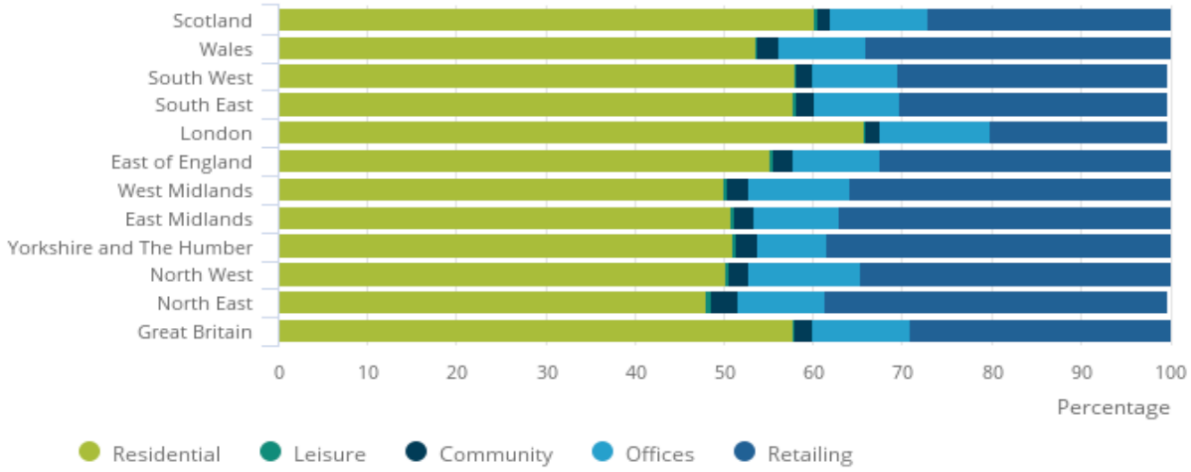
Eliminating Food Waste-

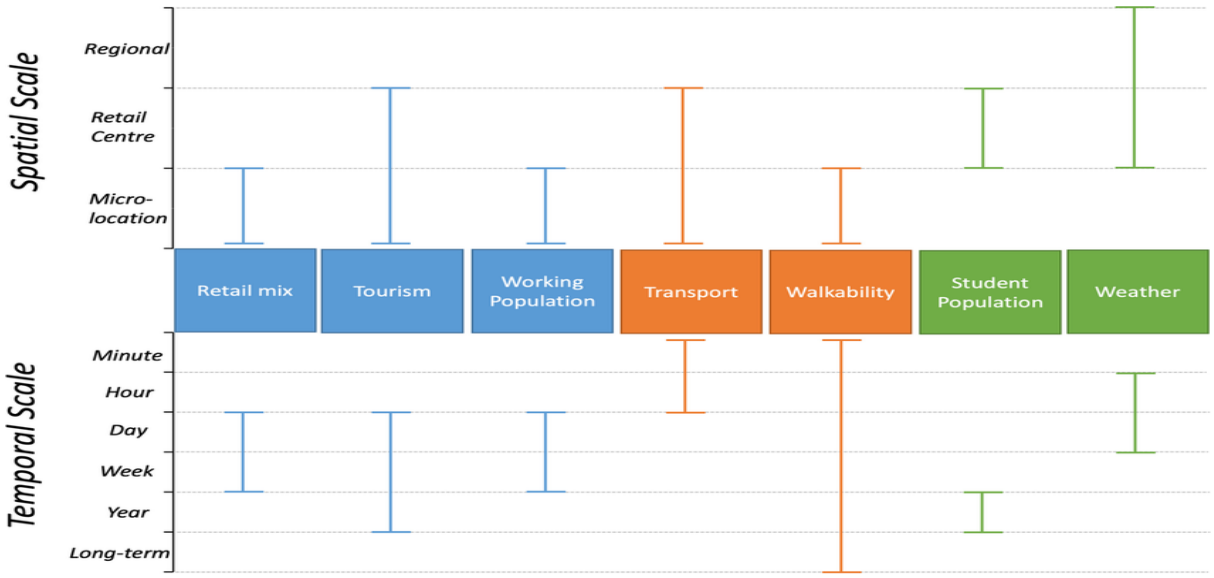
In addition to saving you money, cutting down on food waste at your restaurant helps protect the environment. According to a World Resources Institute study, restaurants can save $7 for every dollar they spend on methods to reduce food waste.
In order to determine how much inventory you need to meet demand, machine learning may combine historical sales data with environmental factors like the weather. Inventory management avoids the possibility of overspending on commodities, which lowers food waste and overhead costs if you can only purchase what you need.

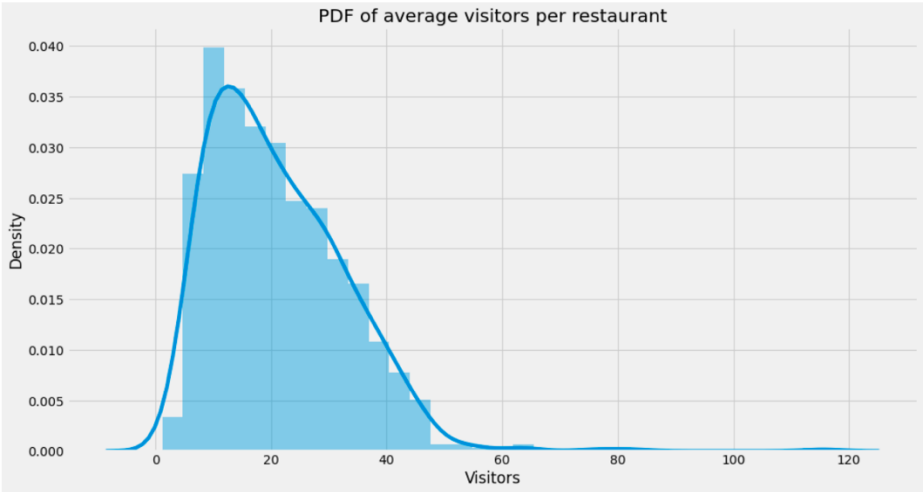
Holidays and Events' Effects-

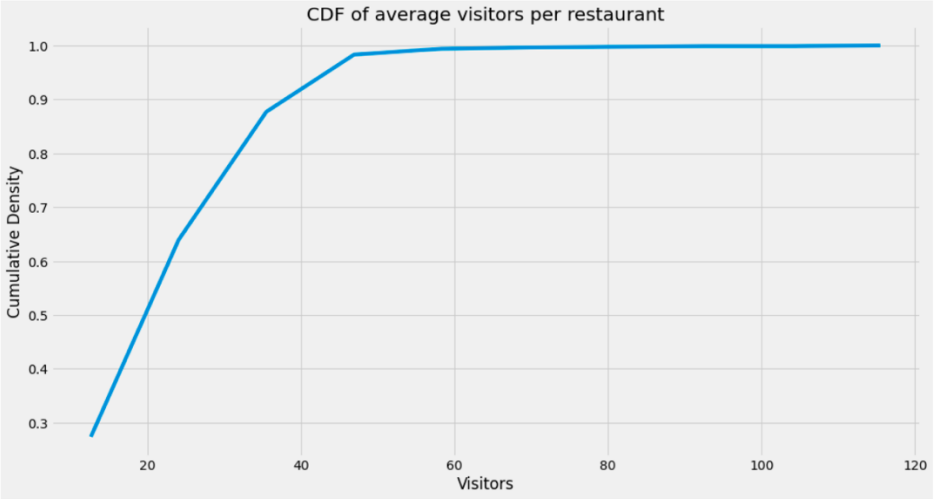
There is a widespread belief that major occasions, such as holidays, increase sales. Sadly, not all restaurants are affected by this problem. According to data compiled by the Houston Chronicle, while many businesses see a spike in sales during particular holidays, some, mostly luxury businesses, face a 60 percent fall in sales.
Utilising AI to predict your sales, inventory, and staffing requirements during seasonal holidays and big events might help you reduce your losses. AI and ML can use your historical sales data to generate precise forecasts about how much food and beverage will be consumed instead of relying on your intuition to make guesses.

Market Overview & Exploratory Data Analysis



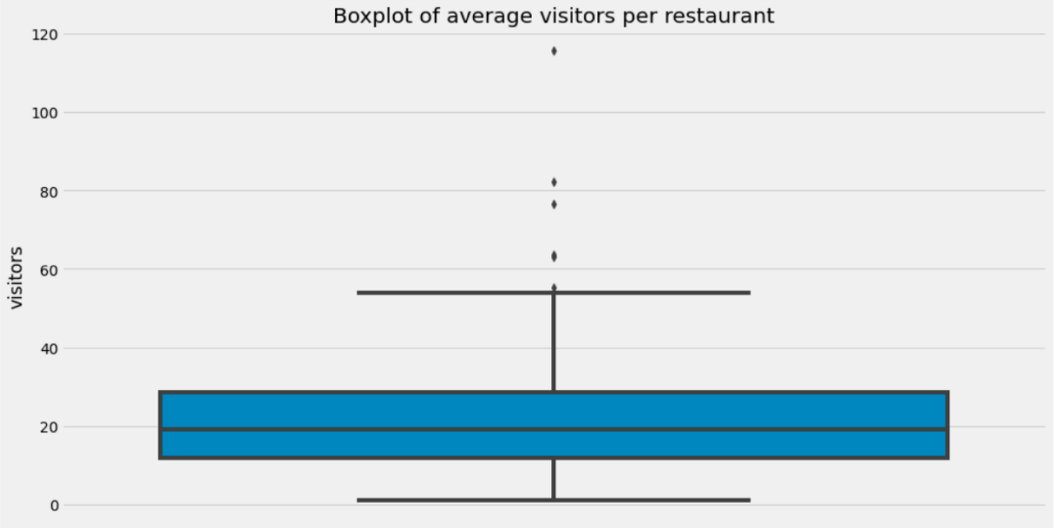

Spatial Scale
Regional
Retail Centre
Micro-location
Retail mix
Tourism
Working Population
Transport
Walkability
Student Population
Weather
Temporal Scale
Minute
Hour
Day
Week
Year
Long-term


PDF of average visitors per restaurant
Density
0.040
0.035
0.030
0.025
0.020
0.015
0.010
0.005
0.000
0
20
40
60
80
100
120
Visitors


CDF of average visitors per restaurant
Cumulative Density
1.0
0.9
0.8
0.7
0.6
0.5
0.4
0.3
20
40
60
80
100
120
Visitors

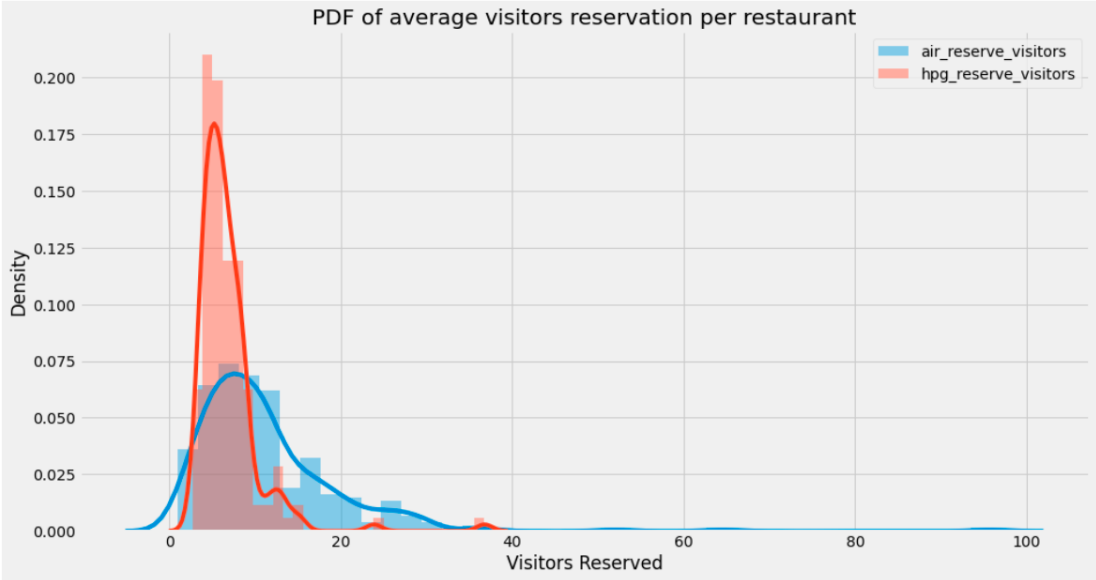
Observations:-

1. As seen in the CDF above, over 99% of restaurants have fewer than 47 (approximate) typical patrons.
2. Less than 40 patrons per day frequent over 90% of the restaurants.
3. It provides an explanation for why Japan has a lot of little eateries.
4. There are very few restaurants with typical guest capacities of above 100.



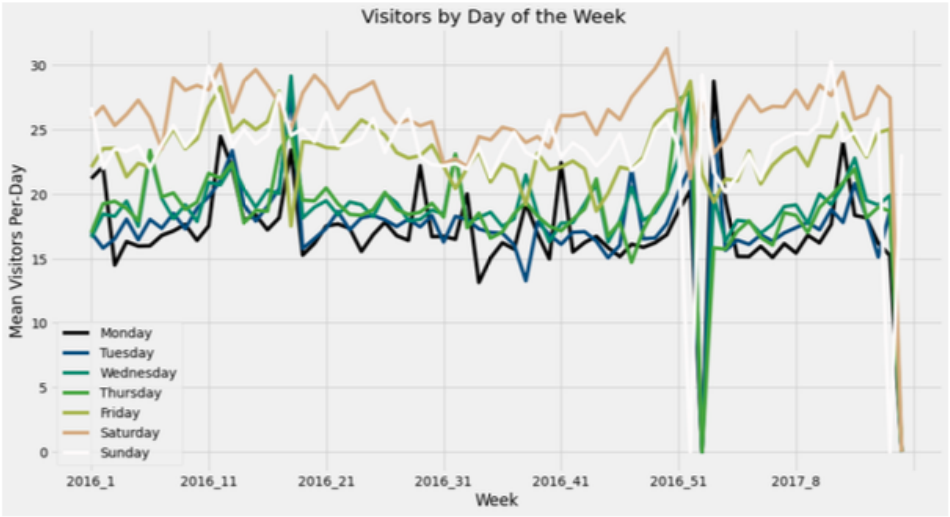
Observations:-

1. The least number of visitors that we can count from this plot is almost nil.
2. The guests' average age is 20 (about).
3. There can be up to 55–60 visitors at a time.
4. We find some incredibly high values (outliers) above 60 and even above 100 visitors.
5. The values in the 25th and 75th percentiles are, respectively, 13 and 30, approximately.



Observations:-

1. A particular finding is that AIR reservations have a wider dispersion than HPG reservations.
2. There are a lot of reservations in HPG with anywhere from 5 to 10 visitors.
3. There aren't many reservations at HPG where there are more than 20 or even 40 guests.
4. The maximum number of visitors allowed to register in AIR is 40, yet there have been more registrations than at HPG.
5. In AIR, the maximum registrations have an approximate visitor count of 8 to 13.
6. The proportion of unregistered visitors to registered visitors is significantly higher.

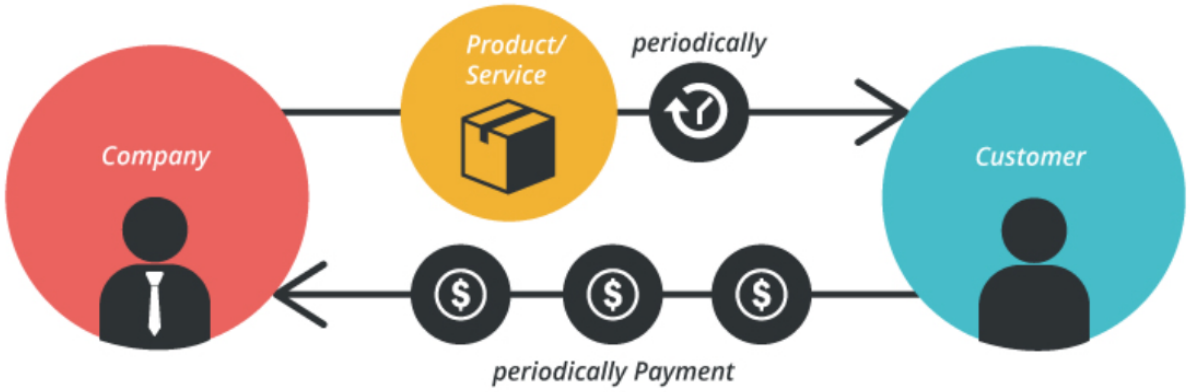


Observations:-

1. Saturday is the day on which most of the people prefer to go out to eat having highest number of visitors along whole year the reason being it is weekend.
2. After Saturday, Even on Sunday there is a peak of visitors.
3. On Monday, least number of people go out to eat.
4. Other week-days have almost similar visitors trend.
5. The sharp decline after 51st week is due to the new year's eve as explained before

Business Model

Customers that use your products or services on a subscription basis pay a weekly, monthly, or annual price. This business model generates recurring revenue. After a specific amount of time, subscribers can renew their subscriptions. With the help of this strategy, we will be able to use our client relationships to generate a consistent flow of revenue. The biggest challenge that can come up is how to turn users into paying customers, or customer conversion.



Financial Model

Restaurant customers' financial modelling may encounter a number of problems or obstacles. Numerous examples include:

1. Informational gaps: Restaurants might not have access to comprehensive data on their customers' demographics, spending habits, and preferences. As a result, developing precise financial models may prove difficult.

2. Seasonal variations: A restaurant's business may significantly alter depending on the time of year, special occasions, or other factors. Because of this, developing models that accurately predict future revenue and expenses may be challenging.
3. Competition: The intense competition that restaurants experience may have an impact on their financial performance. It can be difficult to account for the impact of competition in financial models.
4. Shifting customer preferences: Consumer preferences are subject to swift changes that may have an effect. These changes in financial models might be hard to predict and adjust for.
5. Variations in cost of goods sold (COGS): The availability of ingredients, the season, and other elements can all have a big impact on a restaurant's cost of goods sold. It might be challenging to accurately estimate COGS in financial models.
6. Operational expenses: Depending on the restaurant's size, location, and other factors, running expenses may be high. It can be challenging to predict operating expenses with any degree of accuracy when using financial models.

In order to overcome these problems and barriers, restaurants should gather as much data as they can on their customers, including demographic information, purchasing habits, and preferences. Additionally, they must pay close attention to differences in seasonality, competition, and consumer preferences. They should also routinely review and update their financial models to ensure that they accurately reflect changes in their business and the wider market. Restaurants might consider working with financial specialists who have experience with restaurant financial models to help them overcome these challenges.

Several strategies, such as the following, can be effective in increasing restaurant business:

1. Improve the customer experience: Providing a positive customer experience can help you retain current customers and attract new ones. This can include features like friendly atmosphere, first-rate service, spotless facilities, and a wide selection of cuisine.
2. Offer deals and discounts: Offering deals and discounts, such happy hour specials or coupon codes, can help entice new customers and encourage repeat business.

3. Use social media and digital marketing strategies: Using social media platforms and digital marketing strategies will increase your restaurant's visibility and bring in more customers. Techniques like influencer marketing, email marketing campaigns, and tailored advertising may be used for this.
4. Increase menu options: Offering more options on the menu, such as vegetarian or gluten-free dishes, will help entice more customers.
5. Plan events: Planning unique occasions like live music evenings, wine tastings, or cooking classes will assist you in giving them an unforgettable and one-of-a-kind experience while also bringing in new clients.
6. Work with nearby companies: Working with nearby companies, such as hotels or tourist attractions, can help advertise your restaurant and bring in consumers who might not otherwise visit.
1. Overall, there are a variety of strategies that can be effective in increasing restaurant business. The secret is in knowing your target market's preferences and creating and implementing strategies that will appeal to them and provide an excellent customer experience.

Conclusion

Creating a machine learning (ML) model to predict a restaurant's customer base can have a big impact on the company's bottom line. The number of patrons can be correctly predicted so that restaurant owners may better allocate their resources, change worker schedules, and cut down on waste.
A vital tool for restaurant managers and owners, ML models for predicting customer traffic can offer insightful data and boost the productivity and profitability of the industry.