Forecasting Visitor Traffic with a Machine Learning Approach

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[Github link]

Prototype Selection

I. Abstract

The ability to make accurate forecasts on the number of customers is a pre- requisite for efficient planning and use of resources in various industries. It also contributes to global challenges of society such as food waste. Tourism is a domain particularly focussed on short-term forecasting for which the existing literature suggests that calendar and weather data are the most important sources for accurate prediction. We collected and made available a dataset with visitor counts over ten years from four different businesses representative for the tourism sector in Switzerland, along with nearly a thousand features comprising weather, calendar, event and lag information.

The leisure industry caters to millions of visitors every day, and each one of them arrives with their own set of expectations. Meeting those expectations is the key to getting people to return and, increasingly, leisure operators are turning to advanced analytics solutions for clues about how to keep their customers happy.

II. Problem Statement

Help leisure Industry such as Restaurants to predict visitor numbers accurately, and evaluate how these might be affected by weather, major sporting and public events, or other external factors. A better understanding of visitor numbers throughout the year can also be used for marketing purposes by targeting offers and promotions for the times they are needed most to boost numbers.

III. Market/Customer/Business Need Assessment

To increase revenue of a restaurant by predicting visitor count here are some steps to conduct a market, customer, and business needs assessment:

1. MarketAssessment:
    - Analyze historical data to understand trends in visitor count, including seasonal patterns and peak times of day/week.
    - Research local events, festivals, and holidays that may impact visitor traffic to your restaurant.
    - Gather data on local competitors and their customer traffic patterns to identify opportunities to capture more visitors.
2. Customer Assessment:
    - Use historical data and customer feedback to develop customer personas, which can help you better understand your customers' needs and preferences.
    - Develop a survey or feedback mechanism to collect data on how weather affects customer behavior, such as willingness to dine outdoors, menu choices, or timing of visits.
    - Use social media and other online platforms to gather real- time data on customer feedback and preferences related to weather conditions.
3. Business Assessment:
    - Use historical data and weather forecasts to create a predictive model for visitor traffic to your restaurant.
    - Analyze your restaurant's capacity and staffing need to ensure that you can meet increased demand during peak periods.
    - Develop a marketing plan to promote your restaurant during periods of favorable weather and leverage weather data to make data-driven decisions about staffing, menu offerings, and promotions.

IV. Target Specifications and Characterization

To increase revenue of a restaurant by predicting visitor count and the effect of weather, it's important to develop a target specification that outlines your goals and the strategies you will use to achieve them.

1. Revenue Goals: Specify your revenue goals and the time frame for achieving them. For example, you may want to increase revenue by 10% in the next six months.
2. Visitor Count Goals: Specify your visitor count goals and the time frame for achieving them. For example, you may want to increase visitor count by 20% during the summer season.

3. Weather Metrics: Specify the weather metrics that will impact your restaurant's visitor count, such as temperature, precipitation, and wind. Identify the thresholds for these metrics that will trigger changes in your restaurant's operations, such as offering outdoor seating or adjusting the menu.
4. Marketing Strategies: Identify the marketing strategies that will help you achieve your revenue and visitor count goals, such as targeted advertising, social media promotions, or email marketing campaigns. Specify the budget and resources needed to implement these strategies.
5. Operations Strategies :Identify The Operations Strategies That Will Help You meet increased demand during peak periods, such as optimizing staffing levels, adjusting menu offerings, or expanding seating capacity. Specify the budget and resources needed to implement these strategies.
6. Data and Analytics: Specify the data and analytics tools you will use to measure progress towards your goals and make data-driven decisions about your marketing and operations strategies.

V. 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

VI. Benchmarking

In the market already many services are available such as eat app which forecast Restaurant sales but by their own way of calculating sales forecast. Generally, what it does is that it integrates POS with table management system like Eat App.

VII. Applicable Patents

Weather prediction method for forecasting selected events

The invention provides methods, systems, and computer program products for short term probability forecasting of selected weather- related events. These embodiments are adaptable for any geographical region that can be identified and for which a reasonable number of data points exist. The inventive method uses a data set of n observations of m parameters, where the parameters may be statistically correlated. https://patents.google.com/patent/US7069258B1/en

VIII. Applicable Regulations(Government and Environmental)

FSSAI guidelines for Restaurants & Eateries

Food should be served with the appropriate equipment, and touching food with bare hands should be avoided. If food is maintained at room temperature, it should be consumed within 4 hours. Hot food that is served should be stored above 60-degree Celsius, and cold food should be kept below 5 degrees Celsius.

IX. Applicable Constraints

- Data Availability: The accuracy and reliability of the revenue prediction model will depend on the quality and quantity of data available for analysis. Historical data on visitor count, revenue, and weather conditions will be required to train the model. The availability of data may also be limited by privacy concerns, legal regulations, or technical issues.
- Accuracy: The revenue prediction model needs to be highly accurate to be useful in practical scenarios. Any errors in the prediction can lead to significant financial losses for the restaurant, and a lack of accuracy may lead to the model not being used at all. The model should be validated using real-world data to ensure its accuracy.
- Scalability: The model should be able to scale up to handle large amounts of data and perform predictions in real-time. As the number of visitors increases, the model should be able to adapt to the changing environment and provide accurate predictions in a timely manner.
- Cost: The cost of developing and implementing the revenue prediction model should be reasonable and within the budget of the restaurant. This may involve finding cost-effective data sources, using open-source tools and platforms, and optimizing the model to reduce computational expenses.

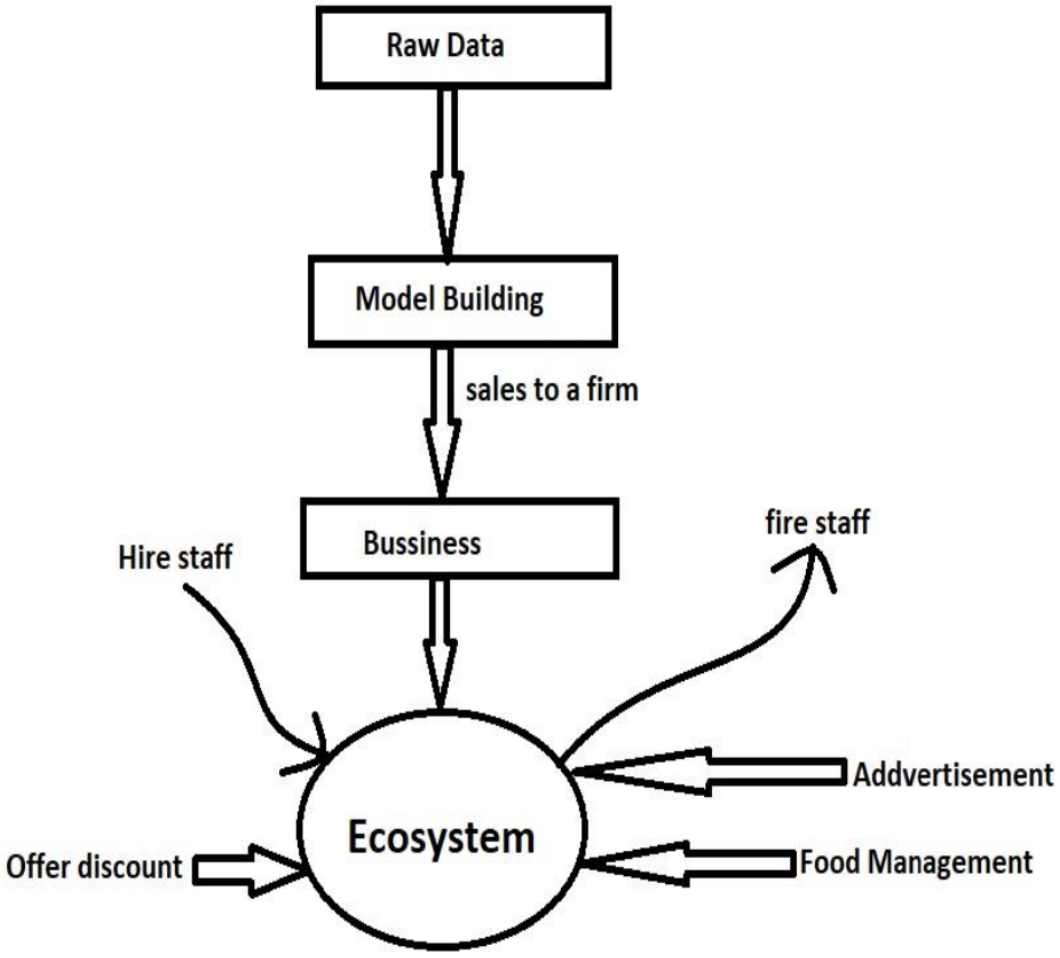
- Ethical Considerations: Any data collected and analysed should be done so ethically, and with the consent of the visitors. Privacy concerns must be addressed, and the restaurant should take steps to ensure that the data is stored securely and not misused. Additionally, the model should be transparent, and the restaurant should be able to explain how the prediction is made.
- Weather Data Availability: The availability of weather data may also be a constraint, especially for small-scale restaurants that may not have access to real-time weather data. In such cases, the restaurant may need to rely on historical weather data or third-party sources for the weather data.

X. Concept Generation

1. Data Collection:Collect historical data on restaurant sales,weather conditions (temperature, precipitation, etc.), holiday information, and major sporting events in the area.
2. Data Pre-processing: Clean the data, handle missing values, and convert categorical data into numerical data.
3. Feature Engineering:Extract features From Collected data that can help predict restaurant sales. For example, we can extract features such as day of the week, time of the day, weather conditions, and whether it is a holiday or a major sporting event.
4. Model Selection: Select an appropriate machine learning model for predicting restaurant sales. Some popular models include linear regression, decision trees, and neural networks.
5. Model Training: Train the selected model using the pre-processed data.
6. Model Evaluation:Evaluate The Performance The trained model using metrics such as Mean Squared Error (MSE), Root Mean Squared Error (RMSE), and R-squared.
7. Model Deployment: Deploy the trained model to make predictions on new data.

Prototype Development

Final Product Prototype



I. Product Details

Model building is the first work and then the model is given to the business firm.

It will use it to effectively manage their staff, food management, offer making, and advertisement.

Data Source: From the past data Algorithm: XGBRegressor

II. Feasibility

Machine learning (ML) has gained a strong foothold across different industries due to its ability to streamline operations, save costs, and reduce human error. Many restaurants have already leveraged the power of AI and ML 1. With machine learning, you'll be able to predict sales based on the weather conditions and past sales performance, allowing you to adjust accordingly. An ML-powered forecasting platform can point you to previous data and inform you of the menu items that sold more, along with the weather conditions at the time. It also tells you if you can expect a surge or decline in customers 1. This can help restaurant managers make informed decisions and improve their business operations.

III. Viability

The Effect of the Weather

According to research data obtained by Forbes, the weather has a direct impact on the customer's perception of the restaurant experience. No matter how impeccable your food and service are, inclement weather can still result in bad reviews.

With machine learning, you'll be able to predict sales based on the weather conditions and past sales performance, allowing you to adjust accordingly. Say you sold more soup-based dishes on rainy days last year. An ML-powered forecasting platform can point you to previous data and inform you of the menu items that sold more, along with the weather conditions at the time. It also tells you if you can expect a surge or decline in customers. This way, managers will have the information to schedule the staff that can accommodate the projected number of customers per shift.

Reducing Food Waste

Reducing food waste in your restaurant doesn't only save you money; it helps in preserving the environment, too. A study conducted by the World Resources Institute found that for each dollar a restaurant invests in food waste reduction solutions, they save $7.

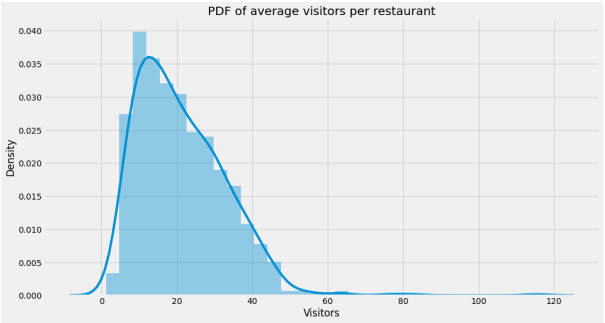
Machine learning can reconcile past sales data and weather conditions to calculate how much inventory you need to meet consumer demand. If you're able only to buy what you need, inventory management eliminates the risk of overspending on goods, thereby reducing food waste and overhead costs.

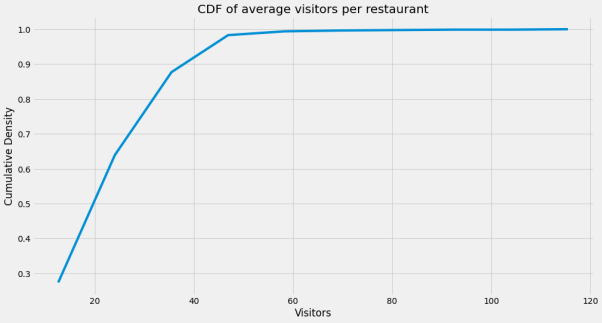
The Impact of Holidays and Events

There’s a massive misconception that holidays and significant events result in a spike in profits. Unfortunately, this phenomenon doesn’t apply to every restaurant. While many experience a surge in sales during certain holidays, there are some, primarily upscale establishments, that see a decline in revenue by up to 60 percent as per data curated by the Houston Chronicle.

You can mitigate your losses by relying on AI to project your sales, inventory, and staffing needs during seasonal holidays and significant events. Instead of relying on your gut to make assumptions, AI and ML can pull from your past sales data and yield accurate predictions as to how much food and beverage and the number of staffing you’ll need to accommodate demand.

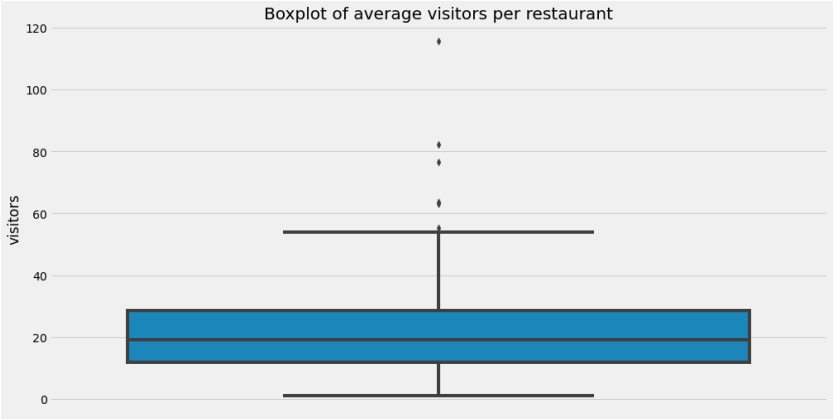
IV. Market Overview & Exploratory Data Analysis





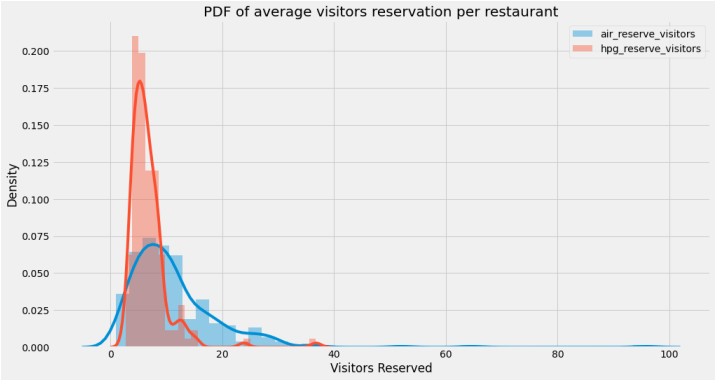
Observations:-

1. In the above CDF, we can observe that almost 99% restaurants have less than 47 (approx) average visitors.
2. Almost 90% of the restaurants have less than 40 visitors/day.
3. It explains the fact that there a large number number of small restaurants in Japan.
4. There is negligible number restaurants which have average visitors capacity more than 100.



Observations:-

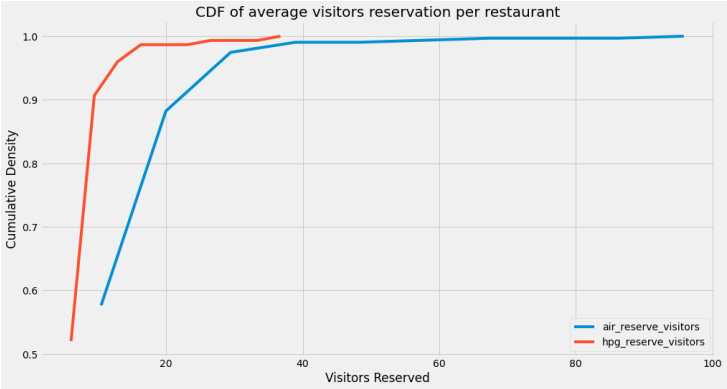
1. The minimum of visitors that we can observe from this plot is almost reaching zero.
2. The mean of the visitors is 20(approx).
3. The maximum number of visitors is between 55-60.
4. We observe certain very high values (outlier) greater than 60 and and even greater than 100 visitors.
5. 25th percentile and 75th percentile values are 13(approx) and 30(approx) respectively.



Observations:

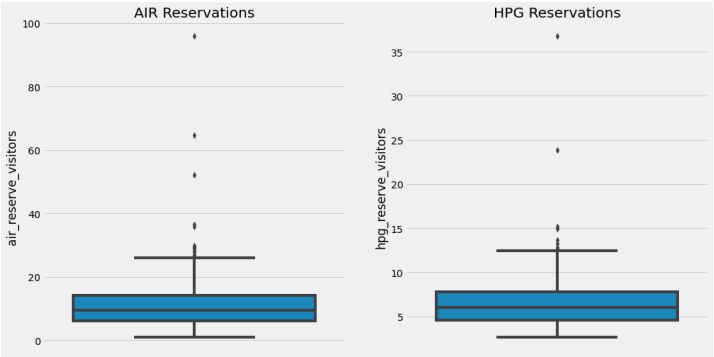
1. The spread of AIR reservations is higher than that of HPG reservations.
2. There is a large number of reservations in HPG with visitors count between 5 to 10.
3. There are few reservations in HPG where the visitors count is more than 20 or even reaching 40.

4. Even in AIR, the maximum number of visitors registered is 40, but the number of registrations are more than that of HPG.
5. In AIR, maximum number of registrations have visitores count between 8 to 13 (approx).
6. The number of unregistered visitors is far more than the number of registered visitors.



Observations:-

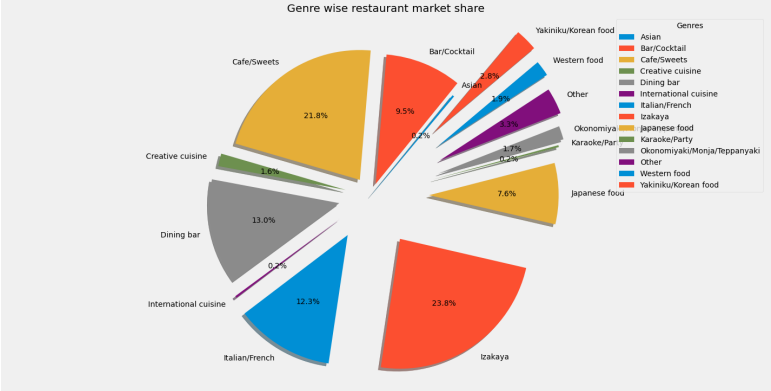
1. form the above CDF,In AIR, almost 99% of per restaurant reservation is less than 40.
2. In AIR, negligible number of reservations are greater than 60.
3. In HPG, almost all reservations count is less than 40.
4. In HPG, approx 99% of the reservations count are less than 20.
5. In HPG, almost 90% of reservations are less han or equal to 10.



Observations:-

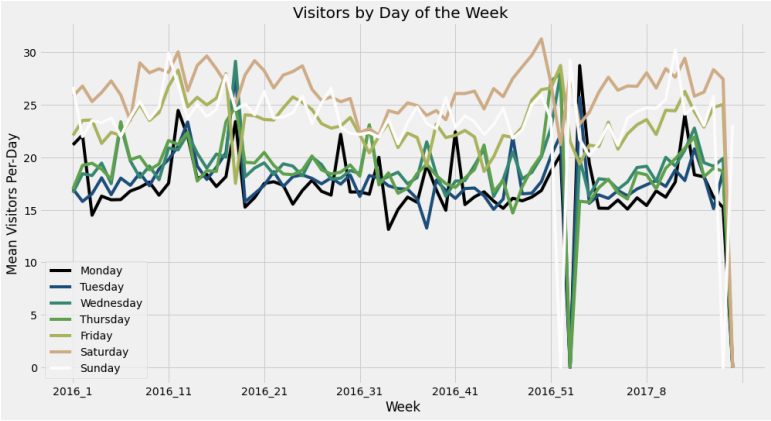
1. from the above boxplots, we can observe that average reservation count is not more than 10.
2. In AIR, average reservation count is 10(approx) and in HPG average reservation count is 6(approx).
3. 25th and 75th percentile reservation count in AIR is 7 and 15 respectively.

4. 25th and 75th percentile reservation count in HPG is 4 and 8 respectively.
5. In AIR,there are certain high values (outliers) we see in the range 40 to 100.
6. In HPG,there are certain high values (outliers) we see in the range 13 to 40.



Observations:-

1. The restaurants in Japan is subdivided in 14 food genres.
2. **Izakaya** is the most popular genre in Japan as almost **23.8%** of restaurants are of **Izakaya** genre.
3. The second most popular genre in Japan is **Cafe/Sweets** having almost **21.8%** restaurant market share.
4. **International cuisine**,**Asian** and **Karaoke/Party** are the least preferred genre having only **0.2%** each market share.
5. Even western and korian food are not popular in japan at all.
6. To start a restaurant business in Japan, choosing foode genre will be the most important decision.



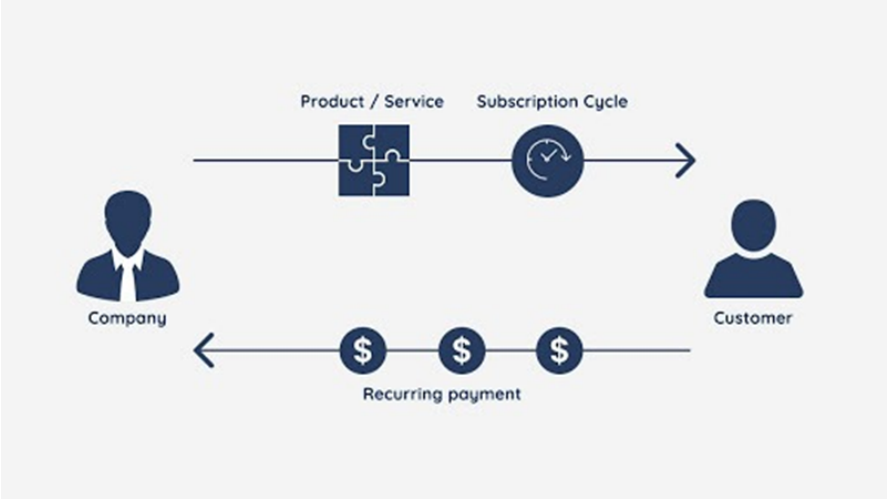
Observations:-

1. Saturday is the day on which most of the people prefere 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

Github link

Business Modeling

A subscription business model is a recurring revenue model in which customers pay a weekly, monthly, or yearly fee in exchange for your products or services. Customers can renew their subscriptions after a certain period of time. This model will allow us to leverage our customer relationships to create a steady stream of income. The main issue that can arise is that of customer conversion, meaning how to convert users into paid users.



Financial Modeling

Financial modeling for restaurant patrons may run into a number of issues or roadblocks. Many instances include:

1. Lack of information: Restaurants might not have access to detailed information on their patrons, such as their demographics, purchasing patterns, and preferences. Building precise financial models may become challenging as a result.
2. Seasonal variations: Depending on the season, holidays, or other events, restaurants may see major changes in their business. Building models that effectively forecast future revenue and expenses may be difficult as a result.
3. Competition: The fierce rivalry faced by restaurants might have an effect on their bottom line. Including the effect of competition in financial models can be challenging.
4. Shifting customer preferences: Rapid changes in consumer preferences can have an impact on Consumer preferences can change quickly. It can be difficult to foresee and take into account these changes in financial models.
5. Cost of goods sold (COGS) variations: Season, ingredient availability, and other factors can all have a significant impact on a restaurant's cost of goods sold. In financial modelling, estimating COGS with accuracy can be difficult.
6. Operational costs: Depending on the size, location, and other aspects of the restaurant, operating costs can be substantial. Financial modelling can make it difficult to anticipate operating expenses with any degree of accuracy.

Restaurants should collect as much information as they can about their patrons, such as demographic data, spending patterns, and preferences, in order to address these issues and barriers. They should also pay special attention to changes in consumer preferences, competition, and seasonal variations. To make sure that their financial models appropriately represent changes in their business and the larger market, they should also periodically examine and update them. Finally, to help them overcome these obstacles, restaurants should think about engaging with financial experts with experience in restaurant financial modelling.

There are a number of tactics that can be successful in boosting restaurant patronage, including:
1. Enhance the customer experience: Giving customers a great experience will help you draw in new business and keep your current ones. This can involve elements like welcoming surroundings, excellent service, spotless facilities, and a varied food.
2. Provide discounts and promotions: Providing discounts and promotions, such as happy hour specials or coupon codes, can help draw in new clients and promote repeat business.

3. Make use of social media and digital marketing: Utilizing social media websites and digital marketing techniques will help your restaurant gain more visibility and draw in more consumers. This can involve strategies like influencer marketing, email marketing campaigns, and customised advertising.
4. Increase menu alternatives: A bigger selection of menu choices, such as vegetarian or gluten-free meals, will assist draw in a wider clientele.
5. Organize events: Organizing special occasions like live music nights, wine tastings, or cooking courses can help you provide clients a one-of-a-kind and unforgettable experience while also drawing in new customers.
6. Collaborate with neighbourhood businesses: Collaborating with neighbourhood businesses, including hotels or tourist destinations, can help promote your restaurant and draw customers who might not otherwise come.
Overall, there are a wide range of approaches that can be successful in boosting restaurant patronage. Understanding your target market's tastes and developing and putting into action methods that will appeal to them and offer a top-notch customer experience are the key.

Conclusion

Developing an ML model to predict the number of visitors to a restaurant can have a significant impact on the business. By accurately forecasting the number of customers, restaurant owners can better plan their resources, adjust staff schedules, and reduce waste.
ML model for predicting restaurant visitors can provide valuable insights and improve the efficiency and profitability of the business, making it a valuable tool for restaurant owners and managers.