Journal of Data Applications
Issue: 2, 2023
E-ISSN: 2980-3357

İSTANBUL UNIVERSITY PRESS

RESEARCH ARTICLE

Forecasting Restaurant Sales with the Sensitivity of Weather Conditions and Special Days Using Facebook Prophet

Ali Kerem GÜLER[1], Ali MUSA[1], Mustafa TARIM[1], Osman SARAÇ[1], Mehmet GÖKTÜRK[2]

ABSTRACT

This article focuses on forecasting sales for restaurant businesses using the Prophet model developed by Facebook. A method is proposed to make more accurate forecasts by accounting for the effects external factors have on sales, including weather conditions and special days. The analyses conducted on the real-time sales data of the daily operations of a restaurant business (provided by PROTEL Inc.) reveal that the Prophet model can forecast the sales of different products based on daily sales and weather data. The prediction performance of the model was evaluated using four error metrics: Mean Absolute Error, Mean Absolute Percentage Error, Mean Squared Error, and Root Mean Square Error. The results revealed that the model produced more consistent and accurate predictions for some product categories. This study, which aims to contribute to the literature through an optimization of operational efficiency and decision-making processes related to the restaurant industry, highlights the importance of external factors in sales forecasting in the restaurant industry and provides a detailed analysis of incorporating these factors into the forecasting process. The findings may support restaurant businesses in obtaining more accurate sales forecasts by taking external factors into account. In particular, understanding the effects of weather changes and special days on sales can contribute significantly to operational decisions in such areas as personnel planning and inventory management. In this regard, the article proposes innovative approaches to the challenges faced by restaurant operations, presenting different approaches found in the literature and a detailed model evaluation process.

Keywords: Machine Learning, Time Series Forecasting, Facebook Prophet

DOI: 10.26650/JODA.1450459

[1]PROTEL A.Ş., Department of Software, İstanbul, Türkiye Turkiye
[2]Gebze Technical University, Department of Computer Engineering, Kocaeli, Türkiye

ORCID: A.K.G. 0000-0003-3405-005X;
A.M. 0009-0000-5829-5698;
M.T. 0000-0001-7079-5062;
O.S. 0000-0002-4870-9823;
M.G. 0000-0002-8030-8923

Corresponding author:
Ali Kerem GÜLER,
PROTEL A.Ş., Department of Software, İstanbul, Türkiye
E-mail: aguler@protel.com.tr

Submitted: 11.03.2024
Revision Requested: 28.03.2024
Last Revision Received: 28.03.2024
Accepted: 03.04.2024
Published Online: 24.06.2024

Citation: Güler, A. K., Musa, A., Tarım, M., Saraç, O., & Göktürk, M. (2023). Forecasting restaurant sales with the sensitivity of weather conditions and special days using facebook prophet. *Journal of Data Applications, 2*, 15-30. https://doi.org/10.26650/JODA.1450459

Introduction

Sales forecasting is the process of predicting future sales of businesses and is essential for planning business strategies and an effective use of resources. Accurate and effective sales forecasting is critical in a competitive business environment. Accurate sales forecasts impact many aspects of restaurant business operations, such as inventory management, supply chain optimization, financial planning, and customer satisfaction. A proper implementation of this procedure allows businesses to prevent stock overages and supply shortages, reduce costs, and obtain a competitive edge.

Traditional sales forecasting methods forecast future sales by taking into account various factors, such as historical sales data and seasonal patterns. In the restaurant industry, understanding and predicting the impact of external factors (such as weather changes and special occasions) on sales can directly impact the profitability of a business and improve customer satisfaction. Today, developments in artificial intelligence and big data analytics have greatly improved the sales forecasting process. Artificial intelligence-based methods can process more complex data sets and provide more accurate predictions.

Facebook's Prophet algorithm is employed in this study to forecast restaurant sales. Prophet (Taylor & Letham, 2018) is unique in that it may detect intricate patterns in time series data and has a flexible architecture. By addressing the sensitivity of external factors on sales forecasts, the research focuses on particular challenges encountered by the restaurant industry and seeks to optimize inventory management and business strategies. Additionally, the present research analyzes the effects that weather and special occasions have on sales, integrating these factors into sales forecasts.

The impact of sales forecasting appears across multiple domains, including inventory optimization, supply chain management, and satisfying customer needs. The restaurant industry has a complex structure which is marked by customer preferences changing overnight and numerous external influences. This study predicts future restaurant sales by incorporating such external factors. Thus, such an analysis enables restaurants to optimize their sales volumes and also the orders of necessary ingredients based on reliable forecasts. This approach allows restaurants to increase operational efficiency while reducing food waste and lowering costs.

The article is structured as follows: The Literature Review section covers relevant studies that have approached the topic from various angles. The Methodology section introduces the dataset, then explains the data processing and modeling techniques used. The Results and Discussion section presents the findings and their outcomes. The Future Work and Recommendations section provides information on potential subjects for further study. The article concludes with the Conclusion section.

Literature Review

Sales Forcasting

In their research, Patricia Ramos et al. (2015) focused on predicting coming sales, which is one of the most important factors of effective business operations. Accurate forecasting of demands is important for retail businesses in terms of production, purchasing, logistics, and workforce organization. The study also included time series of retail sales, which are a type of time series that is characterized by trending and seasonal patterns and presents several challenges in terms of implementing efficient forecasting models. In order to forecast consumer retail sales, the study analyzes the accuracy of state space and ARIMA models. Both single step and multistep forecasts were conducted, with the performance of the forecasts being illustrated by a case study of retail sales in five distinct groups of women's footwear (Boots, Ankle-length boots, Flats, Sandals, and Shoes). The prediction performances of the state space and ARIMA models were measured based on the MAE, MAPE, and RMSE metrics in both single step and multistep predictions. These analyses revealed that the error scores of both models were quite near to one another.

Sébastien Thomassey (2010) conducted a comprehensive analysis while detailed success in the textile-clothing industry, where consumer demands are constantly increasing. The study emphasizes the importance of complex information systems and logistics capabilities based on forecasting systems. Thomassey noted some of the unique challenges of the textile-clothing market, such as variable demand, strong seasonality, a large number of short-lived products, and a lack of historical data. The author provides information that, against these challenges, companies often develop simple but robust forecasting mechanisms. After evaluating current practices in the clothing industry, is the study proposed the use of different forecasting models that provide more accurate and reliable sales forecasts. Such models are built around different and innovative approaches, such as fuzzy logic, neural networks, and data mining techniques, which focus on the specific challenges faced by companies in the sector.

A study by Arunraj and Ahrens (2015) focused on providing an innovative approach to the daily sales forecasting problems encountered in the food retail industry. It is emphasized that food waste and stock outages in this sector are caused by incorrect sales forecasting and, as a result, ordering the wrong product. Time series sales data in the food retail sector can exhibit high variability and skewness. For this reason, it has been mentioned that interval forecasts should be made for retail companies to determine appropriate stock policies. This study demonstrates the effectiveness of a hybrid model called SARIMA-QR, produced by combining SARIMA and Quantile regression, for the difficulties encountered in daily sales forecasting in the industry. Using daily sales data of banana products from a German discount

retail store, the authors developed a model to forecast future banana sales. Considering the variable sales dynamics and various factors affecting demand, the new model offers the potential to obtain more accurate and comprehensive forecasts.

It has been stated that the Bayesian model developed by Posch et al. (2022) for food and beverage sales forecasting in restaurants and cafeterias is more efficient than the existing methods of ARIMA, Seasonal ARIMA, and Exponential Smoothing. In other words, it provides a high accuracy rate and a low margin of error. It has been stated that the results obtained from sales forecasts contribute to reducing food waste and optimizing stock management. is the study pointed out that the model which they used has the ability to efficiently integrate different external factors and seasonal changes as a powerful forecasting tool in the restaurant industry.

Using Machine Learning for Sales Forecasting

A deep learning approach was used to predict the following season's product sales in the retail fashion industry in a study which compared traditional machine learning and deep learning models (Loureiro et al., 2018). Their models were constructed using real data which considered a variety of characteristics, including product physical characteristics and expert recommendations. The researchers revealed that deep learning techniques, as well as more traditional machine learning techniques, can be effective in this area. The study also serves as a reference for comparing deep and traditional machine learning techniques in retail sales forecasting.

Machine learning models were discussed in a study conducted by Tsoumakas (2019) with the aim of predicting the future sales rates of different businesses operating in the food industry (supermarkets, restaurants, and bakeries). The study emphasized that the model obtained from short-term sales forecasts can enable businesses to minimize both their stocks and expired products. In addition, the study also discussed important design processes, such as the temporal granularity of sales data, the input factors to be used in forecasting, and the representation of the output variable. Machine learning approaches used in sales forecasting and appropriate measurement metrics to evaluate the performance of these algorithms have also been included in detail.

Another important study was conducted by Shilong et al. (2021). In this research, which examines the role of the success of sales forecasts for large retail chains on the development, success, and failure of businesses, a sales forecasting model was put forward that allows companies to manage their resources more effectively and produce effective business plans. The basis of this model is to extract features from historical sales data through feature engineering and predict subsequent sales volumes using the Extreme Gradient Boosting (XGBoost) model. The model was shown to work well in terms of cost through experimentation conducted on Walmart retail products.

Using Facebook Prophet for Sales Forecasting

Prophet's model, based on time series decomposition, was applied to six different financial time series datasets with different input parameters in Yusof et al.'s (2020) study. The implemented datasets cover a variety of markets, such as the Hong Kong Hang Seng 300 Index (HS300), the Standard & Poor's 500 (SP500), and the Tokyo Nihon Keizai Shinbun Index (Nikkei). The study presents a new approach to the development of financial forecasting models. It argues that the Prophet model has the potential to effectively model the movements of financial markets with appropriate parameter settings and an average absolute percentage error of six percent.

A study conducted by Zunic et al. (2020) presented a comprehensive framework for using Facebook's Prophet algorithm for sales forecasting in the retail industry. Accordingly, the study purports that the Prophet model has the capacity to manage the effects of seasonality, as well as its effectiveness in monthly and quarterly sales forecasts. In addition, the research highlighted the importance of back testing for measuring forecast reliability and classifying product portfolios. It is emphasized that Prophet can be used effectively in retail forecasting By showing how Prophet can be applied to various product categories with different lengths of historical data, there is an emphasis on the effective use of the algorithm for retail forecasting.

A study conducted by Jha and Pande (2021) recommended using a time series sales rate forecasting model in supermarkets, which contains useful information about time that assists in statistical analyses. The researchers claimed that the model would also increase sales rates. The study reveals the usefulness of the Prophet model for supermarket data, suggesting a low prediction accuracy of this tool at 8.3, based on the MAPE result and other metrics. Additionally, the ARIMA, Holt-Winter, and Prophet models were compared using the same error metrics, concluding that the Prophet model performed better. Thus, the study indicates the benefits of using the Prophet model as a time series forecasting model for supermarket sales forecasting.

Methodology

Dataset

The data sets used in sales forecasting in this study were provided by PROTEL Inc. and include daily sales data of a business on a product basis. These data sets contain sales amounts of different products of businesses and historical information of sales. The data sets used in this study were collected on a daily basis through the Point of Sale (POS) system of PROTEL Inc. company and stored in a time series format. The collected data sets were prepared as .csv files in order to perform analytical processes and modeling.

Since data sets keep real-time sales data gathered from daily workflows of businesses, they present the sales trends of products, seasonal changes, and the impact of other time-related factors on sales in detail. Because these data sets are in a format suitable for time series operations, they have been a useful resource in developing and testing time series models for sales forecasting. Analyzing data sets in detail is very important in making sense of the sales performance of businesses and predicting future sales trends.

In this study, the weather data required for the model to produce precise predictions were obtained from the OpenWeatherMap platform. OpenWeatherMap (OpenWeatherMap, 2024) is an open-source platform that provides weather data via API. During the time period covered by the study, weather data were taken and recorded twice every day, at regular intervals between 9 am and 9 pm. This systematic approach enabled the holistic collection of all weather information required for the model since the inception date of the sales forecast data. The OpenWeatherMap platform contains a wide range of data, including important meteorological measurements, such as temperature, humidity, pressure, wind speed, and cloud information. This data helps the forecasting model better understand the impact of certain weather conditions on sales and make its forecasts more precisely.

This study covers detailed analysis of data sets and modeling processes to help businesses make their sales forecasts more consistent, improve their inventory management, optimize their operational planning, and create marketing strategies more effectively. Thanks to the regularly collected data, the forecast model has the capacity to produce more precise and reliable forecasts by efficiently analyzing daily sales dynamics.

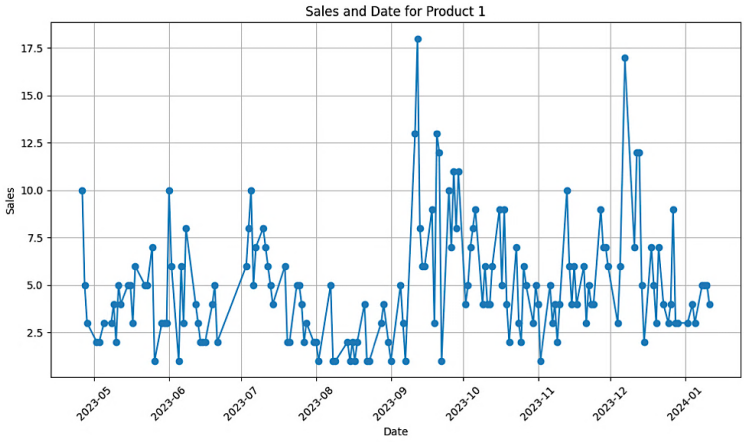

Figure 1. *Graph of historical sales for product 1.*

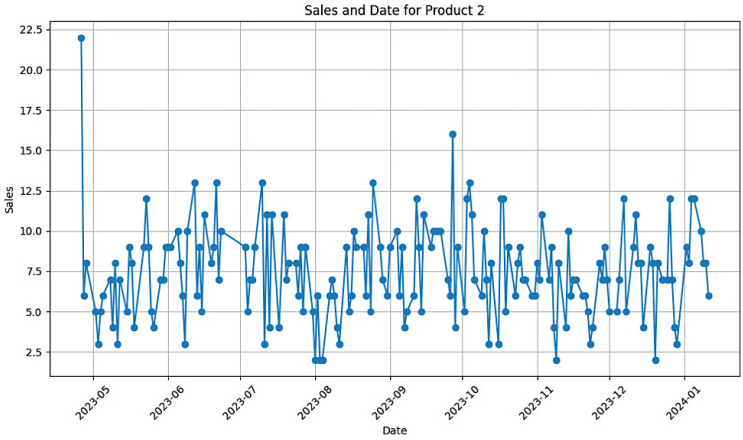

Figure 2. *Graph of historical sales for product 2.*

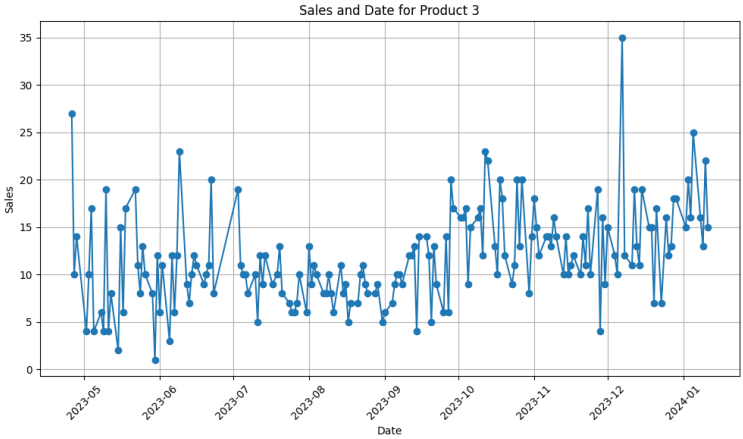

Figure 3. *Graph of historical sales for product 3.*

Eight months' worth of sales data for three different goods of a restaurant business are visualized in Figure 1, Figure 2, and Figure 3. The time series analysis conducted on the sales of each product has been observed within the framework of fundamental concepts such as trend, seasonality, cyclicality, and volatility. These concepts play a crucial role in enhancing the understanding of sales dynamics, thereby contributing significantly to the prediction of future sales. The initial examinations of the graphs indicate the challenges of identifying a clear and direct trend. However, the increases or decreases in sales volumes at certain intervals can be interpreted as potential signs of seasonality. Additionally, the fluctuations in sales data over time point to the influence of external factors. These fluctuations could stem from such environmental changes as economic, social, or weather conditions.

An analysis of the data forms the basis of the sales forecasting model and determines the data patterns that the model needs in order to learn. Additionally, such an analysis is crucial in terms of evaluating the performance of the model and implementing the necessary adjustments to forecast future sales. This holistic approach contributes to the continuous development of the model and will provide more concrete benefits to businesses.

Data Processing

For an accurate and efficient analysis of the time series data of the product sales of businesses, a data processing method, such as that used in this study, is crucial. The process begins by identifying missing data, before filling these gaps. The first area of focus relates to whether the weather data has been integrated into sales data. The weather data is divided into two different time periods of the day: morning and evening. This data includes various features, such as date, temperature, felt temperature, pressure, humidity, wind speed, cloud information, sunrise, and sunset.

A special function has been developed to detect and complete missing data points in case there is a break in the weather data for any reason. This function detects missing weather records for 9 am and 9 pm by using the date and time information in the data set. For each missing data point, an index number is kept along with the date and time information of the relevant record. This approach enabled the locations of missing data points in the data set to be found accurately and easily. Then, the detected missing data points were filled with the values of the weather records from the same time period of the previous day. When consecutive missing data points were detected, this was specifically handled by the function and the missing data were filled by taking into account the values of the last known data point.

The morning and evening weather datasets were equalized in terms of size after the missing data points were filled in. This process is important in terms of correcting the inconsistencies that occur in the start and end dates of the data set. If differences are detected in the start or end dates of the morning and evening, a new record is added to the smaller data set based on the first or last record of the other data set. With this method, morning and evening weather data were completed and checked for deficiencies. Following the verification procedure, the morning and evening weather data sets were combined in the correct order according to the dates.

When each data set used in sales forecasting was analyzed, it was observed that sales information was missing for some dates. These gaps were caused by missing sales records for the products on these dates. To solve this problem, a function that detects and fills in missing data has been developed. This function filled the sales information with a zero (0) value on the relevant dates, assuming that there were no sales on the dates determined for each data set

Following these processes, each sales data set was integrated with weather data on the relevant dates, which prepared everything to be used in sales forecasting.

Modeling

In the modeling part of the study, the open-source Prophet model developed by Facebook was used for time series forecasting. This model has a machine learning-based approach and has been effective in analyzing time series data, especially with its sensitivity to special days (such as holidays) and seasonal effects. The Prophet can model linear and nonlinear trends and automatically detect annual, weekly, and daily seasonality, which is why it was chosen for the modeling phase of this study.

Prophet models were trained separately for each sales data set, including weather information. By giving weather data to the models, they were able to learn the effects of weather conditions on sales (Badorf & Hoberg, 2020). The parameters for "weekly_seasonality" and "daily_seasonality" were adjusted to help the models learn weekly and daily patterns. In this way, the models are able to analyze the changes in sales according to hours of the day and days of the week. The "changepoint_prior_scale" parameter was used to adjust the sensitivity of the models to trend changes in the data sets. This value was determined as 0.09 for all models. In addition, with the "country_code" parameter, the models were enabled to automatically take country-based holidays into account, and thus, the effects of holidays on sales were included in the modeling process. Since the time series data considered belongs to a business in Turkey, the "country_code" was set to 'TR,' enabling the models to take into account holidays specific to the country.

The "make_future_dataframe" function of the Prophet model was utilized to produce future date data frames that would be similar to the training datasets. This function acquires information about the duration and frequency of the forecast through parameters. Since the study used daily sales data, the data frames were also generated with a daily frequency. In order to maintain a forecast period of 30 days, the data frames for the models' predictions were set to 30 data points. Despite the models' capability to generate future data frames, the inclusion of weather data into these frames was necessary for more precise forecasting. For this purpose, seven-day weather forecast data were obtained from the OpenWeatherMap platform via API using the Python programming language. These forecasts were produced with atmospheric measurements and mathematical models instead of machine learning approaches. Considering the possibility of inconsistencies in weather forecasts beyond a certain period, efforts were taken to ensure that the models used the extended data frames with weather forecast data for the first 7 days for their predictions. For the remaining 23 days, the models forecasted without weather data. Subsequently, the sales forecasts made with and without weather forecast data

were merged with accuracy. This approach thoroughly assesses the effects of sales and weather data in a time series analysis, allowing the Prophet model to precisely model the impact of such significant factors as seasonality and trends.

Results and Discussion

Within the scope of this study, Facebook's Prophet model was applied to make forecasts based on daily sales data collected over approximately eight months for each product, provided by PROTEL Inc.

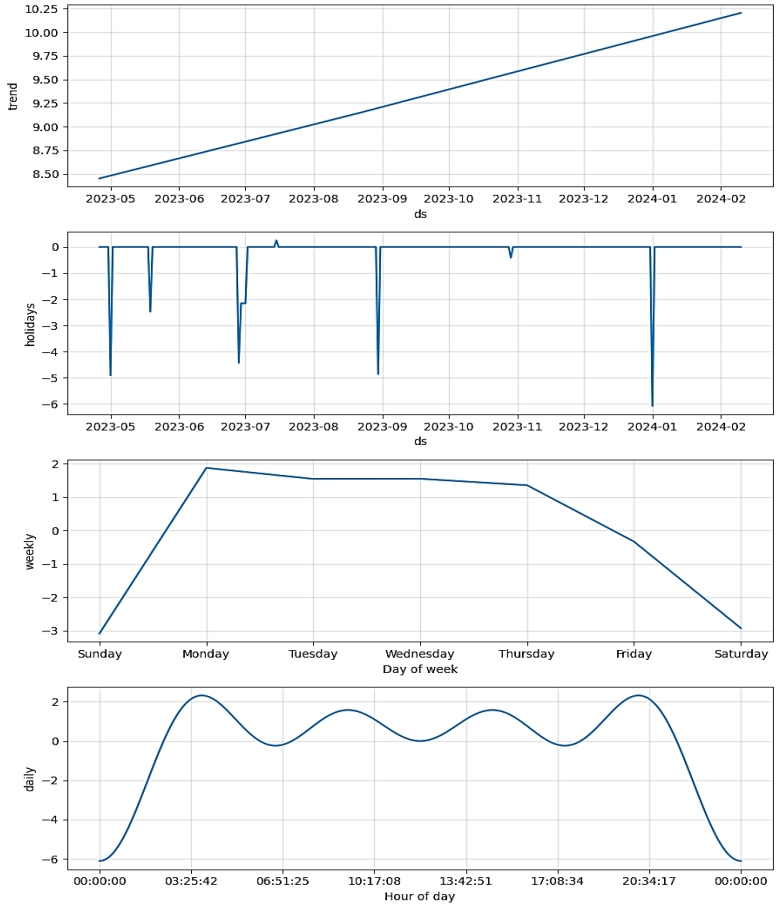

Figure 4. *Component graph from the Prophet model of the Product 1 sales data set.*

The time series analysis conducted using the Prophet model reveals an increasing trend in the sales of Product 1 from May 2023 to February 2024. The component graph provided by Prophet, shown in Figure 4, indicates that this linear and positive trend in sales could potentially point

to factors such as an expanding customer base or an increase in market demand. The model's "holidays" graph reveals that special days have a negative impact on sales. A decrease in sales is observed particularly before and after holiday periods, with sales dropping to their lowest levels on the holidays themselves. This could be attributed to the influence of holidays on customer behavior and the business being closed during these periods. The weekly component analysis shows significant differences in sales across the days of the week, with the highest sales volume reached on Mondays and a gradual decline observed throughout the week until Friday. The daily component graph demonstrates how sales fluctuate during different hours of the day. All these component graphs provide valuable insights into the dynamics of sales for Product 1 over time, supporting decision-making processes in business management.

Figure 5, Figure 6, and Figure 7 below present the forecasts and confidence intervals for three separate products made using the Prophet model. The analyses conducted on the sales data of Product 1, Product 2, and Product 3 demonstrate the extent to which this model can capture different sales dynamics and manage the confidence intervals in making forward-looking predictions.

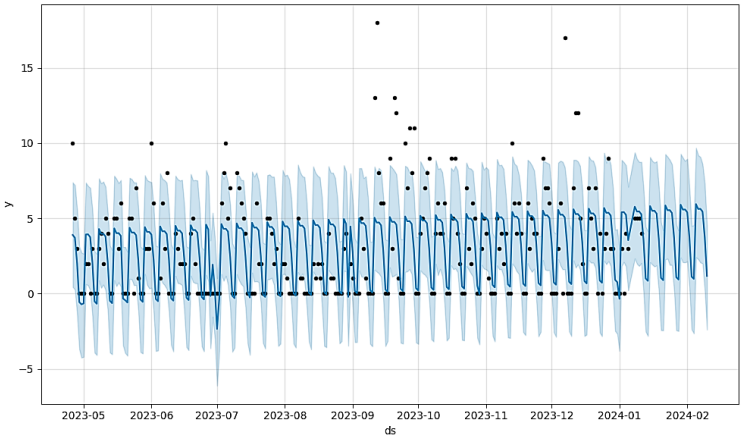

Figure 5. *Forecasts and confidence intervals for Product 1.*

The evaluation on Figure 5 for Product 1 shows that the Prophet model exhibits a good fit with the current sales (illustrated by the dark blue line along the plane with black dots) and future forecasts (continuing as a dark blue line beyond the black dots). The confidence interval, represented by the light blue area surrounding the model predictions, has remained almost constant in width throughout the forecasting period. This indicates that the model has efficiently adapted to past data and demonstrated consistency in future forecasts. This harmony between actual sales data and the model's predictions indicates that the model has the capacity to make sense of historical data and can produce reliable forward-looking forecasts.

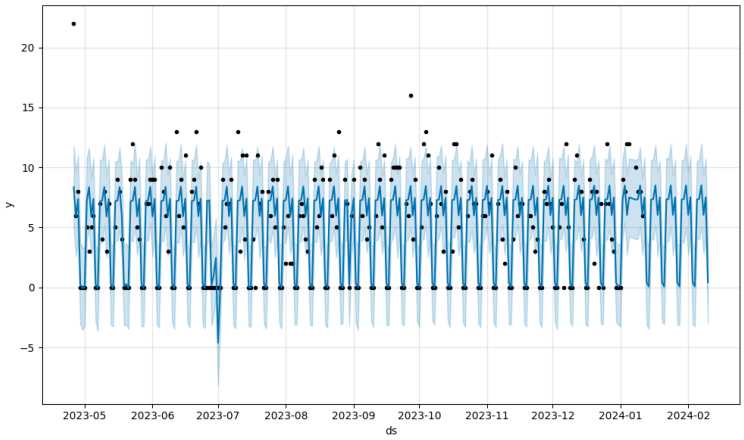

Figure 6. *Forecasts and confidence intervals for Product 2.*

In the analysis of Product 2 presented in Figure 6, it can be seen that the predictions of the model successfully follow the general trend of the actual sales data, with the confidence interval remaining at a regular area around the predicted trend line. However, the widening of the confidence interval in certain periods indicates that the model's predictions are less accurate in these periods and the data points show a greater variance. That said, the model was generally consistent in its predictions.

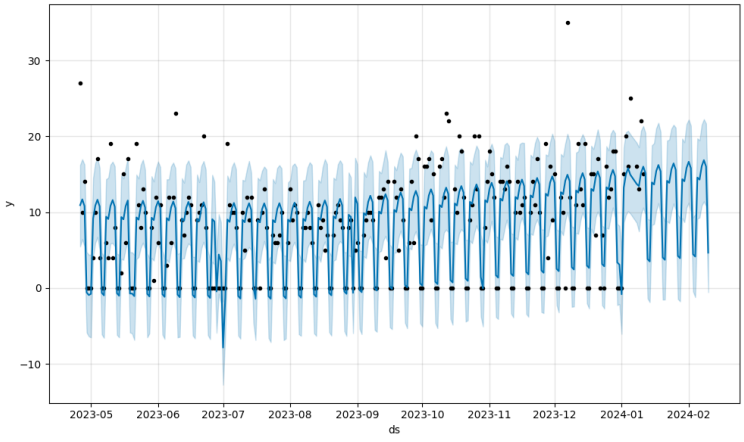

Figure 7. *Forecasts and confidence intervals for Product 3.*

As can be seen in Figure 7 above regarding Product 3, the prediction line produced by the model deviates from the real data from time to time. Although these deviations are not very large, they may indicate that the model is not always able to effectively filter out noise and

high variability in the data set. The widening and narrowing of the confidence interval over time also confirms this situation. When the confidence interval widens, model predictions contain higher uncertainty and, accordingly, the reliability level decreases. The performance of the model for all three products contributed to understanding the model's strengths and weaknesses. This provided valuable insights regarding its interaction with real-world data.

To measure the prediction performance of the model, daily sales data for the last 30 days of each product in the data set were separated from the training data and used as the data set for testing. Following this approach made it possible to evaluate the degree to which the model's daily sales forecasts in each product deviated from the actual sales data for the following 30 days. Four distinct error metrics (Buitinck et. al, 2013) were implemented to evaluate the forecast's performance: Mean Absolute Error (MAE) (Eq. 1), Mean Absolute Percentage Error (MAPE) (Eq. 2), Mean Squared Error (MSE) (Eq. 3), and Root Mean Square Error (RMSE) (Eq. 4).

$$MAE = \frac{1}{n}\sum^{n} |yi - \hat{y}i| \qquad Eq.1$$

$$MAPE = \frac{1}{n}\sum_{i=1}^{n} \left|\frac{yi - \hat{y}i}{yi}\right| 100\% \qquad Eq.2$$

$$MSE = \frac{1}{n}\sum_{i=1}^{n} (yi - \hat{y}i)^2 \qquad Eq.3$$

$$RMSE = \sqrt{\frac{1}{n}\sum_{i=1}^{n} (yi - \hat{y}i)^2} \qquad Eq.4$$

The rrror metrics reveal a detailed analysis of the performance of the model by considering the deviations of the predictions from real values across various dimensions. The RMSE and MAE metrics indicate how far the predictions are from the real values in terms of absolute and squared errors, whereas the MAPE metric uses a percentage technique to express this condition. The MSE error metric aids in observing the performance of the model from a different perspective by lending more weight to larger errors.

Table 1. *Evaluating the Deviations in the Prophet Model's Forecasts for Various Products in the Dataset Using Different Metrics.*

Data	MAE	MAPE	MSE	RMSE
Product 1	1.79	0.17	0.06	2.53
Product 2	4.33	0.19	0.09	5.98
Product 3	0.76	0.18	0.02	0.82

As can be understood from Table 1, reaching different error scores for three different products indicates that the model exhibits varying performances for different products. The varying daily sales quantities and sales trends of each product are also factors that affect the model's performance differently across products. For the first product, low MAE (1.79) and RMSE (2.53) scores demonstrate that the model generally performs well in predictions. The low MAPE (0.17) value for the same product indicates that the model's predictions are consistent in percentage terms. However, slightly higher MSE (0.06) and RMSE (2.53) scores suggest that deviations in predictions for some instances are larger. For the second product, somewhat higher MAE (4.33) and RMSE (5.98) scores indicate that the model makes more errors in predictions. A high MAPE (0.19) score further suggests that sales predictions for this product are less consistent compared to other products. Lastly, for the third product, lower MAE (0.76) and RMSE (0.82) scores reveal that the model produces robust predictions, and the obtained MAPE (0.18) score also shows that sales predictions for the product are consistent in percentage terms.

As a result, by using all error metrics together, the performance of the predictions produced by the model for different products has been analyzed in detail. For some products, the model predicts more reliably and accurately, while it has greater error rates for others. All of this information demonstrates how well the model can understand and predict each product's unique sales trends.

Future Work and Recommendations

This study used Facebook's Prophet model to predict restaurant sales, revealing the positive effects of external factors, such as weather and special days, on sales forecasts. Despite the success of the results, there are several recommendations for further improvement and expansion of the study and directions for future work.

The dataset used in this study is based on a specific enterprise and geographical location. In the future, the scope of the study could be expanded with data from different geographical regions and various businesses. This would improve the model's sensitivity to different market dynamics and customer preferences. Moreover, analyzing data gathered over years that include different seasons can help the model make better sense of long-term trends and seasonal variations. This research was limited in what was considered external factors, only weather conditions and special days (holidays, festivals, etc.). Future studies could integrate other external elements, such as business promotions, campaigns, local events, and economic indicators, into the model. Integrating these additional elements into the model can allow businesses to plan their marketing and operational strategies more efficiently by enabling more precise sales forecasts. As an alternative to Facebook's Prophet algorithm, other time series

forecasting models and machine learning-based approaches can be tested by applying them to similar data sets. Comparing the forecasting performances of different models will reveal the strengths and weaknesses of each model and support the selection of the most appropriate model. A comparative analysis of deep learning models and traditional statistical approaches can provide a broader understanding.

Future studies in line with these recommendations may offer innovative solutions that will enable businesses to gain a competitive advantage in the market by increasing the efficiency of sales forecasting models. This study provides a basis for future research and development in the field of sales forecasting in the restaurant industry.

Conclusion

This study comprehensively analyzed the effectiveness of Facebook's Prophet model in forecasting business sales and the effects of external factors on this process. The model provided insights into the specific challenges faced in the restaurant industry, particularly by accounting for the effects of external factors on sales, such as weather conditions and special days. The results of this research can be useful for businesses in terms of improving their sales forecasting strategies and optimizing their operational efficiency. Furthermore, the analyses provide valuable insights that may allow restaurants to develop future sales strategies in a more effective way.

Peer-review: Externally peer-reviewed.

Ethics Committee Approval: The corresponding author declared that this study falls under the category of research that does not require ethics committee approval for any reason.

Author Contributions: Conception/Design of Study- A.K.G., A.M.; Data Acquisition- A.K.G., M.T.; Data Analysis/Interpretation- M.T., A.K.G., O.S., M.G.; Drafting Manuscript- A.K.G.; Critical Revision of Manuscript- M.G., A.K.G., A.M., M.T., O.S.; Final Approval and Accountability- A.K.G., M.G., M.T., A.M., O.S.; Technical or Material Support- A.K.G., A.M., M.T.; Supervision- M.G.

Conflict of Interest: The authors have no conflict of interest to declare.

Grant Support: The authors declared that this study has received no financial support

References

Arunraj, N. S., & Ahrens, D. (2015). A hybrid seasonal autoregressive integrated moving average and quantile regression for daily food sales forecasting. International Journal of Production Economics, 170, 321-335. https://doi.org/10.1016/j.ijpe.2015.09.037

Badorf, F., & Hoberg, K. (2020). The impact of daily weather on retail sales: An empirical study in brick-and-mortar stores. Journal of Retailing and Consumer Services, 52, 101921. https://doi.org/10.1016/j.jretconser.2019.101921

Buitinck, L., Louppe, G., Blondel, M., Pedregosa, F., Mueller, A., Grisel, O., Niculae, V., Prettenhofer, P., Gramfort, A., Grobler, J., Layton, R., VanderPlas, J., Joly, A., Holt, B., & Varoquaux, G. (2013). API design for machine learning software: experiences from the scikit-learn project. arXiv preprint arXiv:1309.0238.

Jha, B. K., & Pande, S. (2021, April). Time series forecasting model for supermarket sales using FB-prophet. In 2021 5th International Conference on Computing Methodologies and Communication (ICCMC) (pp. 547-554). IEEE. https://doi.org/10.1109/ICCMC51019.2021.9418184

Loureiro, A. L., Miguéis, V. L., & Da Silva, L. F. (2018). Exploring the use of deep neural networks for sales forecasting in fashion retail. Decision Support Systems, 114, 81-93. https://doi.org/10.1016/j.dss.2018.08.009

OpenWeatherMap. (2024). API documentation. OpenWeatherMap. Retrieved from https://openweathermap.org/api

Posch, K., Truden, C., Hungerländer, P., & Pilz, J. (2022). A Bayesian approach for predicting food and beverage sales in staff canteens and restaurants. International Journal of Forecasting, 38(1), 321-338. https://doi.org/10.1016/j.ijforecast.2021.02.008

Ramos, P., Santos, N., & Rebelo, R. (2015). Performance of state space and ARIMA models for consumer retail sales forecasting. Robotics and Computer-Integrated Manufacturing, 34, 151-163. https://doi.org/10.1016/j.rcim.2014.12.001

Shilong, Z. (2021, January). Machine learning model for sales forecasting by using XGBoost. In 2021 IEEE International Conference on Consumer Electronics and Computer Engineering (ICCECE) (pp. 480-483). IEEE. https://doi.org/10.1109/ICCECE51280.2021.9342336

Taylor, S. J., & Letham, B. (2018). Forecasting at scale. The American Statistician, 72(1), 37-45. https://doi.org/10.1080/00031305.2017.1380080

Thomassey, S. (2010). Sales forecasts in the clothing industry: The key success factor of the supply chain management. International Journal of Production Economics, 128(2), 470-483. https://doi.org/10.1016/j.ijpe.2010.07.007

Tsoumakas, G. (2019). A survey of machine learning techniques for food sales prediction. Artificial Intelligence Review, 52(1), 441-447. https://doi.org/10.1007/s10462-018-9656-1

Yusof, U. K., Khalid, M. N. A., Hussain, A., & Shamsudin, H. (2020, December). Financial time series forecasting using Prophet. In International Conference of Reliable Information and Communication Technology (pp. 485-495). Cham: Springer International Publishing. https://doi.org/10.1007/978-3-030-33582-3_42

Zunic, E., Korjenic, K., Hodzic, K., & Donko, D. (2020). Application of facebook's prophet algorithm for successful sales forecasting based on real-world data. arXiv preprint arXiv:2005.07575.