

DEMANDEST – AI POWERED FOOD DEMAND FORECASTER : LITERATURE SURVEY AND CATEGORIZATION OF METHODS

ABSTRACT

Demand forecasting is one of the important inputs for a successful restaurant yield and revenue management system. Sales forecasting is crucial for an independent restaurant and for restaurant chains as well. In the paper a comprehensive literature review and classification of restaurant sales and consumer demand techniques are presented. A range of methodologies and models for forecasting are given in the literature. These techniques are categorized here into seven categories, also included hybrid models. The methodology for different kind of analytical methods is briefly described, the advantages and drawbacks are discussed, and relevant set of papers is selected. Conclusions and comments are also made on future research directions.

Keywords:

- Restaurant sales forecasting
- Guest count prediction
- Forecasting survey
- Revenue management
- Yield management

INTRODUCTION

Demand forecasting is one of the important inputs for a successful restaurant yield revenue management system. Sales forecasting is crucial for an independent restaurant and for restaurant chains as well.

The sales transaction data collected by restaurant chains may be analysed at both *the store level* and *the corporate level*. At the level of single store, exploring the large amounts of transaction data allows each restaurant to improve its operations management (e.g., labor scheduling) and product management (e.g., inventory replenishment, product preparation scheduling), and in consequence reducing restaurant operating costs and increasing quality of serving food. Whereas at the corporate level, extraction of relevant information across the restaurants can greatly

facilitate corporate strategic planning. Management can assess the impact of promotional activities on sales and brand recognition.

assessment of business trends, conduct price elasticity analysis and measure brand loyalty. There do not exist any review of forecasting methods for the restaurant industry. Historically, forecasting of restaurant sales has been judgemental based. This technique is still often used by the majority of the restaurant industry. Judgemental techniques consist of an intuitive forecast based on the manager's experience. But restaurant sales forecasting is a complex task, because it is influenced by a large number of factors, which can be classified as: time, weather conditions, economic factors, random cases etc. This makes judgemental techniques inaccurate. A wide variety of models, varying in the complexity form has been proposed for the improvement of restaurant forecasting accuracy.

REVENUE MANAGEMENT

Revenue management (RM) is the application of information systems and pricing strategies to allocate the right capacity to the right customer at the right place at the right time. The determination of "right" entails achieving both the most revenue possible for the restaurant and also delivering the greatest value or utility to the customer.

In practice, revenue management means determining prices according to forecasted demand so that price-sensitive customers who are willing to purchase at off-peak times can do it at lower prices, while customers who want to buy at peak times (price-insensitive customers) will be able to do it.

A pioneer in Revenue Management was airline industry. Other examples of industries in which RM is implemented nowadays are hotel industry, car-rental industry, tour operators, restaurants and many others.

One critical element in a strategy for Restaurant Revenue Management is to predict future demand. Restaurant managers have always struggled with the question of how many guests will show up this day. Customer demand varies by the time of year, month, week, day and by the day part. Restaurant demand may be higher on weekends (especially on Fridays and Saturdays), during holidays, summer months, or at particular periods as lunch or dinner time. Restaurant operators want to be able to forecast time-related demand so that they can make effective pricing and table-allocation decisions.

Sales forecasting is the answer to the question how high will be sale under certain circumstances. The circumstances includes the nature of sellers, buyers, and the market (e.g., competitors). Thus, important factors are historical sales data, promotions, economic variables, location type or demographics of location. All variables that are useful in predicting demand are listed in Table 1.

Table 1. Variables that can be used as predictors

No	External variable	Range or an example of the variable
1	Time	Month, week, day of the week, hour
2	Weather	Temperature, rainfall level, snowfall level, hour of sunshine
3	Holidays	Public holidays, school holidays
4	Promotions	Promotion/regular price
5	Events	Hockey games, other
6	Historical data	Historical demand data, trend
7	Macroeconomic Indicators (useful for monthly or annual prediction)	CPI, unemployment rate, population
8	Competitive issues	Competitive promotions
9	Web	Social media comments, social media stars
10	Location type	Street/shopping mall
11	Demographics of location (useful for prediction by time of a day)	The average age of customers

1 LITERATURE REVIEW

1.1 Multiple Regression

Multiple regression is a simple, yet powerful technique used for predicting the unknown value of a dependent variable X_t from the known value of two or more explanatory variables (predictors) V_1, \dots, V_k . The equation for multiple regression is:

$$X_t = \alpha_0 + \alpha_1 V_{1t} + \dots + \alpha_k V_{kt} + \varepsilon_t,$$

where ε_t is the error. Coefficients $\alpha_1, \dots, \alpha_k$ can be estimated using least squares to minimize sum of errors .

For example, multiple regression models can be used in econometrics, where regression equation(s) model a casual relationship between the dependent variable (e.g., restaurant sales) and external variables such as disposable income, the consumer price index, unemployment rate, etc. One of the advantages of econometric models created for predicting restaurant sales is that the researchers can logically formulate a cause and effect relationship between the exogenous variables and future sales/demand. Econometric models have however some drawbacks. Geurts and Kelly noticed that the future values of the independent variables themselves have to be predicted, what can cause data in an econometric model to be inaccurate and the model to be weak in its ability to forecast. Also the relationship found between the dependent and independent variables may be pretended or their causal

relationship can change over time, causing the need for constant update, or complete redesign model.

An example of using multiple regression is presented in. The purpose of this study was to identify the most appropriate method of forecasting meal counts for an institutional food service facility. The forecasting methods included naive models, moving averages, exponential smoothing methods, Holt's and Winter's methods, and linear and multiple regressions. The result of this study showed that multiple regression was the most accurate forecasting method.

Also in multiple regression model was used to demonstrate its potential for predicting future sales in the restaurant industry and its subsegments. Authors considered in this study the macroeconomic predictors such as percentile change in the CPI, in food away from home, in population, and in unemployment. They collected data from 1970 to 2011 from a variety of sources, including the NRA, the USDA, the Bureau of Labor Statistics, and the US Census Bureau. The model, trained and tested on aggregated data from the past 41 years, appears to have reasonable utility in terms of forecasting accuracy.

In authors used several regressions and Box-Jenkins models to forecast weekly sales at a small campus restaurant. The result of testing indicates that a multiple regression model with two predictors, a dummy variable and sales lagged one week, was the best forecasting model considered.

Regression model was also used in a specific situation described in , where the restaurant was open and close during different times of the week or year.

1.2 Poisson Regression

Restaurant guest count is an example of variable, that takes on discrete values. When the dependent variable consists of count data, there can be used Poisson regression. This method is one from a family of techniques known as the generalized linear model (GLM). The foundation for Poisson regression is the Poisson distribution error structure and the natural logarithm link function:

$$\ln(X) = \alpha_0 + \alpha_1 V_1 + \dots + \alpha_k V_k,$$

where X is the predicted guest count, V_1, \dots, V_k are the specific values on the predictors, \ln refers to the natural logarithm, α_0 is the intercept, and α_i is the regression coefficient for the predictor V_i .

ARTIFICIAL NEURAL NETWORKS

All the forecasting methods we have discussed in previous subsections have the same strategy: make a functional assumption for the relationship between the observed data and various factors and then estimate the parameters of this function. In contrast, neural network methods, inspired by research on the human nervous system, use interactions in a network architecture to automatically estimate the underlying unknown function that best describes the demand

process. ANNs are systems of connected “neurons”, where the connections have numeric weights that can be tuned based on historical data, what makes that neural networks are adaptive to inputs and capable of learning.

ASSOCIATION RULES (MARKET BASKET ANALYSIS)

Market Basket Analysis (MBA) rules to explore menu items assortments, which are defined as the sets of most frequently ordered menu item pairs of an entre and side dishes. In some cases, MBA does not provide useful information if data-item is the name of goods. The authors proposed a new MBA method which integrates words segmentation technology and association rule mining technology. Characteristics of items can be generated automatically before mining association rules by using word segmentation technology. This method has been applied to a restaurant equipped with electronic ordering system to give recommendations to customers, where the experiments were done. The experiment results show that the method is efficient and valid.

Conclusion

Demand prediction plays a crucial role in planning operations for restaurant’s management. Having a reliable estimation for a menu items future demand is the basis for other analysis. Various forecasting techniques have been developed, each one with its particular advantages and disadvantages compared to other approaches. The evolution of the respective forecasting methods over past 20years has been revealed in the paper. A review and categorization of consumer restaurant demand techniques is presented in the paper. This paper conducts a comprehensive literature review and selects a set of papers on restaurant sales forecasting. It is almost universally agreed in the forecasting literature that no single method is best in every situation.

References

1. Aburto, L., Weber, R.: A sequential hybrid forecasting system for demand prediction. In: Perner, P. (ed.) MLDM 2007. LNCS (LNAI), vol. 4571, pp. 518–532. Springer, Heidelberg (2007).
2. Morgan, M.S., Chintagunta, P.K.: Forecasting restaurant sales using self-selectivitymodels. *J. Retail. Consum. Serv.* **4**(2), 117–128 (1997).
3. Miller, J.J., McCahon, C.S., Miller, J.L.: Foodservice forecasting: differences inselection of simple mathematical models based on short-term and long-term data sets. *J. Hospitality Tourism Res.* **16**(2), 93–102 (1993).

4. 4.Ishigaki, T., Takenaka, T., Motomura, Y.: Customer-item category based knowledge discovery support system and its application to department store service. In: IEEE Asia-Pacific Services Computing Conference (2010).
5. Wen-xiu, X., Heng-nian, Q., Mei-li, H.: Market basket analysis based on text segmentation and association rule mining. In: First International Conference on Networking and Distributed Computing (2010).