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For more information, contact
MIT Global SCALE Network

Postal Address:
Massachusetts Institute of Technology 77
Massachusetts Avenue, Cambridge, MA 02139 (USA)

Location:
Building E40, Room 267
1 Amherst St.

Access:
Telephone: +1 617-253-5320
Fax: +1 617-253-4560

Email: *scale@mit.edu*
Website: *scale.mit.edu*

For full thesis version please contact:
Professor Shardul Phadnis
Director of Research
MISI
No. 2A, Persiaran Tebar Layar, Seksyen
U8, Bukit Jelutong, Shah Alam,
40150 Selangor, Malaysia.
Phone: +6 03 7841 4845
Email: sphadnis@misi.edu.my

Demand Forecasting for Perishable Commodities: A Case Study of Inflight Food Demand for Low Cost Airline

By: Daniel. F. Liman
Thesis Advisor: Dr. Asad Ata

Summary: Inflight food sales have become an important revenue source for low cost airlines where demand forecasting is play a critical role in profitability. By creating a new and improved forecasting method, the research is aiming for reduced waste and lost sales, thus will increase the business profitability.

Daniel holds a Bachelors in Ocean engineering from Institut Teknologi Bandung and MSCM from Malaysia Institute for Supply Chain Innovation, part of MIT global Scale Network. Prior to joining MISI, Daniel work as an field engineer for Hafar Daya Konstruksi, where he handle engineering issue for pipeline construction and rectification.

KEY INSIGHTS

1. The two channels of food service, Pre-Book Meal and Inflight sales, have different demand pool. Thus capturing demand from both channels will greatly increase the revenue.
2. The demand of inflight perishable goods is normally distributed and affected by seasonality.
3. News vendor model provide a more robust solution with significantly less waste.

Introduction & Background
"Low-cost Airlines" or "Budget Airlines" is a term used to address Airlines that generally have lower fares in exchange with less comfort / services. This business model start at 1971 when Southwest airlines, an America based airlines, introduce a concept that eliminate some of the extra services in order to reduce cost and then pass the saving to the customers. A business model that targeting customers from middle and lower class, boosting their demand by reducing the overall price, where they only need to pay for what they need. This model is a perfect picture of "lean" that only accommodate the need of transportation and forsake the other additional services. A business model that has been proven throughout the globe, Started by Ryanair in 1995 at Europe region and finally move to Asia in 2001.

Fresh food is one of the comfort element that get eliminated during the creation of this "lean" business concept. It is a tricky product with uncertain demand and zero salvage value, making it hard for the airlines to maintain stock. In the other hand it will reduce the customer service level when the product is out of stock when customers expect to be able to buy it, creating a fundamental supply chain problem. Many airlines have stopped selling this product to completely remove the expectation or shift to snack product which last longer and has higher salvage value. However the high revenue and profit margin of fresh food product keep tempting some airlines to maintain the services.

Customers, defined as passengers who board the plane, is the major key element that affect the demand. Wubben and Wangenheim have tested the Preto/NBD model, classification of customers based on "hiatus heuristic", to predict which customer will be the best customers in the future based on historical data, an "ideal" way to predict the behavior of each customer and the possible incoming demand (Wübben & Wangenheim, 2008)

Sales for food service is done through two different channel, known as Pre-Book Meal (PBM) and inflight sales. Both channels have different characteristic and degree of profitability, breaking down the characteristics, weaknesses and strengths of each channel is important to understand the research environment.

Research & Analysis
The inflight food industry market size is estimated to be at $18 billion per annum with predicted growth of 5% per year (Jones, 2007), creating a huge profit opportunity for low cost airlines. Recent research of Novie Johan and Peter Jones from University of Surrey has create a "Meal Multiplier" value on 3 region, based on Delphi method on major carrier feedback in each region. However low cost airlines is different from general airlines, it separate the meal cost from the ticket, creating more vulnerability to profit loss from wastage.

Forecasting is a key factor to tackle this problem, so far the partner company has tried a wide spectrum of forecasting method, moving average, practitioner view and the current heuristic method. Goldstein & Gigerenzer (2009), in their paper, "Fast and frugal forecasting", has done a research about implication of stochastic and heuristic forecast method in multiple industry, with a positive result for heuristic method (Goldsteina & Gigerenzer, 2009). However even heuristic method can't produce a 100% accuracy forecast, it is simply impossible for the current system to

get the perfect customer data for each flight. After all the forecasting method should be applicable instead of a theory that exist and has a potential. This condition raise the question of "What is the best forecasting approach to help low cost airlines to reduce waste without losing sales?"

The initial proposition is to bring back the stochastic part to enhance the heuristic method and fill the "gap" of information that exist in the method. Theoretically it will create a random model with less variability by pulling out the certain factor from the variability pool, overall the research will be a deductive research that will try to test and validate this theory

The model

To comply with data availability, the research will be done on specific sample on one sector to control the flight duration, passenger's structure, and flight departure time. A validity test using a different sample with completely different parameters will be done to justify the model.

Seat to food ratio is the bridge that connect the heuristic and stochastic part. Which defined as:

$$\frac{Inflight\ sales}{(total\ passenger\ count - PBM)}$$

The ratio run under the assumption of separated pool of demand between PBM and inflight sales. In this assumption the PBM has its exclusive demand pool that is separated from inflight sales, which come purely from the exposure of products. Therefore the demand pool for inflight sales can be defined as the total passenger count – PBM.

A probability density function (PDF) is then built based on the ratio application on ten months sales data on one sector, which then become a platform for news-vendor model. With a critical ratio of 0,6 that come from the following equation.

$$\frac{Cu}{Cu + Co}$$

Where

$$Cu = Profit\ margin\ \times\ Selling\ price$$
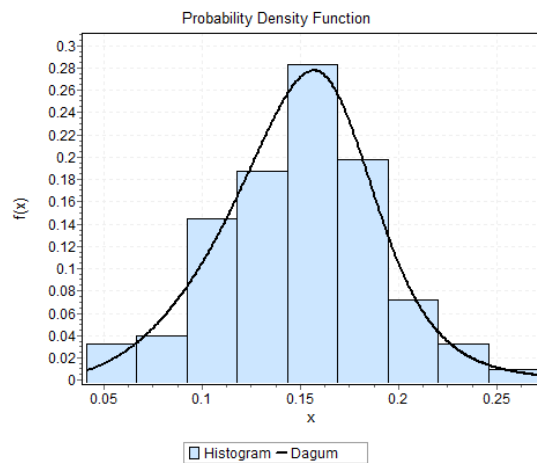
$$Co = Material\ cost$$

Figure 1: Seat to food ratio PDF – Based on 10 months sales data

The model generates an equation that will determine the take up amount (number of products on aggregate level), based on the real time data.

$$Take\ up\ = 0.16\ \times\ (Passenger\ count - PBM)$$

A simulation on historical data is done to test the equation. Using Microsoft Excel as the platform, the take up amount of the equation is compared with the actual sales, with additional two sales for every real life stock out event. The result shows a significant improvement in waste area with a little trade off from sales, the detail can be observed at the table below.

	Sales	Waste	Profit
Current operation	10395	2668	5170
New model	9819	1348	5352

Table 1: Simulation result

Seasonality effect

To tackle this parameter, 2 different approaches will be used. The first approach is by dividing the domain for the news vendor model, each month of the year have its own PDF which capture the change of demand between months. The second approach is by using moving average method to normalize the forecast result based on the seasonality.

Tested on the sample, the first approach show a slight improvement from previous news vendor model with high level of applicability. The second approach in the other hand show no improvement and can be ruled off from consideration.

Test on different sector

The next question is "how consistent is the model?" The answer lie on another test on the model using a flight from another sector with completely different parameter.

Parameters	CGK-KL	HKG- KL
Flight duration	3 hours 50 minutes	1 hour
Flight departure	Morning-noon	Evening
Domain direction	East	south

Table 2: Flight parameters

Once again the model show a significant improvement, with 37% less waste and only 7,4% trade off from sales. Therefore it can be concluded that the model is consistent.

Sensitivity analysis

Sensitivity analysis is an important key in the model application, the model was created based on academic view which means it might not align with the industry goal. Although the optimum result will yield more profit, industry tends to look at other point in providing service such as customer satisfaction or minimize waste. The next figure show the tradeoff between waste and sales, which will become important when the company make a policy to control the minimum sales or maximum waste for the system. Sales and waste has an exponential relation that restraint the model to achieve higher customer service level.
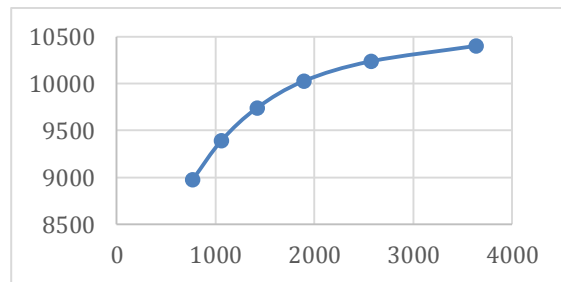

Figure 2: Tradeoff between waste (x axis) and profit (y axis)

The last part of sensitivity analysis shows the correlation of change in mean of ratio B, sales, waste, and expected profit. This analysis becomes important to reveal the real demand distribution of direct sales. Since the operation run at 20% stock out rate, the actual sales data can't represent the higher part of demand, a condition that put the news vendor model into lower end area.
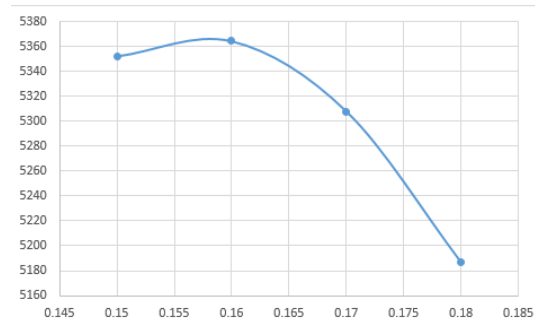

Figure 3: Sensitivity analysis on ratio B mean

This sensitivity analysis will explore the higher end of demand by increasing the mean of the base PDF of the news vendor model.

Conclusion

Based on the simulation of Seat to food ratio, where the model show a better performance under the assumption of different demand pool for PBM and inflight sales, the proposition is accepted and therefore the demand pool of PBM and inflight sales are redeemed different. This concept is in alignment with current forecasting method of the company, where inflight sales is categorized into different entity.

Furthermore, under the assumption of proposition, the application of news vendor model show an improvement in profit for the company, even with data limitation. It shows a 1,5 to 4% profit improvement in historical data test. This reveals a potential of better forecast application for the operation with sufficient data support.

Application of the model, however, might not align with the future policy of the company. Although the model can offer a significant improvement in term of reducing waste within the current sales level, it shows a weakness in achieving higher service level. News-vendor model generate a certain level of stock to accommodate a certain level of probability, it can't specifically adapt for each flight