An analytical model to approach consolidation processes in air freight transportation

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Summary: This thesis proposes a methodology to design an analytical model to guide decision-making for air freight forwarders when addressing their commercial strategy with respect to air cargo tenders. We embedded the model in an integrated database and designed a series of meaningful metrics and visualization tools to depict air density usage efficiency and profitability not only for the current portfolio but also to assess the attractiveness of incoming bids under consideration after estimating their consolidation potential with the current business.

The “1:6” weight/volume air cargo ratio establishes that whenever the cargo ratio is different from 1:6 (1m³:167 kg) forwarders must pay the highest rate: either volume or weight. Given the main constraints in terms of volumetric capacity and density (maximum weight per volumetric unit), the most profitable business opportunities consist of combining in the same load compatible products with different densities through consolidation. The main target is to come close as possible to the desired 1:6 ratio, to minimize the average price per load.

To increase competitiveness, 3PL companies and air freight forwarder firms in particular can improve their consolidation techniques, to combine in the same load cargo with compatible densities. The availability of robust analytical resources will allow airfreight industry companies to improve their rate of success, in terms of enhancing both air usage efficiency (by increasing air volumes and densities) and profitability (by minimizing the Net Achieved Rate).

KEY INSIGHTS

1. Building a complete and well-structured database using a scalable and repeatable process permits to gather, manage and interpret relevant data from past tenders and allows air freight forwarders for having an accurate depiction of levels of air usage efficiency and profitability.
2. Creating meaningful metrics is crucial to assess the attractiveness of incoming bids.
3. Designing intuitive visualization tools helps to refine decision-making when addressing air cargo tenders.

Introduction

Airfreight forwarding companies must develop accurate simulation tools to analyze the suitability of each bidding process, to decide whether to participate in air cargo tenders held by shippers and how to define the optimal commercial strategy.
Our thesis develops an analytical model based on meaningful metrics to provide airfreight forwarders with an accurate and solid analytical tool to address tenders when buying air cargo space to carriers-airlines and reselling it to shipping companies.

The model permits to select the bids under consideration held by the shippers that best match with their current portfolio/current business in terms of air volume usage and density efficiency for a given origin-destination lane. It also predicts breakeven rates to guide decision-making when addressing tenders to increase profitability by minimizing the Net Achieved Rate.

Furthermore, the model provides with a series of visualization tools to help air freight forwarding companies to improve their understanding and depiction of their current situation in order to design their commercial strategy. Finally, it suggests directions for further research.

**Methodology**

The methodology we used to build the analytical model is based on integrating three levels of analytical procedures:

First, we designed an integrated database in SQL Server composed of a selection of meaningful variables addressing physical properties and rates from the different Air Rates spreadsheets that present datasets from past tenders, whether awarded or not, and data from incoming bids / Requests For Quotation (RFQ). We identified significant gaps and data scarcity with respect to gross weight and density, what caused a severe limitation regarding consolidation analysis. However, we decided to perform statistical analysis through goodness of fit tests to identify meaningful patterns in the data available regarding those two variables, so that we could simulate the missing values and populate the database to be able to complete the consolidation analysis.

Second, we designed a series of metrics to assess the attractiveness of each incoming bid with respect to consolidation potential and expected profitability for any given origin-destination lane. The main purpose of those metrics is to bring references to rationalize decision-making when deciding the suitability of each incoming bidding process and to provide with reference values for the rate $\beta$ to be charged to the customer/shipping company to guide decision-making when addressing tenders. Such metrics define four areas of profitability (A, B, C and D) and shape the analytical model. By embedding the analytical model in SQL Server we were able to calculate the meaningful metrics for each origin – destination lane based upon the integrated database. By refreshing the link between the two at any given moment the analytical model calculates the proper metrics in real time.

Finally, we designed via Tableau software a series of visualization tools that depict the main metrics calculated using the analytical model embedded in SQL server through a series of interactive graphs. These visualization tools permit to intuitively assess the attractiveness of each current bid and display in an attractive way all the reference metrics when selecting a certain bid from a certain customer for any given origin-destination lane.

**Building the Database and data simulation**

The thesis emphasizes the relevance of the necessity to create a repeatable, scalable process to gather, store, manage and interpret data regarding both past tenders and current bids, especially with respect to some key variables involved in the consolidation processes. By doing so, air freight forwarders will be able to access complete records and keep traceability of data inputs in an effortless way. Unfortunately, such process is not yet customary in the industry.

To populate the database we selected the 13 more relevant variables from the Air Rates spreadsheets with relevant information regarding 9 customers from different industries (high tech, hardware, retail-clothing, industrial, etc.) that the sponsor company provided us with. Such variables include both physical properties involved in the consolidation processes (gross weight, density, DIM Factor, volumetric weight, chargeable weight, etc.) as well as reference of both air cargo space carrier rates and target rates suggested by the shipper.
Data scarcity with respect to gross weight and density / DIM Factor meant a significant flaw that freight forwarders may have as a result of not having a robust and integrated data management system. Thus, we opted to simulate the missing values performing statistical simulations by using the statistical distribution which presents a better adjustment of the sample values for both variables. The results of tests of goodness of fit according to the Kolmogorov-Smirnov methodology showed that the DIM Factor was adjusted using a Lognormal distribution (see figure 1), whereas the gross weight values show the highest levels of goodness of fit with the Generalized Gamma Distribution.

Populating the database with reasonable assumptions allowed us to complete the consolidation analysis and to have enough critical mass as to apply the model and obtain meaningful results for each origin-destination lane. We exclusively focused our efforts in 9 focus lanes to deal with a manageable amount of datasets. The origin cities are Shanghai, Hong Kong and Beijing, while the destination cities analyzed are New York, Chicago and Los Angeles. However, the process is scalable and can be extended to a whole set of customers and air freight routes.

Analytical model: Metrics and Visualization tools

The metrics designed are grouped in two main categories: Consolidation Performance Metrics relate to physical properties which define compatibility between different loads to be transported via aircraft, whereas Profitability Performance Metrics reflect measurements and references to calculate the level of absolute and percent profits and provide with a series of different reference rates in relation to different scenarios to guide decision-making in the successive rounds and negotiations of the bidding process.

Increased consolidation potential permits to boost overall profitability, as a result of being able to charge twice a rate to different shippers when combining heavier and lighter cargo in the same load. We focused primarily on the surplus that consolidation permits to achieve by leveraging the increased Level of Aggressiveness on Bidding (I) when addressing the last rounds of the RFQ. To remain profitable not only per se, but also as for the whole current business/portfolio for a given route, air freight forwarders can use as reference values the Break-even Rate for Constant Profits ($\beta_\pi$), and the Constant Profitability per Lane Rate ($\beta_\lambda$), that define profitability Areas A, B and C.

\begin{align*}
\beta_\lambda & \quad \text{AREA A} \quad \text{DESIRABLE} \\
& \quad \text{More revenue} \quad \text{More profits} \quad \text{Higher profitability} \\
\beta_\pi & \quad \text{AREA B} \quad \text{ACCEPTABLE} \\
& \quad \text{More revenue} \quad \text{More profits} \quad \text{Less Profitability} \\
\beta_0 & \quad \text{AREA C} \quad \text{More revenue} \quad \text{Less profits} \quad \text{Less profitability} \\
& \quad \text{AREA D} \quad \text{Global losses} \quad \text{for the whole o-d lane}
\end{align*}

Figure 2. The 4 profitability areas defined by the Profitability Performance Metrics created

The $\beta_\pi$ rate guarantees the same profits in absolute numbers overall per lane. It can be used as a lower bound, threshold or minimum value to determine the rate ($\beta$) to propose to the shipper; whereas As seen on Figure 2, Constant Profitability per Lane Rate ($\beta_\lambda$) guarantees the same level of profitability as the current business. Higher rates, if awarded, would bring not only more profits in absolute terms to the air freight forwarder, but also a level of profitability which is higher than the current one for a given lane.
Conclusions

The main contributions achieved by this thesis are described as follows:

1.- architecture of the database to make it as simple, complete and usable as possible; identifying gaps in tracking information, suggesting software procedures to improve data traceability.

2.- metrics to analyze and depict current portfolio or current business for any given origin – destination lane with respect to air usage efficiency and profits.

3.- Designed an analytical process to select the most attractive business opportunities and define benchmarks to establish rates to increase profitability while being competitive.

4.- Constructed a series of visualization tools (see Figure 3) that describe the results of the analytical model and depict the main characteristics of the incoming bids under consideration to provide senior management with accessible, synthesized information to face decision-making in the commercial strategy. The analytical model developed in this thesis serves to build a methodology to rationalize decision-making criteria when addressing tenders. However, since it primarily focuses on strategic aspects of the commercial policy, there is from our perspective a need to combine such high level approach with operational constraints to build a comprehensive methodology. Therefore, we suggest that further research in this field should center its efforts on aligning the commercial strategy with operational procedures built upon constraints and limitations that occur at a consolidation execution level. One possible path to be followed would be to combine the analytical model embedded in SQL Server with Lagrangian-relaxation heuristics to solve through software such as CPLEX the optimization of the consolidation problem at an operational level.

By having a better understanding of both their current business and the business opportunities that arise, managers from air freight forwarders and logistics professionals can rationalize decision when addressing consolidation with a rigorous approach: better understanding will lead to better decisions.