"An analytical model to increase air volumes and minimize the Net Achieved Rate in air freight transportation"
AGENDA

1. - PROBLEM DEFINITION
2. - BUILDING THE DATABASE: KEY VARIABLES
3. - INTEGRATED DATA MANAGEMENT SYSTEM
4. - DATA SCARCITY AND SIMULATION
5. - METRICS DESIGN
   5.1. - PHYSICAL PROPERTIES
   5.2. - PROFITABILITY
6. - VISUALIZATION TOOLS
7. - CONCLUSIONS & FURTHER RESEARCH

An analytical model to increase air volumes and minimize the Net Achieved Rate in air freight transportation
1.- PROBLEM DEFINITION

Airfreight forwarding companies must develop accurate simulation tools to assess the attractiveness of each bidding process, to decide whether to participate in air cargo tenders of buying and reselling of air cargo space and how to define the optimal commercial strategy.

“1:6” weight/volume 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.

<table>
<thead>
<tr>
<th>Chargeable Weight (carrier/airline)</th>
<th>α</th>
<th>kg</th>
</tr>
</thead>
<tbody>
<tr>
<td>Rate paid to carrier</td>
<td>ρ</td>
<td>$/kg</td>
</tr>
</tbody>
</table>

| Chargeable Weight (shipper)        | σ      | kg |
| Rate charged to shipper            | β      | $/kg |

An analytical model to increase air volumes and minimize the Net Achieved Rate in air freight transportation
To increase competitiveness, 3PL companies and air freight forwarder firms 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 increase their rate of financial success, in terms of enhancing both efficiency (by increasing air volumes) and profitability (by minimizing the Net Achieved Rate).
1.- PROBLEM DEFINITION

Main operational constraints for air cargo:

<table>
<thead>
<tr>
<th>Volumetric capacity</th>
<th>Vt</th>
<th>M3</th>
</tr>
</thead>
<tbody>
<tr>
<td>Density</td>
<td>δ</td>
<td>Kg/M3</td>
</tr>
</tbody>
</table>

The most profitable business opportunities consist of combining in the same load different products with compatible densities through consolidation.

Main target: to come close as possible to the desired 1:6 ratio for the DIM Factor, to minimize the average price per load.

Net Achieved Rate = \( \text{NAR} = \frac{\sum_{k=1}^{n} \alpha_i \cdot q_i}{\sum_{k=1}^{n} \sigma_i} \)  
Profits \( \Pi = \sum_{k=1}^{n} \sigma_i \cdot \beta_i - \sum_{k=1}^{n} \alpha_i \cdot q_i \)
1.- PROBLEM DEFINITION

Main questions this thesis addresses:

1.- Which are the most attractive incoming bids for any given o-d lane?

2.- To what extend is a particular current bid under consideration compatible with our current portfolio / current business for a given o-d lane to maximize the air volume and density usage and profitability surplus derived from consolidation?

3.- How to choose the rates so that we maximize profitability while still being competitive when addressing RFQs?

4.- How to depict such questions through visualization tools in an attractive and intuitive way to be able to rapidly address decision-making when facing air cargo transportation tenders?
THESIS OUTLINE

This thesis develops an **analytical model based on meaningful metrics** to provide airfreight forwarders with an accurate and solid forecasting tool to:

1.- **select the most attractive bids under consideration**, those that best match with their current portfolio/current business in terms of air volume usage and density efficiency for a given origin-destination lane.

2.- **predicts breakeven rates to guide decision-making** when addressing tenders to increase profitability by minimizing the Net Achieved Rate.

3.- **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.
An analytical model to increase air volumes and minimize the Net Achieved Rate in air freight transportation.
# Boundaries of the Research Project

<table>
<thead>
<tr>
<th>Air Rates Customer ID</th>
<th>Industry</th>
</tr>
</thead>
<tbody>
<tr>
<td>C1, C9</td>
<td>Lifestyle/clothing</td>
</tr>
<tr>
<td>C2, C6</td>
<td>Retail - clothing</td>
</tr>
<tr>
<td>C3, C4</td>
<td>Industrial</td>
</tr>
<tr>
<td>C5, C7</td>
<td>Technology - hardware</td>
</tr>
<tr>
<td>C8</td>
<td>Toy industry</td>
</tr>
</tbody>
</table>

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LITERATURE REVIEW

Main research gap: The current state-of-the-art research covers different areas with respect to the operational aspects of the consolidation problem, but does not present a methodology to assess through visualization tools the attractiveness of current bids / bids under consideration with respect to the commercial strategy.


2. BUILDING THE DATABASE: KEY VARIABLES

Main given variables for consolidation of air cargo:

**Origin** = Origin Gateway for a certain bid

**Destination** = Destination Gateway for a certain bid

**o-d lane** = origin-destination pair, for each lane

**Shipper** = the company who ships cargo to the consignee. The shipper in the context of this thesis is the client of the air freight forwarder

**Carrier** = the airline, the legal entity that is in the business of transporting goods for hire

**Request For Quotation**: the tender, a negotiating approach whereby the buyer asks for a price quotation from a potential supplier from specific transportation services that a buyer needs over a certain time and at a fixed price
2.- BUILDING THE DATABASE: KEY VARIABLES

Main given variables for consolidation of air cargo:

\( \gamma_w = \) gross weight, the total weight in kg for a certain bid
\( v = \) volume, the total volume for a certain bid in CBM (cubic meters, \( m^3 \))
\( v_w = \) volumetric weight, the total volume for a certain bid, normalized using the 1:6 WV Ratio
\( \delta = \frac{\gamma_w}{v} \) density of cargo, as gross weight per volumetric unit, in \( \frac{kg}{m^3} \)

\( \tau_r = \) Target Rate for a given o-d lane, reference provided by the shipper
DIM Factor = 1:X Weight/Volume Ratio for a certain bid, being \( X = \frac{1000}{\frac{\gamma_w}{v}} = \frac{1000 \cdot v}{\gamma_w} \)
\( \omega_v = 1:6 \) Weight/Volume Ratio for air freight, equivalent to the maximum density (upper bound, threshold) permitted in a certain shipment on average: 167 \( \frac{kg}{m^3} \)
3.- INTEGRATED DATA MANAGEMENT SYSTEM

To build a complete, accurate and well-structured database, by creating and integrated, holistic database that combines datasets created by different teams can be a challenge for maneuverability of records and data integrity.
3.- INTEGRATED DATA MANAGEMENT SYSTEM

A database management system such as SQL Server permits to integrate the different datasets from different professional teams to help air freight forwarders to acquire a new level of proficiency in data management, by implementing a set of queries to merge pieces of information from different datasets and teams, manipulating data in an efficient way, and creating significant metrics to guide decision-making.

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3. - INTEGRATED DATA MANAGEMENT SYSTEM

SELECT
OriDes, Origin, Destination, COUNT(id) AS [#], SUM(revenue) AS [revenue], SUM(cost) AS [cost],
SUM(revenue)-SUM(cost) AS [profit], (SUM(revenue)-SUM(cost))/SUM(revenue) AS [margin],
SUM(kg_per_year) AS [shipperchkg],
SUM(carrierchkg) AS [carrierchkg],
SUM([gross weight]) AS [totgross],
SUM([Vol weight]) AS [totvol],
1-dbo.InlineMax(SUM([gross weight]), SUM([Vol weight]))/SUM([kg_per_year]) AS [cons],
SUM(cost)/SUM([kg_per_year]) AS [NAR],
(1000/167*SUM([gross weight])/SUM([vol weight])) AS [1:],
(SUM(revenue)-SUM(cost))/SUM([m3]) AS [profit/m3],
SUM([kg_per_year] * [total cost])/SUM([kg_per_year]) AS [WeightedAvgRate], SUM([vol weight]) AS [VW],
SUM([gross weight]) AS [GW],
(CASE WHEN SUM([vol weight])-SUM([gross weight])>0 THEN SUM([vol weight])-SUM([gross weight])
  WHEN SUM([vol weight])-SUM([gross weight])<=0 THEN 0 END) AS [freeGW],
(CASE WHEN SUM([gross weight])-SUM([vol weight])>0 THEN SUM([gross weight])-SUM([vol weight])
  WHEN SUM([gross weight])-SUM([vol weight])<=0 THEN 0 END) AS [freeVW],
SUM([gross weight])/dbo.InlineMax(SUM([gross weight]), SUM([Vol weight])) AS [grosseff],
SUM([vol weight])/dbo.InlineMax(SUM([gross weight]), SUM([Vol weight])) AS [voleff]
3. - INTEGRATED DATA MANAGEMENT SYSTEM

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4.- DATA SCARCITY AND SIMULATION

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.

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4.- DATA SCARCITY AND SIMULATION

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.
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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.
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4. DATA SCARCITY AND SIMULATION

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.

Lognormal Distribution

\[ f(x; \mu, \sigma) = \frac{1}{x\sigma\sqrt{2\pi}} e^{-\frac{(\ln(x) - \mu)^2}{2\sigma^2}} \]

with parameters

\[ \mu = 2.2633 \]
\[ \sigma = 0.33116 \]

An analytical model to increase air volumes and minimize the Net Achieved Rate in air freight transportation.
4. DATA SCARCITY AND SIMULATION

whereas the gross weight $\gamma_w$ values show the highest levels of goodness of fit with the Generalized Gamma Distribution.

Generalized Gamma Distribution

$$f(x; a, d, p) = \frac{p}{\Gamma(d/p)} \cdot x^{d-1} e^{-\left(\frac{x}{a}\right)^p}$$

with parameters

- $a = 0.38684$
- $b = 1906.8$
- $g = 100.0$

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5.1.- PHYSICAL PROPERTIES

<table>
<thead>
<tr>
<th>Metric</th>
<th>Definition</th>
<th>Formula &amp; Units</th>
</tr>
</thead>
<tbody>
<tr>
<td>C%</td>
<td>Consolidation percentage per lane</td>
<td>$C% = 1 - \frac{\sum_{k=1}^{n} x_i}{\sum_{k=1}^{n} \sigma_i} \ [%]$</td>
</tr>
<tr>
<td>$\Delta$</td>
<td>Consolidation Delta per lane</td>
<td>$\Delta = C%(t) - C%(i) \ [%]$</td>
</tr>
</tbody>
</table>

Average density of shipments and aggregate business opportunities by origin

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### 5.2. PROFITABILITY

#### Profitability Performance Metrics

<table>
<thead>
<tr>
<th>Metric</th>
<th>Definition</th>
<th>Formula &amp; Units</th>
</tr>
</thead>
<tbody>
<tr>
<td>$\Gamma$</td>
<td>Level of aggressiveness in bidding</td>
<td>$\Gamma = \beta / \varphi$ [°]</td>
</tr>
<tr>
<td>$\Pi_\lambda$</td>
<td>Profits per lane per year</td>
<td>[$/\text{year}$]</td>
</tr>
<tr>
<td>$\Pi_%$</td>
<td>Profitability per lane per year</td>
<td>[%]</td>
</tr>
<tr>
<td>$\beta_0$</td>
<td>Break-even rate for the whole lane</td>
<td>$\beta_0 = {\beta</td>
</tr>
<tr>
<td>$\beta_\beta$</td>
<td>Break-even rate for the bid</td>
<td>$\beta_\beta = \varphi$</td>
</tr>
<tr>
<td>$\beta_\pi$</td>
<td>Break-even rate for constant profits</td>
<td>$\beta_\pi = {\beta</td>
</tr>
<tr>
<td>$\beta_\lambda$</td>
<td>Constant profitability per lane rate</td>
<td>$\beta_\lambda = {\beta</td>
</tr>
</tbody>
</table>

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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 ($\Gamma$) when addressing the last rounds of the RFQ.

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To remain profitable for the whole current business/portfolio for a given route, air freight forwarders can use as reference values:

**Break-even Rate for Constant Profits** ($\beta_\pi$), rate guarantees the same profits in absolute numbers overall per lane. It can be used as a lower bound or minimum value to determine the rate ($\beta$) to submit to the shipper;

**Constant Profitability per Lane Rate** ($\beta_\lambda$), guarantees the same level of profitability as the current business.
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6. VISUALIZATION TOOLS

Visualization tool 01: Consolidation Delta with respect to Portfolio DIM Factor (Hong Kong – LA route)

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By selecting one bid in particular, the visualization tool displays the whole sets of meaningful variables and metrics.

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6. VISUALIZATION TOOLS

Display of underlying data table in Tableau

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7.- CONCLUSIONS

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.

FURTHER RESEARCH

To align the commercial strategy with operational procedures built upon constraints and limitations that occur at the consolidation execution level. E.g., 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.