Low-cost and Full-service carrier’s effect.

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The fare estimation model proposed in this paper was set up by analyzing the
domestic United States air transportation market 2005 year database. A division
analyses into seven different studies is presented. There exists substantial fare dispersion
in the airline transportation industry for the full-service carrier market whilst very little
dispersion can be found for the low-cost carrier market. Both airlines business models
were also divided into four different markets. Major fare dispersion has been found for
the routes dominated by full-service carriers without the presence of a low-cost carrier
and the presence of low-cost carriers make full-service carriers low fares. Routes
dominated by low-cost carriers without the presence of full-service carriers price routes
with more dispersion than the routes fighting with full-service carriers.

Keywords: Airfare pricing; Airfare pricing determinants; Airline business; Airport
business; Airline-airport relationship.

Nomenclature

\[ F_{real} = \text{real fare data} \] [dollars]
\[ F_{est} = \text{fare estimation} \] [dollars]
\[ D = \text{distance between city-pair} \] [miles]
\[ A = \text{constant} \] [dollars*miles\(^{(n+1)}\)]
\[ N = \text{constant} \] [-]
\[ f = \text{strategy cost factor} \] [-]
\[ i = \text{carrier} \] [-]
\[ C_m = \text{origin city cost factor} \] [dollars]
\[ C_k = \text{destination city cost factor} \] [dollars]
\[ m, k = \text{represent different cities} \] [-]

I. Introduction

Since the deregulation and liberalization in the 1970’s¹, the United States air transportation industry has been
in a continual state of evolution. Airline deregulation has proven to be successful and the low-cost airline
(LCC’s) business model is having a profound effect on the airline fares. The reason of this is the very low
operating costs and aggressive expansion that low-cost airlines implement as a strategy². The arrival of low-cost
 carriers has had a dramatic impact and the competition between airlines has increased³. The level of fares low-
cost airlines charged comparing to full-service carriers (FSC’s) appears to be what has made them growth and
be so competitive to other business carriers. Markets that have low-cost carriers show lower average fares
compared with markets that do not have LCC’s explaining why airlines fares are an important factor to
dominate routes, increase market share and passenger volume.

The differences between airlines cost, competition and willingness of consumers to change to another carrier
are main factors that cause different route fares⁴. Others factors affecting route fares are airport fees and airline
operation costs. Airlines choose different airports to operate according to their strategies because airport charges
have a direct implication on airline fares. Thus, airport costs must be considered when airlines price their route
tickets. Airports charge airline fees for operating routes as an origin or destination. Low-cost carriers have
performed strategies to fly from different type of airports lowering airport costs⁵ and reducing airline fares. In
other words, airports represent an important strategy to reduce the overall costs of travel⁶.

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The theory of price discrimination is commonly used to pricing in the airline markets. Price discrimination explains that airlines offer different fares to consumers who satisfy various restrictions, not a common fare for all passengers in flying the same route.

In this study, a model is proposed to estimate the average fare depending on the cities-pair and the largest carrier serving the route because the data available just include the average fare per route. The fare estimation model main problem is the existence fares dispersion between cities-pair routes with same distance but different prices.

A. Statement of problem

In the air transportation industry, the estimation of the average fare between two different cities is very helpful for airlines to make a decision whether or not to enter or exit routes. A model that calculates airline fares enable airlines to decide for themselves; what fares to charge, which markets to serve, estimate their potential revenues, profits, and the advantages and disadvantages in routes with a lot of competition.

Normally, airlines forecast fares for air transport using time series data together with econometric models by extrapolating observed patterns of growth into the future. Those statistical methods are useless when a new route is considered because no time series data is available. In that case the average ticket price could be determined by the comparison with airfares charged on a similar route. In this paper a mathematical model is proposed for calculating airfares on a certain route by a specific airline to study the effect of low-cost carriers in the United States domestic markets. This model has been set up by using data available in the United States Domestic Airline Fares Consumer Reports 2005. Each quarter of the year the United States (US) Department of Transportation Office of Aviation Analysis releases a Domestic Airline Fares Consumer Report that includes information of 1,000 largest city-pair markets in the 48 contiguous states. The reports include the number of one-way passenger trips per day, the nonstop distance, average fares per route, the average market share, the airlines with the largest market share and the airlines who offered the cheapest average fare, and their respective market shares for twenty eight United States (US) airlines, one hundred and thirty three US cities (more than one hundred thirty three airports).

B. Literature

A number of studies document the subject of airfare pricing. T.M Vowles used the same database to study airline pricing and develop an econometric model. His studies show the effect of low fare carriers on airfares in the US and concluding that pricing in hub-to-hub markets is affected by different variables such as route type, presence and type of low fare carriers, the competition in hub-to-hub markets and a classification between tourism and non-tourism cities. His results showed that low-fare carriers have a high influence in airfares determinants in the US. Windle and Dresner looked at the role of the low fare carrier entrance into air transportation markets. They found that the presence of low fare carriers in the air transport markets was significant while market concentration was not. They also studied Delta airlines reaction to ValuJet entering routes showing that fares on routes where both airlines compete went low but Delta did not increase fares on routes without competition to compensate lost revenues.

Pels and Rietveld developed models to estimate fares for different airlines. They found that FSC’s do not follow the fare movements of LCC’s. Some carrier appears to lower their fares when competitors raise their fares and all airlines increase their fares as the departure date gets closer. These results show how difficult is to estimate airfares.

K. Obeng developed a conceptual model to analyze airlines fares in a medium size market using on-line daily information fares, plane and flight characteristics, and trip characteristics collecting data using ORBITZ Internet search engine. His results show large differences in fares among the airlines, large variation in daily fares offered, and fare differentiation. Fare dispersion can originate from price discrimination (airlines that segments their customers and charges each segment different fares), Edgeworth cycles (period of time or seasonal), peak load pricing (airport charges different cost according to peak operation times) and cost differentials (different airline and airport costs).

Giaume and Guillou developed a model to explain the phenomenon of multiple prices offered in the intra-European routes collecting data on ticket prices of all flights from Nice Airport to European destinations. Their results showed that concentration and price discrimination are negatively related.

Borenstein and Oum found that when airlines have a monopoly at their hubs, consumers pay higher fares. They concluded that hubs are detrimental to low fares for consumers because there is not competition between airlines. Borenstein found that an airline with a dominant position in an airport charges higher fares than in other airports operated by the airline.

C. Research question

The aim of this paper is to propose a model to estimate fares using the distance as main factor, airport fees and airline operating costs as secondary factors. Using the model, seven analyses were developed to understand low-
cost and full-service carrier effects over the US domestic air transportation market. Chapter 2 develops the air fare model. Chapter 3 shows the analyses. Chapter 4 is a conclusion of this paper.

II. Model design and variables

From the analyses of the United States Domestic Airline Fares Consumer Reports data, it turns out that distance between origin and destination is the major factor that affects the prices level charged by airlines on the United States domestic market. The relation between the distance and the fare per miles for 4,000 dates per year that correspond to 1,000 city-pair markets, one data point per quarter year city-pair for 2005 is showed by Figure 1. The figure shows that as distance increases the unite price per mile decreases and less dispersion between data exist, i.e. the influence of other variables decreases as distance increase.

To evaluate and develop a mathematical model to estimate route fares between city-pairs a power regression analyses on the 2005 data was done. The model can be expressed as follows:

$$ F_{\text{real}} = AD^b $$  \hspace{1cm} (1)

From equation 1 a mathematical model to estimate fares based just on the distance factors is calculated using equation 2.

$$ F_{\text{est}} = AD^{b+1} $$  \hspace{1cm} (2)

A. Airline and city costs factors

Since the low-cost carrier business model appears, the routes competition between airlines has increased. It has been important for all airlines, in particular for FSC’s, to minimize the costs of their operations. Today FSC’s are applying operational costs strategies to lower their cost, drop fares and be more competitive against LCC’s fares. However, they also have developed strategies that are opposite to LCC model such as the expansion of the share capacity allocation to high fares and business class by increasing seat quality. These differences in strategies increase the dispersion fares between airlines flying different routes with same travel distances but at very different prices.

Some of the airlines’ costs affecting the strategy cost factor are: flight crew salaries and expenses, fuel and oil, airport and en-route charges, aircraft insurance, rental/lease of flight equipment/crews, engineering staff costs, spare parts consumed, maintenance administration, flight equipment, ground equipment and property, crew training, ground staff, buildings, equipment, transport, handling fees, cabin crew salaries and expenses, and passenger insurance.

Among aircraft costs affecting the strategy cost factor are: crew salaries, block hours, fuel price, aircraft performance, mile flown, labor rates, aircraft design and age, number of flight hours, aircraft size, number of departures, salaries and contract rates.

To minimize operation costs, drop fares and maximize profits, airlines apply different strategies. Those strategies can be represented by a strategy cost factor indicating which airlines are the cheapest and which are the most expensive ones. In this study airlines factor costs have been introduced and are calculated maximizing the correlation between the real fare data and the fares calculated using the fare estimation model, equation 3.

$$ F_{\text{est}} = (AD^{b+1} + C_m + C_k) f_i $$  \hspace{1cm} (3)

* American Airlines (AA), Aloha Airlines (AQ), Alaska Airlines (AS), Jetblue Airways (B6), Continental Airlines (CO), Cathay Pacific Airways (CX), Independence Air/Discovery Airways (DI), Delta Airlines (DL), Boston-Maine Airways DBA Pan Am (E9), Frontier Airlines (F9), Airtran Airways (FL), Allegiant Air (G4), American West Airlines (HP), Spirit Airlines (NK), Northwest Airlines (NW), Skywest Airlines (OO), Pan American Airways (PN), Horizon Air (QX), Sun County Airlines (SY), American Trans Air (TZ), USA 3000 Airlines (US), United Airlines (UA), US Airways (US), Southwest Airlines (WN), Casino Express (XP), Mesa Airlines (YV), Midwest Express Airlines (YX).
Variables which determine the advantages and disadvantages that airports have over each other are: geographical location, tourism, population, catchment area, accessibility and available capacity of the airports. These variables determine the contractual conditions between an airport and an airline. In other words, these variables determine whether an airport has the power to charge airlines or whether it has to finance routes in order to attract more passengers and to increase the number of passengers. In this model, the economic factor $C_i$ increase or decrease fares and represent airport and city cost factors, equation 3. Some of these airport costs are: landing fees, terminal area air navigation fee, airport noise charge, passenger charge or terminal service, cargo service charge, ground handling charge and local taxes.

Finally, in this study city factor costs $C$ have been introduced by minimizing the percentage error between the real fare data and the fares calculated using the fare estimation model.

### III. Analyses of the low-cost and full service carriers air transportation system

We start the analysis showing the correlation model results between fares estimated using the fare estimation model equation 3 and the real fares from the US Domestic Airline Fares Consumer Report data base 2005. Table 1 shows the correlation results and the constants values of the model $A$ and $n$ for the complete market, the LCC and the FSC markets separately. The model estimates fares with a correlation over 84% for the complete air transportation market as it is shown in Figure 2. The LCC market shows higher correlation over 92% meaning that this market does not have high dispersion between different routes with same distance and the model factors are good enough to estimate fares of low-cost market as it can be observed in Figure 3. On the other hand, the FSC market shows a correlation over 76% because of the different fares that full-service carriers charge to their customers flying routes with similar travel distances but very different fares per mile as it is shown in Figure 4. For this market, the model found difficult to estimate fares meaning that other factors not considered in our model have an influence on the way full-service carriers price their fares where they dominate the route market. Table 2 shows the percentage data included in the interval error of $\pm 10\%$ and $\pm 20\%$. These results confirm that the model estimates fares better for the low-cost market, 90% of the data is included in $\pm 20\%$ interval error and 61% inside the $\pm 10\%$ interval error. The results show that the model estimates fares with less confidence for the full-service market and for all the market data together. Figure 5 to 7 shows how the estimated fares errors are distributed with respect of the percentage error.

<table>
<thead>
<tr>
<th>Year 2005</th>
<th>Complete market data</th>
<th>LCC market data</th>
<th>FSC market data</th>
</tr>
</thead>
<tbody>
<tr>
<td>$A$</td>
<td>10.65</td>
<td>12.19</td>
<td>4.38</td>
</tr>
<tr>
<td>$n$</td>
<td>-0.60</td>
<td>-0.63</td>
<td>-0.48</td>
</tr>
<tr>
<td>$R$</td>
<td>0.84</td>
<td>0.92</td>
<td>0.76</td>
</tr>
<tr>
<td>$R^2$</td>
<td>0.70</td>
<td>0.84</td>
<td>0.58</td>
</tr>
<tr>
<td>Routes</td>
<td>4000</td>
<td>1420</td>
<td>2580</td>
</tr>
</tbody>
</table>

Figure 2. Correlation analysis 2005 between fares estimated and real fares data

Figure 3. Correlation analysis LCC market 2005 between fares estimated and real fares data.

Figure 4. Correlation analysis FSC market 2005 between fares estimated and real fares data.

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The results can be considered as a very high correlation between the fares estimated with the model and the real fares data showing that airlines and mainly cities or airport costs have a high influence in the fares charge to the customers flying different routes with same distances.

Table 2. Percentage of data interval errors.

<table>
<thead>
<tr>
<th></th>
<th>±10% error</th>
<th>±20% error</th>
</tr>
</thead>
<tbody>
<tr>
<td>2005 market</td>
<td>40%</td>
<td>70%</td>
</tr>
<tr>
<td>FSC market</td>
<td>40%</td>
<td>72%</td>
</tr>
<tr>
<td>LCC market</td>
<td>61%</td>
<td>90%</td>
</tr>
</tbody>
</table>

Figure 5. Error distribution market data 2005.
Figure 6. Error distribution FSC market.
Figure 7. Error distribution LCC market 2005.

Figure 8 shows the factors cost for twenty one airlines. As it was expected, FSC operation costs are higher than low cost carriers. Frontier Airlines (F9) is the only low cost carrier that shows very high operation costs, as much as the FSCs during 2005.

The city costs factor \((C's)\) for all the United States city-pair markets are shown in Figure 9. A negative city cost factor means that the estimated fare will be lower. Cities in this case appear to charge cheaper fees to airlines than the cities with positive cost factors. The negative cost factor means that those cities have cheaper fares. Thus, when \(C>0\) fares are higher and if \(C<0\) fare are lower.

Cincinnati, Memphis and Charlotte have the most expensive city costs factors over 50 dollars. The majority of the cities have cost between 20 and -20 dollars. City hubs such as New York, Dallas Ft. Worth and Atlanta have cost between 20 and 50 dollars. Most of the cities have cost factors less than -20 dollars. Finally, the cities with the lowest city cost factors are in tourism places. Fort Lauderdale, Fort Myers, West Palm Beach, Orlando and Tampa have the lowest cost factors. These can be explain by the fact that city governments mainly based on tourism economy can reduce taxes, as a strategy, to help airlines low fares and increase passenger volume and tourism. The increment of tourism is a benefit for the city because economic factors will growth such as GDP and Income per capita. At the same time, the increment of passenger using the city airport increase airport non-aeronautical revenues.
A. Airlines business models competition.

In this section a competition analyses is presented. The United States Domestic Airline Fares Consumer Report includes information of the airlines with the largest market share and the airlines who offered the cheapest average fare in each route. Depending on the type of airline with the largest market share and the airline who offered the lowest fare per route, we have divided the database into four different groups: Routes dominated by low-cost carriers (LCC-LCC), Routes dominated by low-cost carriers in competition with full-service carriers (LCC-FSC), Routes dominated by full-service carriers (FSC-FSC) and Routes dominated by full-service carriers in competition with low-cost carriers (FSC-LCC).

Table 3 shows the constants values \( A \) and \( n \), and the correlations between the fare estimation model and real fares for four different cases. From table 3 the results explain that the routes dominated by full-service carrier’s price their routes with different fares for similar travel distance generating more dispersion to the fare estimation model than the routes dominated by the low-cost carriers.

The full-service carrier market division groups (FSC-LCC and FSC-FSC) show better correlation results than the study for the complete full-service carrier market. The air transportation market has more routes dominated by full-service carriers with 2580. We found that when a low-cost carriers is offering the lowest fare in a market dominated by a full-service carrier, the low-cost carrier is making the full-service carriers to low fares to keep the routes market share, whilst for the case of the FSC-FSC the airlines does not feel competition from low-cost carriers showing the highest fare of the market. In both cases we found higher dispersion than in the LCC market with correlations over 79% and 80% for the FSC-LCC and FSC-FSC markets respectively as they are shown in Figure 10 and Figure 11. The division of the FSC market into FSC-LCC and FSC-FSC is convenient and allows the model to have better estimation fares. Table 4 shows the percentage data included in the estimation error of ±10 and ±20 error. These results confirm that the errors diminished for the FSC-FSC

<table>
<thead>
<tr>
<th>Models</th>
<th>LCC-LCC</th>
<th>LCC-FSC</th>
<th>FSC-LCC</th>
<th>FSC-FSC</th>
</tr>
</thead>
<tbody>
<tr>
<td>( A )</td>
<td>9.72</td>
<td>9.25</td>
<td>7.31</td>
<td>17.22</td>
</tr>
<tr>
<td>( N )</td>
<td>-0.62</td>
<td>-0.60</td>
<td>-0.53</td>
<td>-0.65</td>
</tr>
<tr>
<td>( R )</td>
<td>0.93</td>
<td>0.95</td>
<td>0.79</td>
<td>0.80</td>
</tr>
<tr>
<td>( R^2 )</td>
<td>0.86</td>
<td>0.91</td>
<td>0.62</td>
<td>0.63</td>
</tr>
<tr>
<td>Number of routes</td>
<td>1134</td>
<td>286</td>
<td>1043</td>
<td>1537</td>
</tr>
</tbody>
</table>

Table 3. Fare estimation model constants values \( A \) and \( n \), and correlation results competition analyses.
market, 50% of the data is included in ±20 error and 80% inside the ±10 error, whilst for the FSC-LCC market also diminished, 55% of the data is included in ±20 error and 77% inside the ±10 error. Figure 12 to Figure 13 shows how the estimated fares errors are distributed with respect of the percentage error.

The low-cost carrier market has 1134 routes. From the database we know that 1420 routes where dominated by a low-cost carrier and 2580 routes by a full-service carriers. From the 1420 routes, full-service carriers offer the lowest fare in 286 routes trying to compete and win more market share competing against the low-cost carriers. Southwest is the airline dominating more routes. Figure 14 and Figure 15 shows that the model estimates fares with a correlation over 93% for the LCC-LCC market and 95% for the LCC-FSC market. The low-cost market division does not show a substantial correlation increment. Even thought, Table 5 shows the percentage data included in the estimation error of ±10% and ±20%. These results confirm that the errors almost disappear for the LCC-FSC market, 99% of the data is included in ±20% error and 88% inside the ±10% error. For the LCC-LCC market the model estimates fares with the same error percentages as for the low-cost market, 90% of the data is included in ±20% error and 64% inside the ±10% error. Figure 16 to 17 shows how the estimated fares errors are distributed with respect of the percentage error for the LCC-LCC and LCC-FSC markets respectively. This result shows that when a low-cost carrier does not have high competition from full-service carriers, the airlines fare routes with more freedom producing more fare dispersion.

<table>
<thead>
<tr>
<th>Table 4. Percentage of data interval errors FSC-FSC and FSC-LCC markets.</th>
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<tbody>
<tr>
<td>±10%</td>
</tr>
<tr>
<td>FSC-FSC</td>
</tr>
<tr>
<td>FSC-LCC</td>
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<tr>
<th>Table 5. Percentage of data interval errors LCC-FSC and LCC-LCC markets.</th>
</tr>
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<tbody>
<tr>
<td>±10%</td>
</tr>
<tr>
<td>LCC-FSC</td>
</tr>
<tr>
<td>LCC-LCC</td>
</tr>
</tbody>
</table>

IV. Conclusion

This study confirms that the best relationship variables to estimate fares between two cities are FARE/DISTANCE VS DISTANCE. The relation found shows that as distance increases the unite price per mile decrease and less dispersion between data exist.
Since the low-cost carrier business model appears, the route competition between airlines has increased. The different kinds of airlines apply different strategies that increase the fare dispersion between airlines flying different routes with same travel distances but at different prices. Airports also charge different fees according with the agreements they have with airlines flying their connection routes to other airports.

The model correlation results shows over 84% for the complete 2005 year air transportation market what can be considered as a good correlation results. Even though, when separating air transportation data into full-service carriers and low-cost carriers according with the airline dominating each route, better correlation result was found for the low-cost carriers market over 92%. The division into two separated markets shows that full-service carriers charge to their customers very different fares per mile depending on the routes where they have the domination. For this market, the model found difficult to estimate fares meaning that other factors not considered in the proposed model has an influence on the way full-service carriers price their fares where they dominate the route market. The model estimates fares better for the low-cost market, 90% of the data is included in ±20% interval error and 61% inside the ±10% interval error. The results can be considered as a very high correlation between the fares estimated with the model and the real fares data showing that airlines and meanly cities or airport costs have a high influence in the fares charge to the customers flying different routes with same distances.

Depending on the type of airline with the largest market share and the airline who offered the lowest fare per route, we have divided the database into four different groups: Routes dominated by low-cost carriers (LCC-LCC), Routes dominated by low-cost carriers in competition with full-service carriers (LCC-FSC), Routes dominated by full-service carriers (FSC-FSC) and Routes dominated by full-service carriers in competition with low-cost carriers (FSC-LCC). The full-service carrier market division groups (FSC-LCC and FSC-FSC) show better correlation results that the study for the complete full-service carrier market 79% and 80% respectively. The division of the FSC market into FSC-LCC and FSC-FSC is convenient and allows the model to have better estimation fares. When a low-cost carrier is offering the lowest fare in a market dominated by a full-service carrier, the low-cost carrier is making the full-service carriers to low-fares and keep routes market share, whilst for the FSC-FSC the airlines do not feel enough competition to low fares.

On the other hand, for the low-cost carrier market division (LCC-LCC and LCC-FSC) the models estimate fares with better correlation results, over 79%. Even though, the complete LCC market result is good enough and it would not be necessary to divide this market.

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References


