Airfare Impact: LCC vs. FSC Models & Key Factors

Portfolio Project By Omar Mendy

Overview

This analytical approach aims to determine the most suitable business model (LCC or FSC) for the hypothetical airline, considering both passenger counts and flight distance.

Dataset

Found in J.M. Wooldridge's book, 'Introductory Econometrics: A Modern Approach' (6th edition), and accessible via the 'Wooldridge' package in 'R', this dataset offers an overview that can be examined online. To have an overview of the dataset, visit the Boston College website at the following link: http://fmwww.bc.edu/ec-p/data/wooldridge2k/AIRFARE.DES

TABLE 1: AIRFARE DATASET DATAFRAME (HEAD)

Index	Year	ID	Dist	Passen	Fare	Bmktshr	ldist	Y98	Y99	Y00	Lfare	Ldistsq	Concen	Lpassen
1997-1	1997	1	528	152	106	0.8386	6.269096	0	0	0	4.663439	39.30157	0.8386	5.023880
1997-2	1997	2	861	282	104	0.5798	6.758094	0	0	0	4.644391	45.67184	0.5798	5.641907

TABLE 2: AIRFARE DATASET DATAFRAME (TAIL)

Index	Year	ID	Dist	Passen	Fare	Bmktshr	Ldist	Y98	Y99	Y00	Lfare	Ldistsq	Concen	Lpassen
2000-1144	2000	1144	1105	169	134	0.6235	7.007601	0	0	1	4.897840	49.10647	0.6235	5.129899
2000-1145	2000	1145	298	162	193	0.9510	5.697093	0	0	1	5.262690	32.45687	0.9510	5.087596

Airline Business Models Overview

The airline industry features three primary business models: Full-Service Carrier (FSC), Low-Cost Carrier (LCC), and Charter Carrier (CC). LCCs emphasise route profitability by utilising cost-effective aircraft on in-demand, high-frequency regional routes centred around a few key hubs. In contrast, FSCs prioritise long-haul flights to boost network profitability, even if some routes underperform. Although FSCs have higher operating costs than LCCs for equivalent routes and fares, they offset these expenses by offering a wider array of services and targeting less competitive, often long-distance, routes where customers are less price sensitive.

Carrier Model	Focus	Key Features	Benefits
Low-Cost Carrier (LCC)	Cost-efficiency and affordability	Simplified fare structures, reduced operational costs, and fewer amenities	Lower airfares, increased accessibility for budget-conscious passengers, and potential for higher passenger volumes
Full-Service Carrier (FSC)	Passenger experience and premium services	Comprehensive fare structures, higher operational costs, and extensive amenities and services	Enhanced in-flight experience, tailored services for various passenger segments, and potential for higher customer loyalty

Competitive landscape

Statistical method	Aim
Panel Regression	Assessing the overall relationship between passenger counts, flight distance, and airfare, and to to identify any potential trade-offs between the LCC and FSC business models
Year-wise Analysis (Fixed Effect Model)	Investigating yearly variations in the impact of passenger counts and flight distance on airfare
Sensitivity Analysis	Testing the robustness of our findings by altering key assumptions and model specifications
Subgroup Analysis	Exploring how the effects of passenger counts and flight distance on airfare differ across various market segments
Outlier Analysis	Identifying potential anomalies that may influence the overall results

Analyses

1. Panel Regression: Pooled Ordinary Least-Squares Model
2. Panel Regression: Heteroscedacity, Hausman & Fixed-Effect Model
3. Panel Regression: Random Effects Model
4. Year-wise Analysis (Using Fixed Effect Model)
5. Sensitivity Analysis
6. Subgroup Analysis
7. Outlier Analysis & Regression Model

Pooled Ordinary least-squares (OLS) Models

The OLS results using lm and plm functions show similar coefficients and significance levels. The interpretation of the coefficients is as follows:

1. y98 (year 1998): The coefficient is 0.026 and is significant at the 10% level ($p<0.1$). This means that, on average, airfares in 1998 were about 2.6% higher than the base year (not included in the model), holding all other variables constant.
2. y99 (year 1999): The coefficient is 0.040 and is significant at the 5% level ($p<0.05$). This suggests that airfares in 1999 were on average 4.0% higher than the base year, ceteris paribus.
3. y00 (year 2000): The coefficient is 0.103 and is significant at the 1% level ($p<0.01$). This indicates that airfares in 2000 were on average 10.3% higher than the base year, holding all other factors constant.
4. ldist (natural logarithm of distance): The coefficient is 0.390 and is significant at the 1% level ($p<0.01$). This means that a 1% increase in distance is associated with a 0.39% increase in airfare, all else equal.
5. lpassen (natural logarithm of passengers): The coefficient is -0.083 and is significant at the 1% level ($p<0.01$). This suggests that a 1% increase in passengers is associated with a 0.083% decrease in airfare.

The model has an R-squared of 0.405, meaning that approximately 40.5% of the variation in airfare can be explained by the independent variables included in the model. The F-statistic (623.656) is significant at the 1% level, indicating that the model is overall statistically significant.

```
> summary(pooled2)
Pooling Model

Call:
plm(formula = lfare ~ y98 + y99 + y00 + ldist + lpassen, data = airfare_df,
    model = "pooling")

Balanced Panel: n = 4, T = 1149, N = 4596

Residuals:
     Min.   1st Qu.    Median   3rd Qu.      Max.
-1.291418 -0.270828 -0.043955  0.261082  0.981858

Coefficients:
              Estimate Std. Error  t-value  Pr(>|t|)
(Intercept)  2.9457571  0.0650188  45.3063 < 2.2e-16 ***
y98          0.0258724  0.0140577   1.8404  0.065769 .
y99          0.0402396  0.0140617   2.8616  0.004234 **
y00          0.1029086  0.0140654   7.3164  2.99e-13 ***
ldist        0.3896167  0.0075902  51.3318 < 2.2e-16 ***
lpassen     -0.0833423  0.0056651 -14.7115 < 2.2e-16 ***
---
Signif. codes:  0 ‘***’ 0.001 ‘**’ 0.01 ‘*’ 0.05 ‘.’ 0.1 ‘ ’ 1

Total Sum of Squares:    875.09
Residual Sum of Squares: 521.09
R-Squared:      0.40454
Adj. R-Squared: 0.40389
F-statistic: 623.656 on 5 and 4590 DF, p-value: < 2.22e-16
```

Heteroscedasticity & Hausman tests with Fixed Effect Model

Tests

1. Heteroscedasticity test: The plots of residuals against the average passengers per day and fitted values show no clear pattern or change in the variance of the residuals as the fitted values increase. This indicates that there is no heteroscedasticity observed in the model.
2. Hausman Test and Fixed Effects Model: The Hausman test determines whether to use a fixed effects (FE) or random effects models in panel data analysis. In this case, the output shows the results of the fixed effects model.

Conclusion

The fixed effects model has an overall R-squared of 0.50047, higher than the R-squared of 0.405 from the previous OLS model. The adjusted R-squared is 0.33333. The F-statistic is 862.363 with 4 and 3443 degrees of freedom, and the p-value is significant at < 2.22e-16, indicating that the model is overall statistically significant.

Looking at the coefficients, all the independent variables (lpassen, y98, y99, y00) are significant at the 1% level. The negative coefficient of lpassen (-0.3703994) suggests that as the natural logarithm of passengers increases, the natural logarithm of airfare decreases. The positive coefficients for y98, y99, and y00 indicate that, compared to the base year, airfares were higher in these years. The fixed effects model improves the explanatory power (R-squared) compared to the OLS model, and all the independent variables are statistically significant. There is no evidence of heteroscedasticity in the model.

Panel Regression

This analytical approach aims to determine the most suitable business model (LCC or FSC) for the hypothetical airline, considering both passenger counts and flight distance.

Airline Business Models Overview

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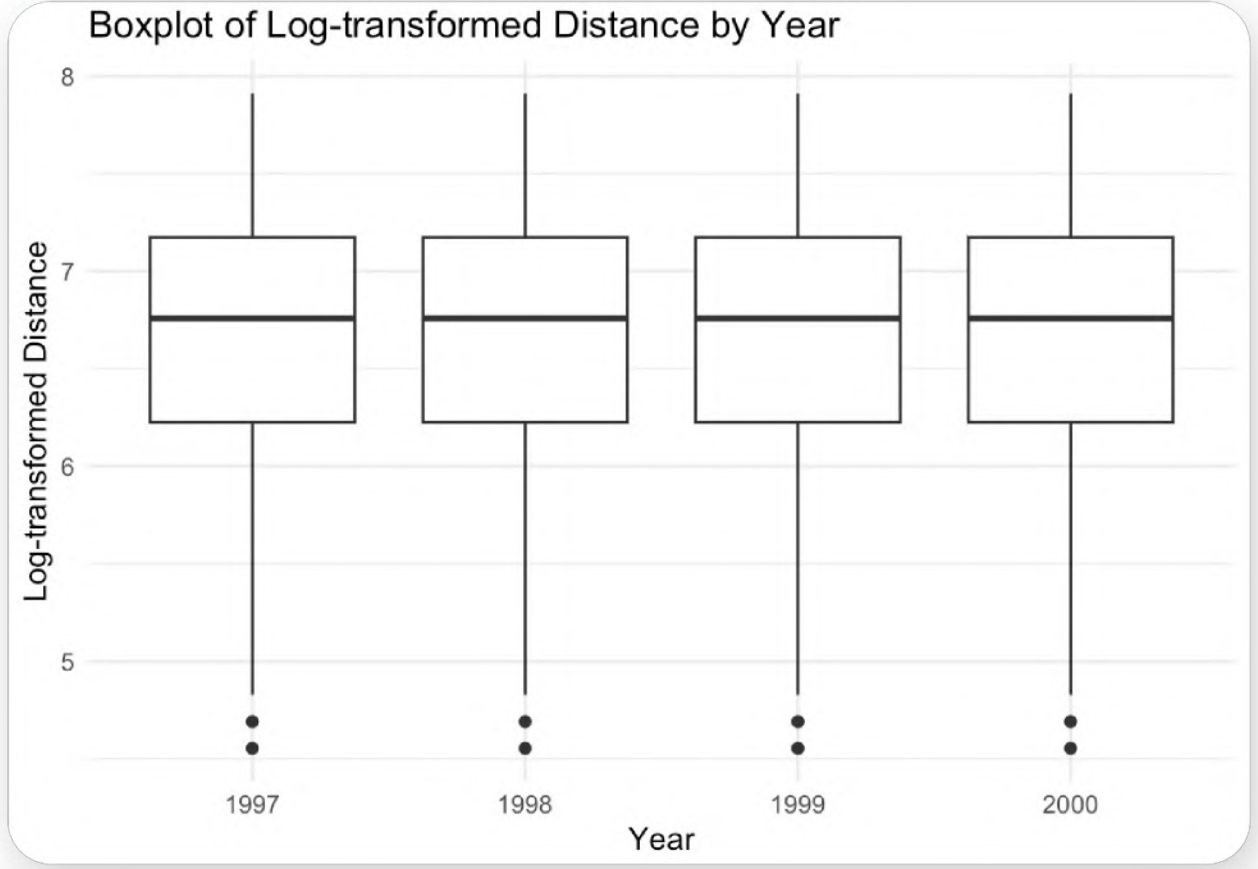
Sensitivity Analysis



Outlier Analysis

- No outliers found in boxplots for lfare, lpassen, and ldist
- Data is relatively clean and well-distributed

Regression Model Summary: Effects on Airfare (lfare)

1. Passenger Counts (lpassen)
   - Estimate: -0.083 (1% increase in passengers → 0.083% decrease in airfare)
   - Highly statistically significant (p-value = 6.61e-48)

2. Flight Distance (ldist)
   - Estimate: 0.390 (1% increase in flight distance → 0.390% increase in airfare)
   - Highly statistically significant (p-value ≈ 0)

Interpretation

- Both passenger counts and flight distance significantly affect airfare
- Increase in passenger counts leads to decrease in airfare (LCC business model)
- Increase in flight distance leads to increase in airfare (FSC business model)
- Airline should consider these trade-offs when deciding on business model

Suggestion

- Hypothetical airline may benefit from the LCC model, considering the sensitivity of airfare to passenger counts

Year-wise Analysis (Using Fixed Effect Model)

```
Oneway (individual) effect Within Model

Call:
plm(formula = lfare ~ lpassen + ldist, data = airfare_2000, model = "within")

Balanced Panel: n = 1, T = 1149, N = 1149

Residuals:
     Min.   1st Qu.    Median   3rd Qu.      Max.
-0.638732 -0.261674 -0.054696  0.245612  0.941579

Coefficients:
         Estimate Std. Error t-value  Pr(>|t|)
lpassen -0.084054   0.010655 -7.8889 7.072e-15 ***
ldist    0.361544   0.014808 24.4147 < 2.2e-16 ***
---
Signif. codes:  0 ‘***’ 0.001 ‘**’ 0.01 ‘*’ 0.05 ‘.’ 0.1 ‘ ’ 1

Total Sum of Squares:    199.66
Residual Sum of Squares: 125.04
R-Squared:      0.37374
Adj. R-Squared: 0.37264
F-statistic: 341.949 on 2 and 1146 DF, p-value: < 2.22e-16
```

Conclusion

- Airfare seems more sensitive to passenger counts than flight distance
- The hypothetical airline may benefit more from adopting a Low-cost carrier (LCC) business model
- Consider other factors (cost structure, market demand, competitive landscape) before making a final decision

Key Findings

1. *lpassen (log-transformed average number of passengers per day)*
   - Estimated coefficient: -0.084 (significant at 0.001 level)
   - Interpretation: A 1% increase in passenger count leads to a 0.084% decrease in airfare, holding flight distance constant
   - Implication: Aligns with the LCC model, which focuses on attracting more passengers through lower airfares

2. *ldist (log-transformed flight distance)*
   - Estimated coefficient: 0.362 (significant at 0.001 level)
   - Interpretation: A 1% increase in flight distance leads to a 0.362% increase in airfare, holding the passenger count constant
   - Implication: Consistent with both LCC and FSC models, as longer flights tend to have higher operating costs

R-Squared

- Value: 0.37374 (approx. 37.4% of variation in airfare is explained by passenger counts and flight distance)
- Interpretation: Passenger counts and flight distance have some explanatory power, although the value is low

Sensitivity Analysis

Model 1 (No Interaction): Fixed effects model without an interaction term between passenger counts and flight distance.

AIC = 3041.278

Model 2 (Interaction): Fixed effects model with an interaction term between passenger counts and flight distance.

AIC = 2806.388 *(Lowest AIC Value)*

Model 3 (Quadratic): Fixed effects model with a quadratic term for flight distance.

AIC = 2943.912

Best Model: Model 2 (Interaction) is the best fit, as it has the lowest AIC value, suggesting a significant impact of the interaction between passenger counts and flight distance on airfare.

AIC_fe_interaction	2806.38801639072
AIC_fe_model1	3041.2777008838
AIC_fe_quad	2943.91211188953
res	Named num [1:4596] -0.306 -0.286 -0.216 -0.204 -0.464 ...
yhat	Named num [1:4596] 4.97 4.95 4.94 5.02 5.11 ...

Subgroup Analysis

```
> summary(short_haul_fe)
Oneway (individual) effect Within Model

Call:
plm(formula = lfare ~ lpassen * ldist + factor(year), data = short_haul,
    model = "within")

Balanced Panel: n = 4, T = 915, N = 3660

Residuals:
     Min.   1st Qu.    Median   3rd Qu.      Max.
-1.354258 -0.256113 -0.046704  0.265556  1.129960

Coefficients:
               Estimate Std. Error  t-value  Pr(>|t|)
lpassen       -1.085674   0.071487 -15.1870 < 2.2e-16 ***
ldist         -0.612232   0.068929  -8.8821 < 2.2e-16 ***
lpassen:ldist  0.153732   0.011175  13.7572 < 2.2e-16 ***
---
Signif. codes:  0 ‘***’ 0.001 ‘**’ 0.01 ‘*’ 0.05 ‘.’ 0.1 ‘ ’ 1

Total Sum of Squares:    600.2
Residual Sum of Squares: 419.83
R-Squared:      0.30052
Adj. R-Squared: 0.29937
F-statistic: 523.146 on 3 and 3653 DF, p-value: < 2.22e-16
```

```
> summary(long_haul_fe)
Oneway (individual) effect Within Model

Call:
plm(formula = lfare ~ lpassen * ldist + factor(year), data = long_haul,
    model = "within")

Balanced Panel: n = 4, T = 234, N = 936

Residuals:
     Min.   1st Qu.    Median   3rd Qu.      Max.
-0.631492 -0.208477  0.034125  0.192991  0.705746

Coefficients:
               Estimate Std. Error t-value Pr(>|t|)
lpassen       -0.458581   0.454806 -1.0083   0.3136
ldist          0.325839   0.359505  0.9064   0.3650
lpassen:ldist  0.063156   0.059756  1.0569   0.2908

Total Sum of Squares:    75.179
Residual Sum of Squares: 61.462
R-Squared:      0.18246
Adj. R-Squared: 0.17718
F-statistic: 69.1127 on 3 and 929 DF, p-value: < 2.22e-16
```

Long-haul flights:

- No significant coefficients: lpassen, ldist, lpassen:ldist (p-value > 0.05)
- Unclear relationship between passenger counts, flight distance, and airfare
- Insufficient evidence to suggest preference for LCC or FSC business model
- Recommendation: Conduct further research or consider a hybrid business model for long-haul flights

Short-haul flights:

- Significant coefficients: lpassen, ldist, lpassen:ldist (p-value < 0.001)
- Increased passenger counts and decreased flight distance associated with lower airfare
- Effect of passenger counts on airfare varies depending on flight distance
- Recommendation: Focus on Low-cost carrier (LCC) business model for short-haul flights

Additional considerations:

- Consider other factors (e.g., market demand, competition, operational costs)
- Perform additional analyses before making a final decision

Findings

Analyses

Year-wise Analysis (using Fixed Effect Model)

- Both passenger counts and flight distance significantly affect airfare
- An increase in passenger counts leads to a decrease in airfare (supports LCC model)
- An increase in flight distance leads to an increase in airfare (supports FSC model)

Subgroup Analysis

- The hypothetical airline may benefit from the LCC model, considering the sensitivity of airfare to passenger counts.

Outlier Analysis

- Data is relatively clean and well-distributed, ensuring reliable results.

Sensitivity Analysis

- LCC model recommended for short-haul flights
- Further research or a hybrid model suggested for long-haul flights

Conclusion:

Our analyses suggest that the hypothetical airline should consider the LCC business model, particularly for short-haul flights, as airfare is sensitive to passenger counts. Further research and exploration of a hybrid model should be considered for long-haul flights to maximise profitability and cater to diverse customer needs

Recommendations & Future Research

Target Audience & Market Position

- Focus on attracting price-sensitive travellers, as airfare is sensitive to passenger counts
- Consider targeting short-haul flights, where the LCC model appears to be most effective

Strategic Recommendations

- Adopt the LCC model for short-haul flights to maximise profits from higher passenger counts and lower airfares
- Explore the possibility of offering premium services for long-haul flights, potentially adopting a hybrid model to cater to different customer segments

Future research & Analysis

- Conduct additional studies to confirm the most suitable business model for the hypothetical airline, based on other factors (e.g., market conditions, competition, operational costs, etc.)
- Explore the potential benefits of a hybrid model, especially for long-haul flights

Links

GitHub

https://github.com/OLMENDY/Time-Series-and-Panel-Data-Analysis-of-Airfare-Pricing-Strategies

LinkedIn

https://www.linkedin.com/in/omar-mendy/

Code

https://github.com/OLMENDY/Time-Series-and-Panel-Data-Analysis-of-Airfare-Pricing-Strategies/blob/main/Omar%20Mendy%20%7C%20Portfolio%20Project%20%7C%20Passenger%20airfare

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