EMPIRICAL INDUSTRIAL ORGANIZATION

UPDATED TAKE-HOME EMPIRICAL PROJECT

BASED ON THE ORIGINAL VERSION

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1 INTRODUCTION

Before the 2008 financial crisis, U.S. airlines had been leading the market in the global airline transportation industry. In 2007, U.S. domestic and foreign airlines serving the United States had an all-time record of 838.4 million passengers on scheduled routes according to TransportationStatistics (2015). However, due to the financial crisis of 2008, the global airline market has been hit hard, and the prosperous US domestic airline market is no exception. Since 2009, the number of passengers in the airline market in the United States has stepped out of the trough and has shown an increasing trend year by year. And finally broke the historical record set in 2007 with a 1.2 percent advantage in 2014. Since then, until the coronavirus pandemic in 2019, the US domestic aviation industry has continued to expand for five years.

We are interested in measuring the competition in the US domestic airlines market in successful 2014 breakout of all-time highs. Our original data source is the US domestic airline market in Q2 2014, from the DB1B database provided by the US Department of Transportation. Inspired by Berry (1992), which focused on firm heterogeneity, we would like to apply an empirical entry model to study the degree of competition between firms with different market conditions. Cleeren et al. (2010) which studied two types of companies, suggests an entry model to study the intra-format and inter-format competition. Although airlines are quite different from the grocery industry in terms of attributes, this paper still motivates us to apply an analogy between Legacy Carriers and Low-Cost Carriers in the US domestic market with supermarkets and discounters, and study the competition of inter- and intra-format in the US domestic airline market. To adapt to Cleeren et al. (2010), we defined US Airways (US), American Air-lines (AA), Delta Airlines (DL), Southwest Airlines (WN) and United Airlines (UA) as the legacy carriers (LEG). The rest of the airlines are the Low Cost Carriers (LCC).

The purpose of this project is to apply the study of Cleeren et al. (2010), Intra- and Inter-Format competition among discounters and supermarkets to the US domestic airline market. We will focus on the two types of carriers, legacy carriers and low cost carriers.

2 DATA AND AIRLINES

2.1 Treatment of the Data

We first selected the important variables which will be explained later. Then grouped by market, the data are aggregated so that an observation consists of one market, the number of legacy carriers, the number of low cost carriers, and other explanatory variables. The final dataset consists of 875 markets.

2.2 Control Variables

We use the same control variables as Ciliberto and Tamer (2003).
- $Distance$ is the distance between the two-end points.
- $Population$ is a proxy of market size, which is one of the important factors for a company to enter the market.
- AA, DL, WN are the presence of American Airlines, Delta Airlines, and Southwest Airlines in one market, respectively.

- AL is the existence of another large carrier after considering the above three airlines.
- OS is the existence of at least one small carrier.

According to Ciliberto and Tamer (2003), the difference between large and small carriers is the number of markets they serve. Large carriers are airlines serving more than 16 markets.

2.3 Descriptive Analysis

Airline percentage in 875 markets are: AA, DL and WN exist in 19.09%, 35.43% and 63.77% of markets respectively. 51.66% of the market has other large airlines. 31.31% of markets have at least one small airline. More variable information can be found in the table.

[Insert Table 1 here]

We build a contingency table to present the number of carriers per type of LEG and LCC. In our data, each market has a maximum of 4 LEGs and a maximum of 4 LCCs. Nearly half of the markets have one legacy carrier (46.97%, LEG=1). And about half of the markets have one low cost carrier (48.57%, LCC=1). Starting from the coordinate (1,1), the percentage decreases as the number of companies increases. There are 179 markets with no LCC but one LEG, accounting for 20.46%. And 187 markets with no LEG and one LCC, accounting for 21.37%. Overall, the market as a whole is concentrated in the range of # of LCC or # of LEG ≤ 2, which cover over 90% of the markets (821 of 875 and 803 of 875).

[Insert Table 2 here]

According to the quartile of the market size variable, we divide the market into 4 scales: small with $msize \in (0, 4.16]$, medium-small with $msize \in (4.16, 7.47]$, medium-large $msize \in (7.47, 13.76]$ and large market $msize \in (13.76, max(msize)]$.

In each market size scale, when we look at the log of distance and of population, we come to the same conclusion as Ciliberto and Tamer (2003), that is, the means of the $LogDistance$ and of the $LogPopulation$ are similar across market size scales. That means the demographic and technological characteristics of the market do not differ significantly for different market sizes. However, the characteristic of number of total carriers (the sum of LEG and LCC) in our data shows a different performance. The larger the market is, the larger the total number of carriers there is. And the variation in the number of carriers decreases with the market size scale.

[Insert Table 3 here]

To further explore the explanation of the variation in the number of carriers by the size of the potential demand, we show the distribution of the number of carriers by market size scales for LEG and LCC, respectively. Observing the distribution of the number of carriers by market size, we find that the distribution of LCC is more homogeneous than that of LEG. And a large market must have at least one LEG carrier but may have no LCC (see coordinate (0, Large)).

[Insert Table 4 here]

[Insert Table 5 here]

In more detail, the first three rows of table 4 show that the number of markets varies significantly with the market size. In the first three rows, the number of markets in small size markets decreases as there are more LEG carriers, and conversely, markets in large size markets increase. Looking at all rows, for all market size scales, when LEG reaches a certain number, the number of markets will begin to decrease, and the number of large size markets decreases the slowest in all markets (from LEG=2 to 4). It is also the slowest in table 5. However, in table 5, the number of markets in each row and vertical trends in the first three rows do not present greater variations than those in table 4. That is, the number of LCCs is not as sensitive to changes in market size as LEGs. This also implies the characteristic of # of Carriers in table 3 explained by market size was much largely brought by LEG carriers.

3 ENTRY MODEL WITH PRESELECTED TYPES

3.1 Model

The profitability model of a type i is defined as:

$$\pi_i\left(N_{LEG}, N_{LCC}\right) = \alpha_i MSIZE + \beta_i X_m - \lambda_i\left(N_i\right) - \gamma_i\left(N_{-i}\right)/N_i, i = LEG, LCC.$$

where, X_m are the explanatory variables of market characteristics, $\lambda_i^{N_i}$ and $\gamma_i^{N_{-i}}$ are fixed effects, respectively explaining the impact of the number of intra-format and inter-format companies.

3.2 Assumptions: Intra-format substitutability and Inter-format substitutability

In this section, we follow exactly the assumptions suggested in Cleeren et al. (2010).

Assumption 1: Like Cleeren et al. (2010), our first assumption is that airlines in the same category negatively influence each other's profitability, i.e., intra-format substitutability.

$$\pi_S\left(N_{LEG}+1, N_{LCC}\right) < \pi_S\left(N_{LEG}, N_{LCC}\right)$$
$$\pi_D\left(N_{LEG}, N_{LCC}+1\right) < \pi_D\left(N_{LEG}, N_{LCC}\right)$$

Assumption 2: we assume that competitors of the other type produce negative impacts as well on profitability.

$$\pi_S\left(N_{LEG}, N_{LCC}+1\right) \leq \pi_S\left(N_{LEG}, N_{LCC}\right)$$
$$\pi_D\left(N_{LEG}+1, N_{LCC}\right) \leq \pi_D\left(N_{LEG}, N_{LCC}\right).$$

In addition to the second assumption, we also assume that, the substitubility is greater in intra-format than inter-format.

$$\pi_S\left(N_{LEG}+1, N_{LCC}-1\right) < \pi_S\left(N_{LEG}, N_{LCC}\right)$$
$$\pi_D\left(N_{LEG}-1, N_{LCC}+1\right) < \pi_D\left(N_{LEG}, N_{LCC}\right).$$

3.3 Equilibrium

Based on the assumptions below, we then are able to derive the Nash Equilibrium.

First, any company will only stay in the market if profit is greater than 0, and if an additional company of same firm will result in profit of less than 0, then a Nash equilibrium is formed. In this way, the profit functions of the two major categories in our analysis, LEG and LCC, satisfy the following conditions:

$$\begin{cases} \pi_{LEG}\left(N_{LEG}, N_{LCC}\right) - \varepsilon_{LEG} \geqslant 0 \\ \pi_{LEG}\left(N_{LEG}+1, N_{LCC}\right) - \varepsilon_{LEG} < 0 \end{cases} \begin{cases} \pi_{LLC}\left(N_{LEG}, N_{LCC}\right) - \varepsilon_{LCC} \geqslant 0 \\ \pi_{LCC}\left(N_{LEG}, N_{LCC}+1\right) - \varepsilon_{LCC} < 0 \end{cases}$$

Combining the above equations, we then can draw the Nash Equilibrium, where the market shocks ε_{LEG} and ε_{LCC} satisfy the following conditions:

$$\begin{gathered} \pi_{LEG}\left(N_{LEG}+1, N_{LCC}\right) < \varepsilon_{LEG} \leq \pi_{LEG}\left(N_{LEG}, N_{LCC}\right) \\ \pi_{LCC}\left(N_{LEG}, N_{LCC}+1\right) < \varepsilon_{LCC} \leq \pi_{LCC}\left(N_{LEG}, N_{LCC}\right). \end{gathered}$$

However, according to Bresnahan and Reiss (1991), some Nash equilibria also exist in some realizations of the error terms, which will lead to a multiplicity problem. To explain these Nash equilibria more clearly, we can consider two multiplicity areas:

(1) The area of multiplicity with $(N_{LEG}+1\ , N_{LCC}-1)$

$$\begin{cases} \pi_{LEG}\left(N_{LEG}+1, N_{LCC}\right) - \varepsilon_{LEG} < 0 \\ \pi_{LEG}\left(N_{LEG}+1, N_{LCC}-1\right) - \varepsilon_{LEG} \geqslant 0 \end{cases} \begin{cases} \pi_{LEC}\left(N_{LEG}, N_{LCC}\right) - \varepsilon_{LCC} \geqslant 0 \\ \pi_{LCC}\left(N_{LEG}+1, N_{LCC}\right) - \varepsilon_{LCC} < 0 \end{cases}$$

$$\Rightarrow \begin{cases} \pi_{LEG}\left(N_{LEG}+1, N_{LCC}\right) < \varepsilon_{LEG} \leq \pi_{LEG}\left(N_{LEG}+1, N_{LCC}-1\right) \\ \pi_{LCC}\left(N_{LEG}+1, N_{LCC}\right) < \varepsilon_{LCC} \leq \pi_{LCC}\left(N_{LEG}, N_{LCC}\right). \end{cases}$$

(2) The overlapped area with $(N_{LEG}-1, N_{LCC}+1)$ is:

$$\begin{cases} \pi_{LCC}\left(N_{LEG}, N_{LCC}+1\right) - \varepsilon_{LCC} < 0 \\ \pi_{LCC}\left(N_{LCC}-1, N_{LCC}+1\right) - \varepsilon_{LCC} \geqslant 0 \end{cases} \begin{cases} \pi_{LEG}\left(N_{LEG}, N_{LCC}\right) - \varepsilon_{LEG} \geqslant 0 \\ \pi_{LEG}\left(N_{LEG}, N_{LEG}+1\right) - \varepsilon_{LEG} < 0 \end{cases}$$

$$\Rightarrow \begin{cases} \pi_{LCC}\left(N_{LEG}, N_{LCC}+1\right) < \varepsilon_{LEC} \leqslant \pi_{LCC}\left(N_{LEG}-1, N_{LCC}+1\right) \\ \pi_{LEG}\left(N_{LEG}, N_{LEG}+1\right) < \varepsilon_{LEG} \leqslant \pi_{LEG}\left(N_{LEG}, N_{LCC}\right) \end{cases}$$

In this way, we finally get the unique subgame perfect equilibrium outcome:

$$\begin{aligned} P\left(N_1 = N_{LEG}, N_2 = N_{LCC}\right) = & \int_{\pi_{LEG}(N_{LEG}+1,N_{LCC})}^{\pi_{LEG}(N_{LEG},N_{LCC})} \int_{\pi_{LCC}(N_{LEG},N_{LCC}+1)}^{\pi_{LCC}(N_{LEG},N_{LCC})} \phi\left(u_{LEG}, u_{LCC}\right) du_{LEG} du_{LCC} \\ & - \int_{\pi_{LEG}(N_{LEG}+1,N_{LCC})}^{\pi_{LEG}(N_{LEG}+1,N_{LCC}-1)} \int_{\pi_{LCC}(N_{LEG}+1,N_{LCC})}^{\pi_{LCC}(N_{LEG},N_{LCC})} \phi\left(u_{LEG}, u_{LCC}\right) du_{LEG} du_{LCC}, \end{aligned}$$

The unique subgame is in perfect equilibrium if ε_{LEG} and ε_{LCC} satisfy the Nash equilibrium condition, unless conflict with Nash equilibria where more Legacy Carriers would enter.

4 EMPIRICAL RESULTS

To simplify the calculation, we only selected $distance$, $Msize$ and OS as explanatory variables for market characteristics, and assuming that the legacy carriers are leaders.

4.1 Maximum Likelihood Estimation with & without correlation of shocks

We considered both cases with and without the correlation of two profit shocks within market and estimated our model by maximum likelihood. We do not calculate standard errors for the specification without correlation, but we apply deltamethod for that with correlation to calculate standard errors of coefficients and derive the significance of the effect. All standard error results in the following sections are computed by deltamethod.

We can see in Table 6 that, our $Msize$ shows the same sign as that in Cleeren et al. (2010), regardless of whether we consider correlation or the category of the company. However, only $Msize$ of legacy carriers has a significantly positive impact, which means that $Msize$ will not play an important role in low-cost carriers' profitable function. OS shows a significantly positive impact on both LEGs and LCCs' profit, and this effect was nearly 9 times greater in LCCs than in LEGs.

When we set correlation to 0, our model is reduced to two separate ordered probit models, one for LEG and one for LCC. In fact, the correlation of profit shocks within market is significantly 0.340. The significantly positive correlation means that unobservable factors affecting LEGs' market attractiveness are positively correlated with those affecting LCCs. Compared to the estimation without correlation, λ_{LCC}^{1} has changed from positive to negative, which means an improvement in profitability.

[Insert Table 6 here]

As for the performance of $Distance$, our results were not quite the same as in Cleeren et al. (2010). In the two results obtained by MLE with & without correlation, the $Distance$ of legacy carriers shows a significantly negative effect, which is consistent with that in the literature. However, the results in low-cost carriers are the opposite: 1 increase in $log(distance)$ will bring a significant positive impact of 0.270 on the market outcome.

Furthermore, our profit function settings are very similar to theirs, and our fixed effects $\lambda_i^{N_i}$ and $\gamma_i^{N_{-i}}$ show similar results. Our $\lambda_i^{N_i}$ and $\gamma_i^{N_{-i}}$ show an increasing trend with N in both LEG and LCC types, regardless of whether correlation is considered. This is also consistent with our first and second assumptions. However, unlike the authors, our $\lambda_i^{N_i}$ and $\gamma_i^{N_{-i}}$ do not show much larger intra-format than inter-format substitutability for LEGs. This assumption holds true only for the low-cost carriers and the fixed effects of LCCs are in line with the authors. In addition, some $\lambda_i^{N_i}$ shows significantly negative values, which implies the impact of the number of intra-format companies could be positive when N is small especially in legacy carriers. In markets with less than 3 legacy carriers, the impact of the number of intra-format companies is significantly positive for legacy carriers. And this positive effect will attenuate as the number of LEGs increases until there is a negative effect on profitability. The 4 inter-format fixed effects of LEGs are not significant.

Compared with maximum likelihood results in Berry (1992), our results also show almost the same signs in $Msize(LogPopulation)$ and $Distance$ except that of LCCs.

4.2 Threshold Calculation & Ratio Calculation

We calculated different entry thresholds and their 95% confidence intervals. We applied the deltamethod to calculate standard errors before obtaining our confidence intervals. When the market outcome is equal to zero, the market size is the entry threshold. Our entry thresholds are defined as, given N_i and N_{-i}, the minimum market size of the companies of format i need, which is calculated as:

$$T_i^{N_i,N_{-i}} = \frac{-\beta_i \mathrm{X} + \lambda_i^{N_i} + \gamma_i^{N_{-i}}/N_i}{\alpha_i}$$

Note that our threshold is the level of $Msize \approx log(Population)$, so a negative number in the threshold result means a very small population. For example, in Table 7, the threshold of -20.365 in (1, 0) case implies a population level of $exp(-20.365) \approx 0$.

[Insert Table 7 here]

In the list of entry thresholds of LEGs, the first 3 lines shows nearly no requirement of the market size. The minimum market size needed by LEGs to sustain the given number of companies starts to evidently increase from (1, 3). We notice that, when the number of companies changes from $(N_i, 0)$ to $(N_i, 1)$, the difference between the thresholds is higher than those within $(N_i, 1)$ to $(N_i, 4)$. For example, when number of LEGs is 2, the differences of thresholds from (2,0) to (2,4) are 8.81, 1.19, 1.51 and 4.14, respectively. The same is true when the number of LEGs is 3 and 4, and this rule is even more obvious.

The entry thresholds of LCCs are very extreme, either there is no demand for market size, or there is a huge demand, just imagine how big the population $exp(1313.287)$ will correspond to. These overly large values are almost a 500-fold difference compared to LEGs for the same row. We think the reason for this is that Table 6 MLE shows that the market size has a negligible effect on the profit of LCCs, which is 0.002 and insignificant. The α used as the denominator in the threshold calculation is too small, resulting in a very large value of the threshold. By observing the mean value and confidence interval of the entry thresholds of LEGs and LCCs, the thresholds of LEGs show their accuracy, and the confidence interval of LCCs is too large enough to prove that their entry thresholds have no reference significance.

Next, we calculated the intra-format threshold ratio and inter-format threshold ratio.

$$INTRA\_TR_i^{N_i} = \frac{T_i^{N_i,0}}{T_i^{N_i-1,0}} \times \frac{N_i - 1}{N_i}.$$

$$INTER\_TR_i^{N_{-i}} = \frac{T_i^{1,N_{-i}}}{1} / \frac{T_i^{1,N_{-i}-1}}{1} = \frac{T_i^{1,N_{-i}}}{T_i^{1,N_{-i}-1}}$$

Generally, when the entry threshold ratio is equal to 1, it means that the entry will not change the competitive conduct and no more market size is required. The intra-format threshold ratio measures the extend of the increase of the market size needed to sustain an extra entry of the same type. When the intra-format ratio is greater than 1, it means that an extra entry brings a disproportionate amount of market size growth, which can be explained by an increase in the degree of competition within the format (Bresnahan and Reiss (1991)). The inter-format threshold ratio measures the extend of the increase of the market size needed to sustain a monopolist of one type while an extra entry of the other type.

Since previous threshold calculations have shown negative numbers, it is not surprising to see a value less than 0 in the threshold ratio.

[Insert Table 8 here]

[Insert Table 9 here]

Table 8 shows that, for both LEGs and LCCs, when there are 2 companies in the market, the ratios are 1.488 and 1.237, implying the needed increase of market size per company. When there is more exiting companies, the third line in our results shows smaller ratios of 1.118 and 0.975. There are no more companies per market in our data, so we cannot observe results for larger N. The first three rows in Table 9 show that no ratio is greater than 1 when the number of other types of firms is less than three. And $INTER\_TR_i^4$ shows 2.948, which means that the market size that needs to be increased could be large.

4.3 Counterfactual with Distance reduced by 20%

In this part, we would like to measure, how will the estimates change with $Distance$ reduced by 20%.

[Insert Table 10 here]

Compared with our previous ML estimation, firstly, the market size effect of low-cost carriers in this counterfactual scenario is still insignificant and remains at 0.002, while their fixed effects perfectly satisfy all assumptions. The correlation of shocks is still significantly positive, but decreased from 0.340 to 0.202. However, legacy carriers still violate the assumption of stronger intra-format substitutability than inter-format.

Unlike previous estimations, the inter-format fixed effects of LEGs have become significant. Overall, the fixed effect of entry is sensitive to changes in distance. When the distance is slightly narrowed, the inter-format effects of LEGs are significantly increased, and the entry of LCCs will have a significant threat to the profitability of LEGs. In the LCCs column, the negative effect of LEGs on their profit became smaller, but the negative intra-group effect became larger. These changes in fixed effects will result very different entry threshold ratios, so that our threshold ratios are not robust when changing the market characteristics.

4.4 Robustness Check with changing the order of entry

So far, the previous studies are based on the assumption that legacy carriers are leaders. In this part, we reconstruct the likelihood function so that low-cost carriers lead the market.

[Insert Table 11 here]

Compared to the previous entry order, the values, significance, and signs of all coefficients and of the correlation are almost unchanged. We have reason to believe that our entry threshold ratios are very robust.

5 CONCLUSION AND EXTENSION

We apply an empirical entry model to study the competition pattern of the US domestic airline market and find evidence of intense intra-format and inter-format competition in the market. Review the interesting results from observable explanatory variables. Although we expect market size to have a positive effect on profitability and distance to have a negative effect, we found that only legacy carriers met our expectations, while market size variables for low-cost carriers had little or no correlation with market outcome, and that greater distances benefited them more.

We also found that the fixed-effects results of LCCs fully satisfied the three assumptions of negative effects of intra-format entry, negative effects of inter-format entry, and greater negative entry effects of intra-format. However, LEGs violate the third assumption, and the inter-format impact is not even significant. When we make a small change to a variable, we find that our estimation of entry threshold ratio is sensitive to market observable variables. However, when we changed the order of entry, the estimation still maintained the original results and significance, which shows that our estimation is robust from the perspective of order-of-entry. Our correlation of shocks shows significantly positive whether in our original MLE, or MLE with counterfactual, or with changing the order of entry. This means that in our market, unobservable factors affecting LEGs performance are positively correlated with those affecting LCCs.

Based on the above results, we hope to be able to relax the third assumption that intra-format has a larger negative impact, and only make LCCs satisfy this assumption but LEGs do not need. However, since we are building a multiple equilibrium model, relaxing the assumptions complicates the study.

As an extension, we would like to propose the following ideas from the perspective of cross-sectional data and panel data, respectively. From a cross-sectional point of view, we first hope to build a model with more market-specific variables, such as company popularity, per capita GDP in the market and other important factors. In this project, our research objects are of two types: LEG and LCC. Since the estimation of LEG cannot fully satisfy our assumptions, we hope to try to find a suitable indicator to help us divide LEGs into two new groups. In this way, we can detect which part of the original LEG that caused the violation, and reconstruct the entry model with the categories of LEG1, LEG2, and LCC, however, requiring more number of companies. From the perspective of panel data, we hope to use the dynamic panel model to improve the entry model in the time dimension.

References

Bresnahan, Timothy F. and Peter C. Reiss (1991). “Entry and Competition in Concentrated Markets”. In: *Journal of Political Economy, Vol. 99, No. 5 (Oct., 1991*, pp. 977–1009.

Berry, Steven T. (1992). “Estimation of a Model of Entry in the Airline Industry”. In: *Econometrica, Vol. 60, No. 4*, pp. 889–917.

Ciliberto, Federico and Elie Tamer (2003). “Market Structure and Multiple Equilibria in Airline Markets”. In: *Econometrica*.

Cleeren, Kathleen et al. (2010). “Intra- and Inter-Format Competition Among Discounters and Supermarkets”. In: *Marketing Science, Vol. 29, No. 3*, pp. 456–473.

TransportationStatistics (2015). “Summary 2014 U.S.-Based Airline Traffic Data”. In: *https://www.bts.gov/newsroom/summary-2014-us-based-airline-traffic-data*.

6 APPENDIX

Variable	Description	Mean	Standard Deviation
N_{Leg}	Number of Legacy Carriers in a market.	1.15	0.92
N_{Lcc}	Number of Low Cost Carriers in a market.	1.04	0.85
AA	Equal to 1 if American Airlines presents in a market.	0.19	0.39
DL	Equal to 1 if Delta Airlines presents in a market.	0.35	0.48
WN	Equal to 1 if Southwest Airlines presents in a market.	0.64	0.48
AL	Equal to 1 if another one large carrier presents after counting AA, DL and WN.	0.52	0.50
OS	Equal to 1 if at least one small low cost carrier presents in a market.	0.31	0.46
POP	Log of the product of the populations of the connected cities.	29.71	0.88
distance	Log of the distance in non stop miles between the endpoints.	6.75	0.69
msize	Log of the geometric mean of the two endpoints' populations .	12.40	16.27

Table 1: Description of Variables used in this Study

LEG / LCC	0	1	2	3	4	Sum	Percentage
0	0	187	22	3	0	212	(24.23%)
1	179	138	83	11	0	411	(46.97%)
2	43	74	36	25	2	180	(20.57%)
3	8	18	17	10	3	56	(6.40%)
4	6	8	2	0	0	16	(1.83%)
Sum	236	425	160	49	5	875	
Percentage	(26.97%)	(48.57%)	(18.29%)	(5.60%)	(0.06%)		1

Table 2: Number of market per market structure

Served	**# of Carriers**	**Log Distance**	**Log Population**	**N**
All Markets	2.19 (1.33)	6.75 (0.69)	29.71 (0.88)	875
Large Markets	3.38 (1.31)	6.80 (0.77)	30.88 (0.54)	219
Medium-Large Markets	2.38 (1.23)	6.76 (0.72)	29.94 (0.18)	217
Medium-Small Markets	1.69 (0.99)	6.78 (0.69)	29.37 (0.17)	220
Small Markets	1.32 (0.60)	6.68 (0.58)	28.66 (0.28)	219

Table 3: Market Characteristics: Mean, sd

LEG	Small	Medium-Small	Medium-Large	Large	Sum
0	112	75	25	0	212
1	98	122	123	68	411
2	9	18	50	103	180
3	0	5	17	34	56
4	0	0	2	14	16
Sum	219	220	217	219	875

Table 4: Distribution of the Number of LEG by Market Size

LCC	Small	Medium-Small	Medium-Large	Large	Sum
0	64	73	61	38	236
1	138	103	94	90	425
2	17	37	47	59	160
3	0	7	14	28	49
4	0	0	1	4	5
Sum	219	220	217	219	875

Table 5: Distribution of the Number of LCC by Market Size

	MLE without correlation		MLE with correlation			
	Legacy Carriers	Low-Cost Carriers	Legacy Carriers		Low-Cost Carriers	
	Estimate	Estimate	Estimate	St. Error	Estimate	St. Error
Distance	-0.417	0.263	-0.357^a	0.077	0.270^a	0.102
Market Size	0.045	0.002	0.042^a	0.003	0.002	0.004
OS	0.536	5.326	0.592^a	0.233	5.485^a	1.851
λ_i^1	-3.346	0.214	-3.075^a	0.447	-0.125^c	0.905
λ_i^2	-1.615	5.741	-1.312^a	0.388	5.756^a	2.048
λ_i^3	-0.466	7.605	-0.186	0.435	7.650^a	2.023
λ_i^4	0.534	8.645	0.813^b	0.472	8.883^a	2.013
γ_i^1	0.494	1.466	0.736	0.880	1.902^a	0.553
γ_i^2	0.573	1.529	0.835	0.874	1.995^a	0.558
γ_i^3	0.651	1.625	0.962	0.898	2.124^a	0.600
γ_i^4	0.767	1.824	1.181	1.005	3.170^a	0.694
Correlation	0		0.340^a with St. Error of 0.082			

Letters a, b, c indicate whether this coefficient is significant. ${}^c p < 0.10, {}^b p < 0.05, {}^a p < 0.01.$

Table 6: Estimation Maximum likelihood without and with correlation

Entry Thresholds and Confidence Intervals: With $T_i^{N_i,N_{-i}}$ defined by the level of log(Pop)				
	Entry Thresholds of LEGs		Entry Thresholds of LCCs	
(N_i, N_{-i})	$T_{LEG}^{N_{LEG},N_{LCC}}$	Confidence Interval	$T_{LCC}^{N_{LCC},N_{LEG}}$	Confidence Interval
(1, 0)	-20.365	[-51.002; ;10.273]	-2175.280	[-12592.858; 8242.297]
(1, 1)	-2.727	[-14.494; ;9.039]	-1047.111	[-6473.568; 4379.346]
(1, 2)	-0.343	[-11.975; 11.288]	-991.6815	[-6473.568; 4379.346]
(1, 3)	2.694	[-10.923; 16.311]	-915.1831	[-5759.746; 3929.380]
(1, 4)	7.942	[-15.956; 31.839]	-294.632	[-2252.163; 1662.899]
(2, 0)	21.901	[6.729; 37.073]	1313.287	[-5409.266; 8035.840]
(2, 1)	30.720	[23.885; 37.555]	1877.372	[-7303.345; 11058.088]
(2, 2)	31.912	[25.037; 38.788]	1905.086	[-7402.845; 11213.018]
(2, 3)	33.431	[25.597; 41.265]	1943.336	[-7528.358; 11415.029]
(2, 4)	36.055	[23.394; 48.716]	2253.611	[-8723.587; 13230.809]
(3, 0)	48.886	[38.786; 58.986]	2436.902	[-9605.861; 14479.666]
(3, 1)	54.765	[46.609; 62.921]	2812.959	[-10888.57; 16514.49]
(3, 2)	55.560	[47.329; 63.791]	2831.435	[-10955.49; 16618.36]
(3, 3)	56.572	[47.822; 65.323]	2856.935	[-11039.82; 16753.69]
(3, 4)	58.321	[47.196; 69.447]	3063.785	[-11840.71; 17968.28]
(4, 0)	72.845	[61.960; 83.731]	3168.421	[-12359.98; 18696.82]
(4, 1)	77.255	[66.574; 87.936]	3450.463	[-13325.24; 20226.17]
(4, 2)	77.851	[67.102; 88.600]	3464.321	[-13375.56; 20304.20]
(4, 3)	78.610	[67.568; 89.653]	3483.445	[-13438.95; 20405.84]
(4, 4)	79.922	[67.651; 92.193]	3638.583	[-14040.55; 21317.72]

Table 7: Different Entry Thresholds with 95% Confidence Intervals

Estimated Intra-format threshold ratios		
$INTRA\_TR_i^{N_i}$	LEGs	LCCs
$INTRA\_TR_i^{2}$	-0.538	-0.302
$INTRA\_TR_i^{3}$	1.488	1.237
$INTRA\_TR_i^{4}$	1.118	0.975

Table 8: Intra-format Threshold Ratios

Estimated Inter-format threshold ratios		
$INTER\_TR_i^{N_{-i}}$	LEGs	LCCs
$INTER\_TR_i^{1}$	0.134	0.481
$INTER\_TR_i^{2}$	0.126	0.947
$INTER\_TR_i^{3}$	-7.857	0.923
$INTER\_TR_i^{4}$	2.948	0.322

Table 9: Inter-format Threshold Ratios

MLE with $distance$ reduced by 20%				
	Legacy Carriers		Low-Cost Carriers	
	Estimate	St. Error	Estimate	St. Error
Distance	-0.470^a	0.072	0.352^a	0.076
Market Size	0.045^a	0.003	0.002	0.003
OS	0.473^a	0.095	8.914^a	2.208
λ_i^1	-3.655^a	0.386	0.936^a	0.322
λ_i^2	-1.605^a	0.380	9.830^a	2.230
λ_i^3	-0.465	0.382	11.547^a	2.236
λ_i^4	0.534	0.395	12.579^a	2.243
γ_i^1	1.244^a	0.059	0.698	
γ_i^2	1.320^a	0.072	0.817	
γ_i^3	1.436^a	0.127	0.945	
γ_i^4	1.613^a	0.335	1.144^a	0.080
Correlation	0.202^b with St. Error of 0.080			

Letters a, b, c indicate whether this coefficient is significant. $^cp < 0.10, ^bp < 0.05, ^ap < 0.01$.

Table 10: Estimation Maximum likelihood - Counterfactual

MLE with Inverse Order of Entry				
	Legacy Carriers		Low-Cost Carriers	
	Estimate	St. Error	Estimate	St. Error
Distance	-0.388^a	0.059	0.259^a	0.072
Market Size	0.042^a	0.003	0.002	0.003
OS	0.492^a	0.136	5.267^b	2.528
λ_i^1	-3.305^a	0.479	-0.040	0.647
λ_i^2	-1.448^a	0.373	5.435^b	2.583
λ_i^3	-0.309	0.376	7.316^a	2.586
λ_i^4	0.691^c	0.391	8.603^a	2.589
γ_i^1	0.431	0.422	1.960^a	0.331
γ_i^2	0.540	0.477	2.036^a	0.348
γ_i^3	0.607	0.493	2.169^a	0.376
γ_i^4	0.635	0.494	2.968^a	0.685
Correlation	0.313^b with St. Error of 0.083			

Letters a, b, c indicate whether this coefficient is significant. $^cp < 0.10, ^bp < 0.05, ^ap < 0.01$.

Table 11: Estimation Maximum likelihood - Inverse Order of Entry