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Competition Analysis of Low Cost Carriers and Full Service Carriers of South Korean Airline Industry: A Lotka-Volterra approach for Jeju Island Travelers

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Abstract

Since the global emergence of low cost carriers (LCC) in airline industry, shift of business is observed. LCC are gaining more market share as compared to conventional airlines known as full service carriers (FSC). LCC manage to cut costs by cutting extra services and make it possible for passengers to travel on much lower cost. Introduction of LCC has brought change in airline industry throughout the world; similarly it has emerged in South Korea as well. This paper performs competition analysis on South Korean Airlines using Lotka-Volterra (LV) model, examines and discusses the effect of emergence of LCC on FSC. LV model is also used for forecast.

Keywords

Low Cost Carriers, Lotka-Volterra, Competition Analysis, Airline Industry

1. Introduction

Since the global emergence of low cost carriers (LCC) in airline industry, shift of business is observed. LCC are gaining more market share as compared to conventional airlines. Conventional airlines also called Full service carriers (FSC) are service focused, on the other hand low cost carriers focus on low cost. LCC manage to cut costs by cutting extra services and make it possible for passengers to travel on much lower cost. FSC provide customized services like routes, class of cabins, infant services, and airports while LCC has standardized the services like routes, cabin class, airports and even aircrafts. Introduction of LCC has brought change in airline industry throughout the world; similarly it has emerged in South Korea as well. Previously, South Korean airline industry was ruled by two major airlines; however, there operate about eight different airlines now. This paper tries to analyze the competition between FSC and LCC of South Korea. South Korean air industry has grown up immensely and there are several domestic routes, but this paper intends to consider a competition analysis on just one route between Seoul, the capital of South Korea, and Jeju Island. Korean Air (KAL) and Asiana Airlines (AAR) are operating since 1962 and 1988 respectively and are considered to be the giants of South Korean airline industry. After the emergence of AAR in 1988, T'way Airlines was the first airline entered in South Korean airline industry in 2004 with a gap of sixteen years. From 2004 to 2016, five more airlines Jin Air (JNA), Jeju Air (JJA), Easter Jet (ESR), Air Seoul (ASV) and Air Busan (ABL) have entered the industry, as presented in Table.1. This paper performs competition analysis on

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South Korean Airlines using Lotka-Volterra (LV) model, examines and discusses the effect of emergence of LCC on FSC. LV model is used for forecast as well. AAR and KAL are considered FSC while LCC consist of remaining six airlines. Section 2 describes the relevant literature. Methodology and experiment are discussed in Section 3. Section 4 presents results followed by conclusion and limitation of results in section 5.

Table 1. Operational Airlines of South Korea

Airline	Airline code	Commenced Operations
Korean Air	KAL	1962
Asiana Airlines	AAR	1988
T'way Airlines	TWB	2004
Jeju Air	JJA	2005
Jin Air	JNA	2008
Air Busan	ABL	2008
Easter Jet	EST	2009
Air Seoul	ASV	2016

2. Literature Review

There are several studies available where LV model is used for dynamic competition analysis and forecast. LV model can be applied for a two species competition as well as three species competitions. An n-dimensional LV is also explained (Plank. 1995). Some of preexisting studies are worth mentioning like Lo (2012) applied LV model as dynamic competition model for the analyses of passenger volume of domestic airline and high-speed rail. He modified the conventional LV model by considering external variable. He added oil price as an external variable to modify the model, used this modified model to forecast and compared it with single equation inferring the modified model as a better model. Spencer and Tanner (2008) used LV model and a variety of other models in which transition probabilities do not depend on the state abundances to a long-term coral reef data set. LV model described the data much better than all models. Wu *et al.* (2012) mixed Grey prediction theory and LV model using linear programming to estimate parameters in terms of MAPE. The integrated model approach yielded far better prediction results than the ordinary conventional LV model. LV approach has been used widely and since long in various fields of science statistics and even arts, yet never implemented in airline industry.

A number of debates already exist regarding effects of LCC on FSC. Gillen (2003) discussed the competition between LCC and FSC and proposed model illustrated that there is a partial and conditional competition between LCC and FSC which can encourage price stability as well as low price. Barrett (2004) elaborated how the services demand is different at airports for LCC and FSC. Frank (2004) explained that LCC can deliver 80% of service quality with less than 50% of cost of FSC considering the LCC and FSC of United Stated and Europe. Fu *et al.* (2006) explained the effects of competition between LCC and FSC on airport pricing and regulations. Recently, Wang *et al.* (2016) explained the entry patters of LCC in Hong Kong and its implications to the regional market. Halpern *et al*. (2016) investigated the LCC developments and their impact on traffic and financial performance of UK airports. Though many studies debate the competition between LCC and FSC, considering LV to analyze competition between LCC and FSC is quite unique and new approach. LV does not only allow the information about the existence of competitive relationship but also reveals the type of competition.

3. Methodology

A two species LV model as well as three species LV model is performed. The data used for experiment ranges from year 2000 to year 2016. Data is available for each airline and consists of total number of passengers traveling on the Seoul-Jeju route. There are two airports in Seoul, one is Incheon (ICN) and the second one is GIMPO (GMP) airport. Both the airports are considered. Jeju Island is most famous tourism place of South Korea that is why data has seasonality. To overcome seasonality data is preprocessed. Preprocessing is carried out in two parts, first, quarterly data is de-seasonlized and then 12 order moving averages are applied. Further, to observe the competitive relationship more closely, we divide our data in three different spans. First span is pre-emergence span; this span implies a two species LV model between the two FSC (AAR and KAL) of South Korean airline industry. Figure.1 (a) represents pre-emergence span and shows number of passengers using KAL and AAR before the emergence of LCC. During this complete span KAL seems to be dominant over AAR.

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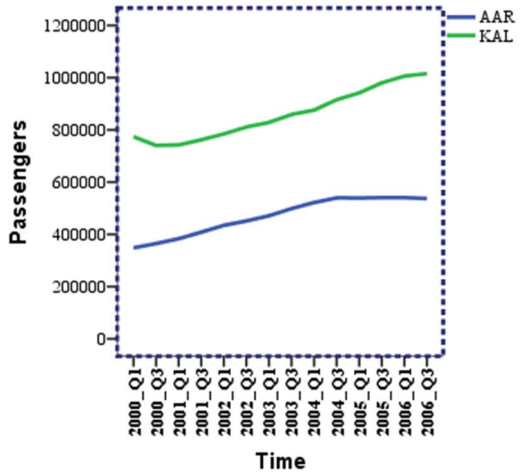

Figure 1. (a) Pre-emergence span

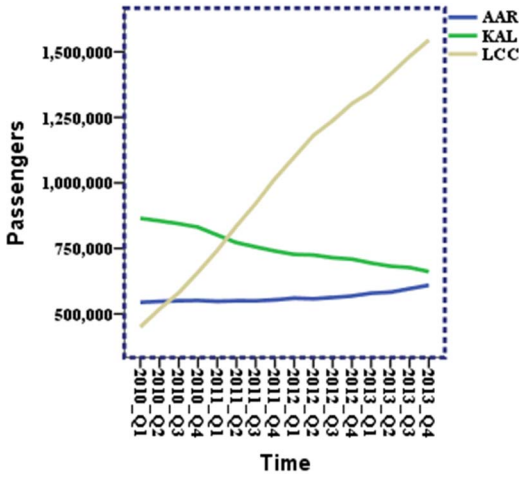

Figure 1. (b) Emergence span

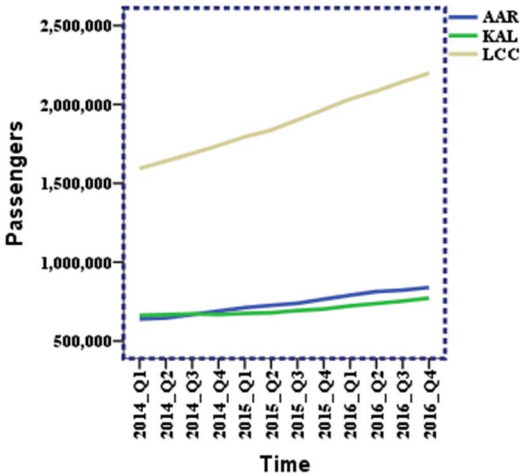

Figure 1. (c) Post emergence span

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Second span is emergence span; when LCC enters market and destroys the bi-poly of South Korean airline industry shown in Figure.1 (b). Third span is post-emergence span where FSC react to the emergence of LCC as expressed in Figure.1 (c). Three species LV model is applied to emergence span and post-emergence span. To construct two species and three species models for all three spans following notations are denoted to the variables:

L_t: Market share of LCC at month *t*
K_t: Market share of KAL at month *t*
A_t: Market share of AAR at month *t*

As a two species LV model is applied for pre-emergence span, the general form two species LV can be expressed in terms of pre-emergence is as follow:

$$\frac{dK}{dt} = K(a_1 - b_1K - c_1A)$$
$$\frac{dA}{dt} = A(a_2 - b_2A - c_2K)$$

As we need to use time series data and the general form is continuous form of LV model, it is required to be converted in to discrete form. Following expressions can be used as discrete form of LV model described by Leslie (1958).

$$K_{t+1} = \frac{\propto_1 K_t}{1 + \beta_1 K_t + \gamma_1 A_t}$$
$$A_{t+1} = \frac{\propto_2 A_t}{1 + \beta_2 A_t + \gamma_2 K_t}$$

α_i, β_i and γ_i are the discrete conversion of continuous parameters. α_i and β_i are known as logistic parameters while γ_i represents impact of each species on other and known as interaction parameters. These three parameters have relationship with the parameters of continuous LV model and can be expressed as below:

$$a_i = ln \propto_i, \quad b_i = \frac{\beta_i \ln \propto_i}{\propto_i - 1}, \quad c_i = \frac{\gamma_i \ln \propto_i}{\propto_i - 1}$$

Similarly, a generalized three species LV model for emergence span and post-emergence span can be written as followed:

$$\frac{dK}{dt} = K(a_1 - b_1K - c_1A - d_1L)$$

$$\frac{dA}{dt} = A(a_2 - b_2A - c_2K - d_2L)$$

$$\frac{dL}{dt} = L(a_3 - b_3L - c_3K - d_3A)$$

Discrete form of three species LV model can be described as under:

$$K_{t+1} = \frac{\propto_1 K_t}{1 + \beta_1 K_t + \gamma_1 A_t + \delta_1 L_t}$$

$$A_{t+1} = \frac{\propto_2 A_t}{1 + \beta_2 A_t + \gamma_2 K_t + \delta_2 L_t}$$

$$L_{t+1} = \frac{\propto_3 L_t}{1 + \beta_3 L_t + \gamma_3 K_t + \delta_3 A_t}$$

Values for α_i, β_i, and γ_i are related to a_i, b_i and c_i in similar way as explained above, however d_i can be expressed as:
$d_i = \frac{\delta_i \ln \propto_i}{\propto_i - 1}$ i=1.2.3

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Competitive relationship between two interacting species can be obtained by comparing the signs of interaction parameters. The values of interaction parameters also represent the strength of the relationship between specified species (Modis, 1999) as represented in Table. 2. If both interaction parameters are positive it reflects the pure competition between the species which means growth rate of each has impact on other. If one sign is positive while other is negative, it exhibits that one species is directly eating other species. In case of both having negative signs it shows that both have mutual understanding or win-win situation. If both interaction parameters are zero, it means there is no interactive relationship between two species.

Table 2. Competition relationship between two species

c_1	c_2	Relationship
+	+	Pure Competition
-	-	Mutualism
+	-	Predator-Prey
0	0	Neutralism

4. Experiment and Results

Upon performing experiment using nonlinear regression α_i, β_i and γ_i values for the two species model for pre-emergence span are shown in Table.3. Levenberg-Marquardt method is applied for parameter estimation of nonlinear regression. In pre-emergence span one interaction parameter is negative and the one is positive showing predator-prey relationship between both FSC. Where KAL is predator and AAR is prey it can also be observed in Figure 1 (a) that by the end of post emergence span AAR is dramatically decreasing and effected by KAL.

Table 3. Parameter values for the two species model for pre-emergence span

Pre-emergence span				
$\boldsymbol{\alpha_i}$	β_i	γ_i	Airline	Relationship
2199805212	4306	-3356	KAL	Predator-Prey
356438788	-1194	1085	AAR	

Similarly, with the developed equations for three species LV models for both, emergence span and post-emergence span, values for α_i, β_i, γ_i and δ_i are obtained and presented in Table.4. For three species LV model γ_i and δ_i are interacting parameters and provide the information about type of relationship.

Table 4. Parameter values for the three species model for emergence span and post emergence span

Emergence span				
$\boldsymbol{\alpha_i}$	$\boldsymbol{\beta_i}$	γ_i	δ_i	Airline
750927386.4	677.142	238.010	118.348	KAL
351470778.9	21.464	361.835	62.545	AAR
300263822.8	119.811	432.063	-302.536	LCC
Post-emergence span				
1120172860	2285.087	3193.370	-1511.64	KAL
493629046	1742.925	809.615	-726.930	AAR
2041128862	-2477.86	3760.802	5456.146	LCC

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Figure 1 (b) shows that in emergence span as soon as LCC emerges number of passengers using KAL drops abruptly, while number of passengers using AAR becomes stable initially and starts rising in the end. On the contrary as soon as LCC enters the market it dominates the market. Interaction parameters and relationship between KAL-AAR, AAR-LCC and KAL-LCC are summarized in Table 5 for emergence span and post-emergence span. Emergence of LCC has affected both KAL and AAR in a way that KAL-AAR relationship changes from Predator-prey in pre-emergence span to pure competition in emergence span. LCC has a predator-prey relationship with AAR where LCC is predator and AAR is Prey. However LCC and KAL compete with each other in emergence span.

Table 5. Interaction parameters for emergence span and post-emergence span and relationship between three species

Emergence span			
Airlines	KAL-AAR	AAR-LCC	KAL-LCC
KAL	238		118
AAR	361	62	
LCC		-302	423
Relationship	Pure Competition	Predator-Prey	Pure Competition
Post emergence span			
Airlines	KAL-AAR	AAR-LCC	KAL-LCC
KAL	3193		-726
AAR	809	-1511	
LCC		3760	5456
Relationship	Pure Competition	Predator-Prey	Predator-Prey

In post emergence span, as shown in Figure 1 (c) both the FSC fight back and gain the number of passengers. As the status of relationship between each species remains same as in emergence span but the winners are changed. Winners of each span are expressed in Table 6. In pre-emergence span KAL is predator and AAR is prey. In emergence span there is competition between KAL and AAR and AAR is winning the competition, AAR is prey to LCC and LCC is winning the competition from KAL. KAL is losing to both, LCC and AAR that is why KAL is dropping while AAR is stable. In post-emergence span KAL wins the competition from AAR and LCC, however, AAR preys LCC. These changes in relationship make AAR and KAL stable in post-emergence span. LCC losing to both AAR and KAL in post-emergence span but still increasing steadily shows that the market is expanding and the competition between LCC and FSC is up to a certain level and LCC has set its own market.

Table 6. Winner in each span

Airlines	Pre Emergence Span	Emergence Span	Post Emergence Span
KAL-AAR	KAL wins	AAR wins	KAL wins
AAR-LCC		LCC wins	AAR Wins
LCC-KAL		LCC Wins	KAL Wins

Using the three species LV model the integrated data of span 2 and span 3 is fit for the purpose of forecast. Figure.2 represents the observation and prediction as well as MAPE values for each species. MAPE values for AAR, KAL and LCC are below 1 %, R^2 values for AAR, KAL and LCC are above 0.9 as expressed in Table.7. Such efficient performance measures of data fit ensure that LV model is an authentic choice for future forecast.

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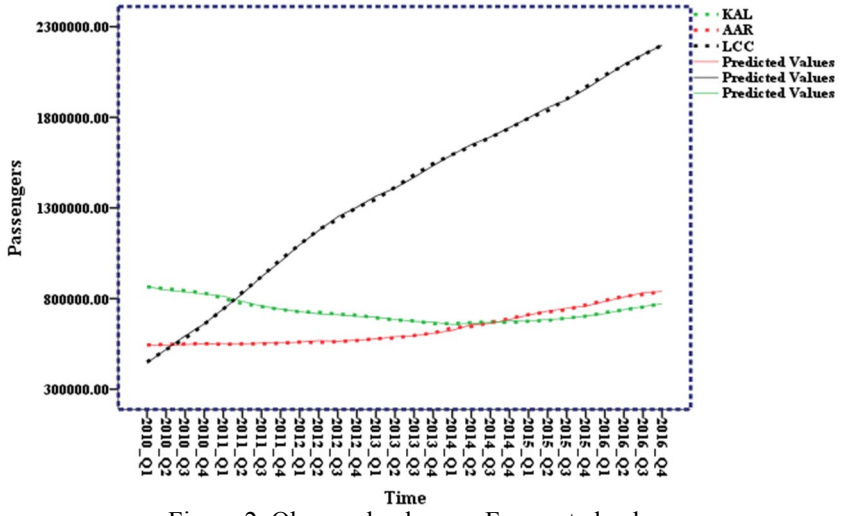

Figure 2. Observed values vs Forecasted values

Table 7. MAPE and R^2 values for Forecast

Airlines	MAPE (%)	R^2
KAL	.65	.93
AAR	.69	.91
LCC	.54	.98

5. Conclusion and Limitation

Applying LV competition model on LCC and FSC of South Korean airline industry reveals interesting competition dynamics. Emergence of LCC has intensified the environment of competition. Both the FSC are affected by the emergence of LCC. Competition dynamics of FSC with each other as well as with LCC may change with the passage of time depends upon action and reaction of airlines. Overall it is observed that customer focused business policies lost to cost focused business policies in terms of market shares. Results reveal that there exists a competition between LCC and FSC but only up-to a certain level; because LCC has set its own market and low costs have encouraged new passengers to travel. Results also show that AAR responded earlier to the emergence of LCC than KAL. LV model can be applied to furnish an efficient forecast.

There are a couple of limitations to the study, first the LV analysis is applied for Jeju Island travelers and overall trend of South Korean Airline Industry may be different or even different type of relationships may exist on different routes. Secondly, there may be several external factors which are not considered in this model. Authors are working to overcome the limitations.

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Biography

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