Extensive-Form Game Theory:

Airline companies joining alliance or staying independent

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Abstract

The paper mainly examines how would a decision of joining the aviation alliance may affect the increasing rate of its revenue by applying the extensive form of the Game Theory. More specifically, we have chosen two companies, South African Airways from South Africa, and EVA Air from Taiwan, to be two examples to study. In the following sections of the "Model" and "Figure" parts, we will show by using a tree diagram to show how the application of the Game Theory is used to analyze their average increasing rate of revenues of 3 years before joining and after joining the Star Alliance. And for the "Figure" part, we may have a more intuitive way to observe the change in their increasing rate of the revenues by showing a tendency curve.

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In the modern aviation industries, many of the airline companies tend to stand together and to cooperate with each other to improve their company reputation or revenues or maybe some other ways that could let more and more people select them when travelling with airplanes. There are two major forms of the cooperation among them:

1. Codeshare agreement partnership. This one is primarily used BETWEEN two airlines in order to operate the same travelling routes. For example, Cathay Pacific's CX691 flight and American Airlines flight AA8890 are both flights from Hong Kong to Singapore. This CX691 flight is operated by the Cathay Pacific with its own flight crews, while American Airlines will not participate in the operation. However, the American Airline will sell tickets for Cathay Pacific's CX691 flight to Singapore. Also, In this case, passengers may take one flight to travel from the United States to Hong Kong, transferring to flight AA8890 (or CX691) to Singapore. This is beneficial to both the passengers and the airline companies.
    a. For passengers, they have a clearer ticket information issued in the same airline format and they can usually be connected to a long-distance-flights more smoothly, shortening the transit time. Also, they are able to enjoy better transferring services. For instance, suppose we have a long-distance-flight delayed for some unpredictable reasons so that we cannot catch up with the code-share flights. In this scenario, the airlines company will take actions to support our trip maybe by arranging hotel for accommodation, compensating meal vouchers, resettling our airplanes tickets, etc. As for our baggage, the

airline company will also have them handled properly to ensure that we can still collect them after our trip is finished.

   b. For companies, they may increase their flight occupancy rate. Since passengers take the same long-distance-flights to get to a place and transfer to a code-sharing flight to reach their destination. In this case, the occupancy for the long-distance-flights will increase. And in this way, the code-sharing flights can have additional passengers. Also one other benefits for the companies is that they can provide more frequent flights. For some destinations dominated by the business travellers, with the help of the code-sharing agreements, airlines companies can provide more frequent flights therefore provide passengers more flights options. For example, on the Hong Kong-Taipei route, Cathay Pacific provides a total of 20 flights per day through a codeshare agreement with its subsidiary, Cathay Dragon.

2. Forming an airline alliance. This is a development based on the codeshare agreements cooperation. The key difference is that an alliance can involve cooperation that is in a larger scale (usually with more than two companies). And for the current time, there are three major alliances in the world: Star Alliance, SkyTeam, and OneWorld. The aviation alliance provides a global aviation network and strengthens the international connections. The advantages of forming an alliance included but not limited to the advantages mentioned in the codeshare agreement.

   a. For passengers in the program Asia Miles or in some other similar frequent flyer programs, they can earn the flying miles more easily with the membership of the alliance to redeem their compliments. Also, as more

choices are involved, the cost of the trips will decrease, and passengers can pay for an airline ticket at a more affordable price. Furthermore, the number of transfers is reduced, and passengers have more selections on the direct flights to reach their destinations.

b. For companies, they can share the maintenance facilities, operating equipment, VIP lounges, and staffs, etc. Also have the support from each other in the alliance for airport ground handling. All of the advantages above contribute enormously to the cost reduction for each company.

Model Deviation[1]

Assumptions

To examine the effect of joining alliance, we compare two airlines that joined the same alliance. Our model focuses on South African Airways and EVA Air which are both current members of Star Alliance. Although airlines can be in partnerships and take other forms to cooperate, instead of being in an alliance, we assume the airlines that do not join any alliances to be independent here.

To quantify the possible benefits or costs of joining alliance, we obtain "passenger revenue" from the annual reports. Passenger revenue is more focused towards the revenue realized by their main service of taking customers on board, compared to overall revenue. Since airlines have to purchase airplanes and other expensive equipment, their costs can vary significantly by the year, and profits fluctuates correspondingly. Thus, we assume that the passenger revenue, out of other key values obtainable from annual reports, best describes and reflects the effect of joining alliance.

As we obtain financial values, we also have to take into account that the airline industry is relatively sensitive to the domestic and international economy, compared to other industries. For example, holding world athletic competitions would increase the air transportation, and recessions and pandemics would likely to decrease it. To reduce the impact of variances in the data due to macroeconomic factors, we take the average of the percent change in the passenger revenue over three years before and after both airlines join the alliance. For when one is in the alliance and the other is not, we take the average of such duration. We also exclude the data from 2008 to 2010 as the values seem to be outliers with sharp drops and rises due to the Great Recession that impacted those years.

The effect of joining alliance is likely to be absorbed over few years rather than within a year. We take at least the three-year average as mentioned above for this reason as well. When the airline joins the alliance later than the first quarter of its fiscal year, we consider that the airline joined from its next fiscal year. We also ignore inflation impacts for our model for simplicity.

Mathematics used in model:

S.African	before				after (S.African joins alliance)								EVA joined		
(R; Rand)	2002	2003	2004	2005	2006	2007	2008	2009	2010	2011	2012	2013	2014	2015	2016
P rev (R million)	13,688	12,926	13,163	12,747	14,230	16,527	17,343	14,598	15,443	15,908	17,716	19,706	18,978	18,910	19,653
%change		-5.57%	1.83%	-3.16%	11.63%	16.14%	4.94%	-15.83%	5.79%	3.01%	11.37%	11.23%	-3.69%	-0.36%	3.93%
avg %change				-2.30%			10.90%					6.04%			-0.04%
												10.68%			
EVA	STAGE1				STAGE2								STAGE3		
	2002	2003	2004	2005	2006	2007	2008	2009	2010	2011	2012	2013	2014	2015	2016
P rev (NT$ million)	32,514	29,196	38,349	42,653	46,326	48,956	50,057	43,950	56,397	59,510	65,783	71,100	77,959	81,872	85,752
%change		-10.20%	31.35%	11.22%	8.61%	5.68%	2.25%	-12.20%	28.32%	5.52%	10.54%	8.08%	9.65%	5.02%	4.74%
avg %change				10.79%			5.51%					7.10%			6.47%
							^ 3-yr after S.African joins					7.69%			
												^ not include 2008-2010; for STAGE2 overall			

(get better table for final paper)

The rows in blue are the annual passenger revenues obtained from each airline's financial statements. Then the annual percentage change is calculated for three stages. Each stage is defined as follows:

STAGE1: both South African Airways (SAF) and EVA Air are independent

STAGE2: SAF is in Star Alliance and EVA is independent

STAGE3: both SAF and EVA are in Star Alliance

(STAGE-H: SAF is independent and EVA is in alliance)

The percentage change is calculated as follows:

$$\%change\ in\ Prev = \frac{Prev_t - Prev_{t-1}}{Prev_{t-1}}$$

where Prev = Passenger revenue.

For STAGE1 and STAGE3, we take the average of annual percentage changes in the passenger revenue over three years. For STAGE2, we calculate the average of annual percentage changes over the years in STAGE2, excluding the years 2008 to 2010 for the reason mentioned above.

Summarized percentage changes (increase/decrease) of passenger revenue by stages:

	STAGE1	STAGE2	STAGE3
SAF	-2.30%	10.68%	-0.04%
EVA	10.79%	7.69%	6.47%

Since the case we are considering has time dependence where SAF and then EVA join the alliance, we develop extensive-form game theory, rather than normal-form.

From our empirical data, the values for the case when SAF is independent and EVA is in Star Alliance is not obtainable, as such case did not exist in reality. We denote this hypothetical case as “STAGE-H”.

	SAF	EVA
STAGE1 to STAGE2	Independent to member (changed by x%)	Remains independent (changed by y%)
STAGE1 to STAGE-H	Remains independent (assume changes by y%)	Independent to member (assume changes by x%)

The movement from STAGE1 to STAGE2 is perfectly the opposite of the hypothetical case of STAGE1 to STAGE-H. We assume that taking the percentage change of moving from STAGE1 to STAGE2 for each firm and applying that percentage change to the opposite firm for

STAGE-H provide us the way to fill in values for the hypothetical case. For example, if SAF and EVA changes by x% and y%, respectively, for STAGE1 to STAGE2, then we find the values for STAGE-H by applying y% and x% change to the values of SAF and EVA in STAGE-H.

As the passenger revenue decreased on average for SAF in STAGE1, the percentage change for SAF from STAGE1 to STAGE2 cannot be obtained with a negative value. Thus, we converted the percentage changes into numbers. For example, the decrease in passenger revenue by 2.30% is the same as obtaining the next year's passenger revenue by multiplying the current value by 0.977 (1-0.0230 = 0.977). The other rates of change are transformed similarly:

	STAGE1	STAGE2	STAGE3
SAF	0.977	1.107	1.000
EVA	1.108	0.077	1.065

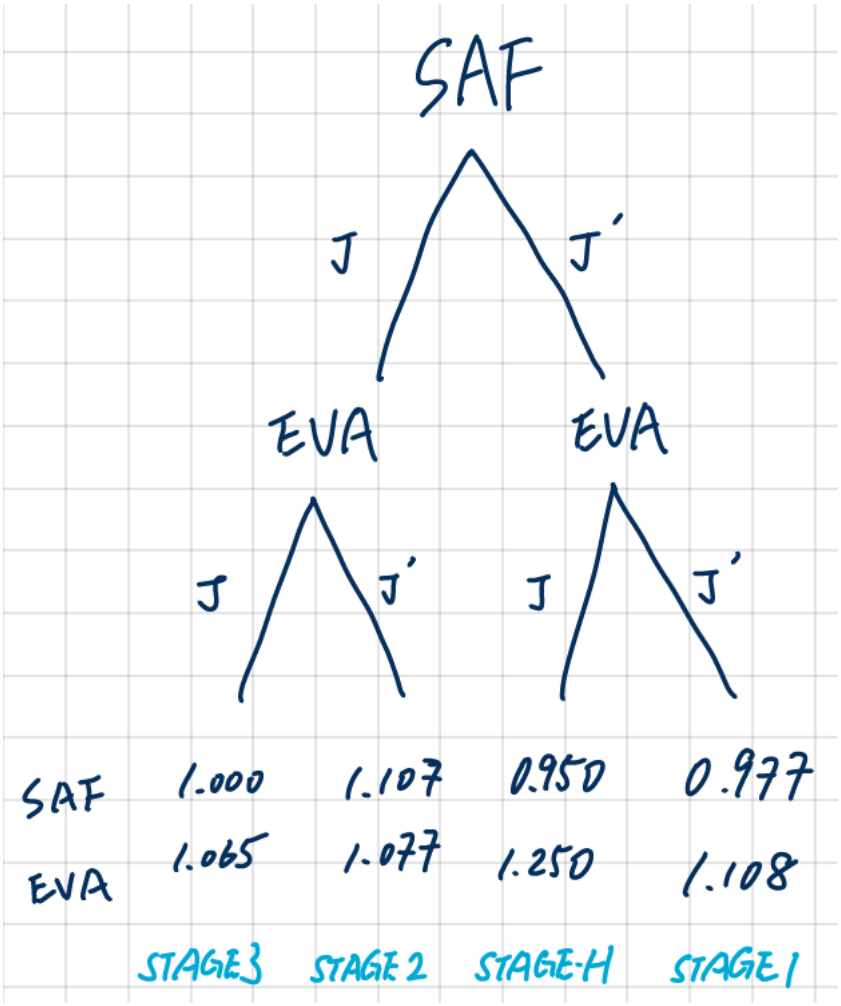
The percentage change of SAF and EVA between STAGE1 and STAGE2 are 12.8% and -2.8% respectively.

$$\frac{1.107 - 0.977}{0.977} = 12.8\%$$

By applying the rate to the opposite firms, we obtain the values of 0.950 for SAF and 1.250 for EVA in STAGE-H.

$$0.977 \times (1 - 0.028) = 0.950$$

After finding the values for STAGE-H, we obtain the following tree diagram representing the extensive-form game theory:



(J: the firm joins and is in alliance, J': the firm is independent)

Model Analysis

When SAF is independent, EVA has higher payoff by being in alliance (1.250>1.108). When SAF is in alliance, EVA would choose to be independent (1.077>1.065). Since EVA's choice dependents on what SAF does first, there is no dominating strategy for EVA. Given this, SAF is left with two options: (J,J') and (J',J) as it knows that EVA would not choose (J',J') and (J,J). Thus, SAF chooses to join the alliance (1.107>0.950). To put in words, this is the scenario where SAF joins Star Alliance and EVA then chooses not to. As they are both current members of Star Alliance, our model contradicts with the reality. However, the difference between the

values, 1.077 and 1.065, which EVA bases on to decide under SAF being in alliance, is quite small. The values could be different in less restrictive model. If such model suggests EVA to be in alliance when given that SAF is also in alliance, then SAF would choose between (J,J) and (J',J). Between these two options, SAF chooses to join the alliance and correspondingly EVA does as well, which then reflects the reality.

Model Assessment

One role of modeling is to identify such gaps in knowledge. There are also other simplifications that limit the extent to which our models should be applied uncritically. We did not consider the form size, since Eva Airways Corporation is newer company compared to South African Airways. However, Asian airline industry are in a high-speed development in recent decades. Also, when we choose the firm, we try to avoid choosing the airline that joined alliance between 2007 to 2010 (Great Recession). Moreover, Great Recession impacts may not be only during 2008 to 2010 that we excluded for our calculation. Also, because we use the data by calculating the average of annual percentage change over 3 years, we did not choose the airline company that joined the alliance close to Eva Airways Corporation (within 2 years), and all the airline company should have annual reports; such that, we can get accurate data to do analysis. Time is also a critical factor. Due to time is irreversible, when we do Eva Airways Corporation (joined time:2013) is joined while South African Airway (joined time:2006) is not joined, we should do some hypothetical cases, we apply the same rate of change in the revenue by examining the reverse case. Some big events may also affect our result, for example 2010 South-Africa World cup. It may cause more visitors to use local air companies. Our models do not consider effects of region. Due to Eva Airways Corporation (in Asia) destinations are different

from South African Airways (in Africa), each other's actions do not have much impact on the other. We use passenger revenue to analyze the effect of joining aviation alliance; however, we are not sure that it is a good measurement for examining the benefits/costs of joining alliance.

Conclusion

In this introductory paper, we have provided a succinct overview of our approach developing a mathematical model for the decision of joining the aviation alliance affect the increasing rate of its revenue by applying the extensive form of the Game Theory. An important strength of this model is that some airlines companies can refer to this model to help them make decisions on whether joining the alliance or not. Also, this model may resemble to other cases in the airline industry.