No. 038/2020/MKT

Airlines Alliances: Fractures in Seamless Service

Trichy V. Krishnan*
Great Lakes institute of management

Siddharth Shekhar Singh*
Indian School of Business

Dipak C. Jain
China Europe International Business School (CEIBS)

August 2020

* Corresponding authors:
1. Trichy V. Krishnan (krishnan61@gmail.com). Address: Great Lakes Institute Of Management, Prince Infocity II,Ist Floor, 283/3, Rajiv Gandhi Salai (OMR), Kandanchavadi, Chennai – 600096, India.
2. Siddharth Shekhar Singh (siddharth_singh@isb.edu). Address: Indian School of Business, Gachibowli, Hyderabad Telangana - 500 111, India.

AIRLINES ALLIANCES: FRACTURES IN SEAMLESS SERVICE

ABSTRACT

Airline alliances benefit global travelers and airlines. Although they enable seamless travel across countries and airlines, many customers complain about less-than-satisfactory services received from 'partner' airlines in an alliance. This is puzzling because quality of service impacts success and service provided by any member of an alliance impacts the evaluation of the entire alliance.

We develop an analytical framework to analyze the problem of variation in service quality experienced by loyal customers during their journey across allied airlines. Our game theoretic framework shows that variation in customer service is inherent in an alliance structure. Therefore, managing customer expectations about service quality could alleviate dissatisfaction due to service quality variation. Both customer service and profitability of an alliance can be improved if its governing board takes more control of the alliance members' service efforts and pushes them to invest in enhancing service infrastructure. Finally, alliance-wide customer service improves when allied airlines provide higher benefits to their loyalty program members by leveraging spare capacity—a new benefit of loyalty programs in the context of airline alliances.

Keywords: Airline, Alliance, service, customer satisfaction

Airlines operate in a highly competitive service industry. The intensity of competition and high fixed cost of operations drive airlines to excel in customer service to maintain a competitive edge. Airlines offer various services at key contact points of customer travel. These include online ticket booking, online printing of boarding passes, fast check-in at airport counters, seat upgrade, seat selection, airport lounges, smooth boarding, on-time departure and arrival, in-flight comforts, baggage delivery with minimum hassle at destination airports, and loyalty programs for frequent travelers to get upgrades, access to airline lounges and free flights in future. To provide these 'conventional' services, every major airline has invested in service infrastructure that includes physical facilities, technology and human resources.

In the 1990s, airlines started offering a novel set of benefits to international travelers through forming global alliances. Airlines in various regions formed inter-regional and global alliances to serve international routes. For example, Star Alliance, formed in 1997, has brought together United Airlines from the US, Lufthansa from Europe, ANA from Japan, Singapore Airlines and Thai Airways from SE Asia, Air China from China, Air India from India, and many other regional airlines like Air New Zealand (see Table 1 in the Web Appendix).

An international air alliance provides a global traveler with "one-stop" benefits in ticket purchasing, seamless travel across member airlines, end-to-end movement of baggage and better price, as evidenced in many studies (e.g. Bamberger, Carlton and Neumann 2004;Brueckner 2001; and Brueckner and Whalen 2000). However, international travelers' overall satisfaction with an alliance is derived not only from the one-stop benefits provided by the alliance but also from the conventional services offered by the different member airlines at various contact points of their travel. While travelers are generally happy with the one-stop benefits, many seem to have issues with the conventional services. They have been registering complaints on websites such as http://www.airlinecomplaints.org to show their dissatisfaction. For example:

"… One-World airlines don't offer any real alliance wide benefits for their most loyal customers. … no alliance wide extra baggage allowance for Ruby, emerald, sapphire members, no upgrade rewards between alliance members. At most you get priority check in, and lounge access…"

"…Downside of the large alliance is that in some places the lounges get very crowded and at Changi they would only let me take one child into the SQ Lounge - though I have never had a problem anywhere else…"

Table 2 in the Web Appendix summarizes examples of such complaints. While some individual complaints can be ignored as trivial, incorrect, or arising from a misunderstanding, a careful analysis points to a variation in service quality experienced by travelers as they move from one airline to another within an alliance network during a journey. Calling the airline where a traveler has loyalty program account as the "home airline" and the other airlines in the alliance as "partner airlines", we summarize the complaints as follows.

a) Lack of services at partner airlines' facilities including lounges[1].
b) Unable to get choice of seating, seat upgrade and luggage allowance at partner airlines.
c) Inconsistency in terms and conditions for accrual of miles travelled with partner airlines.
d) Lack of service/support at partner airlines when unexpected problems come up such as missed flight, lost baggage and extra-sized baggage.

[1] Typically, a global traveler has a loyalty program account with one member of an alliance, say United Airlines in the case of Star Alliance, and travels across the globe using services offered by the member airlines in the alliance.

e) Partner airlines' staff suggesting customers to contact their home airline (i.e. airline with their loyalty program membership) when problems arise.

The complaints *primarily* pertain to perceived deficiencies in conventional services received by a traveler at the *partner airlines*. There are no major complaints reported against their home airline. Further, customers don't seem to have complaints against the one-stop benefits. Customers seem to have taken those benefits for granted now. However, this is clearly not the case with conventional services provided by the partner airlines. Therefore, it can be said that many airlines seem to compromise on the level of service provided to the customers of their partner airlines[2]. This results in significant variation in the services experienced by a global traveler as she[3] travels through different airlines in an alliance during a journey. In fact, during the 6th annual Star Alliance MegaDO event, Star Alliance conducted a focus group to understand complaints about its member airlines. One major complaint concerned variation in customer service across partner airlines.[4] As reported in www.roadwarriorvoices.com (2015), "*… there was a definite sense that some airlines in the alliance believe they're better than others… One attendee complained that he couldn't choose his seat on a Lufthansa flight when flying with United miles, despite being a Star Alliance Gold member...*"

Interestingly, extant research mostly using survey research methodology has shown the negative impact of non-uniform service on customer satisfaction. For example, Weber and Sparks (2004) show that variation in service quality is likely to have negative impact on overall customer satisfaction for the entire alliance. It is also well documented that increase in customer

---

[2] Service aspects that are compromised include seat upgrading, seat choice, lost-baggage handling, extra-wide baggage handling and assistance during emergencies such as when a flight is missed or cancelled.
[3] Specific gender is used for the sake of convenience only.
[4] http://www.roadwarriorvoices.com/2015/06/03/4-of-the-biggest-complaints-about-star-alliance/

satisfaction leads to more loyalty, i.e. apart from what loyalty programs do[5]. In fact, Weber (2005) shows that (conventional) services are important to customers, perhaps even more than miles accumulation. Bolton (1988) has shown that when customer is highly satisfied with the prior services provided by the firm the duration of the provider-customer relationship is longer. In yet another study, Bourdeau, Cronin and Voorhees (2007) investigate service alliances in general and find that when customers are highly satisfied with the service quality at the partner service-provider, their evaluation of their primary (home) service-provider tends to be more favorable, and vice versa. Hence, in light of these findings, the complaints reported on websites such as http://www.airlinecomplaints.org about the service at the partner airlines look surprising. Clearly, these complaints should be of concern to airline alliances.

Alliances, while offering one-stop benefits have perhaps inadvertently affected how a member airline serves customers of its partner airlines. What explains this observation? Is the issue particular to an airline or is it alliance-wide? Are the loyal customers of an airline expecting more than what a partner airline is willing to or can provide to them? What should the alliance and its member airlines do to deal with the problem and thereby improve customer service and satisfaction?

Our primary objective in this research is to analytically investigate the variation in service quality experienced by travelers during their journey across member airlines in a global airline alliance network. We propose a game theoretic model to study the reasons (e.g. limited

[5] Simply put, loyalty programs "buy" loyalty while customer service earns loyalty. Research into effectiveness of loyalty programs in general shows mixed results (Singh, Jain and Krishnan 2008; Dowling and Uncles 1997; Reichheld and Teal 1996).

capacity of airlines) for the existence of service quality variation. We also discuss ways in which airlines can address this issue and improve their profits and travelers' satisfaction.

The rest of the paper is organized as follows. In Section 2, we develop the analytical model. After deriving the key theoretical results we analyze the robustness and credibility of the results using observed data. We also analyze the impact of the main parameters of the model. We also examine if these results hold good under a key variation of the proposed model. In Section 3, we use the insights gained from the sections 2 to suggest several possible solutions to the problem. Section 4 summarizes the paper, giving directions for future research.

MODEL FORMULATION

We focus on the service capability of an airline, which comes under stress when the airline becomes part of an alliance. The reasons for this focus are as follows. First, as new members get added to an alliance to enlarge its geographical reach, each member airline experiences a higher flow of customer traffic resulting in higher strain on its service infrastructure and policy guidelines that were primarily designed to handle only its own customer traffic. Second, member airlines differ in their ability to offer necessary additional services for the members of the partner airlines. Given that the services are airline-specific, the quality of service infrastructure may differ from one member airline to another, or the airlines' priorities may differ.

Third, rules and regulations regarding upgrade, miles accumulation and baggage allowance vary widely across member airlines. The global travelers, however, may not be aware of all these variations. Therefore, they expect similar service from various member airlines during their travel through an alliance network. As a result, some of these customers may demand certain services such as a seat upgrade from a partner airline that might not be available to them because priority is generally given to the partner airline's own loyal customers. In such cases, the service staff at the airline counters would find it difficult to handle the customers' demands, resulting in complaints of poor service.

Fourth, in times of emergencies such as missed flights and lost baggage, an airline may not be able to proactively help a stranded passenger of a partner airline because it might not have access to the passenger's information such as cell phone number, which would be resting in the data base of the customer's home airline. This puts passengers of partner airlines at a disadvantage during emergencies, resulting in perceived poorer service.

It would be incorrect to say that airlines overlook service capacity issues when they form an alliance. However, to what extent these issues are given priority by the executive board of an alliance is not clear because the level of seriousness accorded to the service capacity issue could depend on the nature of the alliance. In general, alliances vary along a continuum based on the level of cooperation—all the way from a "joint venture" to a loose "code-sharing" agreement. To cover the range of alliances and for simplicity, we consider two types of alliances in this research:

Scenario 1: The alliance as the mother organization decides what service level each member airline should offer to customers of the partner airlines. This is akin to a "joint venture".

Scenario 2: Each member airline of the alliance decides the service level to offer to customers of its partner airlines.

We use a linear spatial model to analyze factors influencing service quality variation under both the scenarios. The alliances we see among airlines can either be reduced to one of these two scenarios or may lie somewhere in between (Figure 1 presents the two scenarios along with an overview of the model we develop in this research). For Scenario 1, we use a decision calculus approach for our analysis and for Scenario 2 we augment it with a game theoretic analysis.

We study air journeys that have two parts or sectors. We assume two airlines in the alliance where the first sector of the journey is operated by one airline and the second sector by the other airline. We further assume that for a given customer, the first sector is with the home airline, i.e. the airline with which the customer has her loyalty program membership. We refer to this airline as A1. The second sector is with the partner airline, A2. Customers using the alliance buy one ticket for the whole journey and expect similar conventional services on both sectors.

Description of Scenario 1

In this scenario, the Alliance[6] is the decision maker and the member airlines are expected to follow the guidelines stipulated by the Alliance. We first explain the decision variables and the parameters that give structure to the model, then develop the profit function for the Alliance, and finally derive the optimal price and service level.

SERVICE Level: The customer experiences conventional services offered by the home airline (A1) in the first sector and the partner airline (A2) in the second sector. Assuming that these services could be at different levels, let 0 indicate the poorest service level and 1 indicate the best service level. Further, we assume that to this customer her home airline A1 offers a service level of 1 and A2, the partner airline, offers a service level s ($0 \leq s \leq 1$), to be chosen by the Alliance. Since an airline can easily identify its own loyal customers and those of the partner airline, it can render different levels of service to the two groups, especially with respect to

[6] Henceforth, we use Alliance (with cap A) whenever we want to indicate the alliance as a decision maker.

services such as seat choice, seat upgrade, assistance during missed flights or delayed flights, and extra luggage. There are two caveats here. First, with respect to some services such as lounge access, even the airline's own customers may suffer when lounge is full and those times the customers might be dissatisfied but we assume that those situations will not be frequent enough to make the overall service rendered to them less than 1. Second, when two airlines in an alliance have inherently different service levels, a customer whose home airline has 'inferior' service might find some service aspects at the partner airline better in spite of the partner airline offering less than its full service. This situation can be accommodated in our model. However, for simplicity we assume that the alliance members are similar and inherently offer similar level of service to their customers.

CUSTOMER Segments: We assume that there are two segments of customers: those who travel in economy class (E-class) and those who travel in higher classes (e.g. business class, denoted by H-class). One would expect H-class customers to be more sensitive to service than E-class customers because a major reason for paying higher ticket price is to receive better service. Let the utility obtained by a customer from service level "*s*" be UH(s) for H-class customers and UE(s) for E-class customers. As *s* increases from 0 to 1, the utilities obtained by H and E customers respectively are specified as:

$$UH(s) = s\ Umax \tag{1}$$

$$UE(s) = s\ \delta + (Umax - \delta) \tag{2}$$

where s is the service level experienced by customers, and $0 < \delta < Umax$. Without loss of generality, let Umax = 1. In that case, UH(s) = s and UE(s) = $s\delta + (1 - \delta)$.

Role of δ: As δ gets closer to 0, UE(s) gets closer to 1 implying that E-class customers are completely satisfied with any level of service provided to them and that a change in service level would not influence their satisfaction. On the other hand, if $\delta = 1$, then UE(s) = s implying that E-class customers behave more like H-class customers because their utility would be enhanced by higher service level. Since a higher value of δ means higher service sensitivity (i.e. $\frac{\partial\, UE(s)}{\partial\, s} = \delta$), we consider δ as a measure of service sensitivity of E-class customers.

Since both H- and E-class customers receive full (i.e. the expected) service from their home airline (i.e. s = 1), both would enjoy a utility of value 1 when flying with their home airline. However, when they fly with the partner airline, which offers a service level of $s \leq 1$, the H-class customers enjoy utility UH(s) = s while the E-class customers enjoy utility UE(s) = $s\,\delta + (1 - \delta)$.

COST-to-serve: Since service plays a critical role in how customers value their travel experience, airlines invest significantly in service infrastructure, which includes setting up service centers and counters at airports around the world, deploying well-trained service personnel at various contact points (i.e. check-in counters, baggage areas, gates, and in-flight), employing technology and putting up special processes and service facilities such as lounges to cater to their loyal customers of different grades.

When an alliance is formed, it is aware that to serve the increased customer flow, member airlines have to either expand their service infrastructure, which needs significant investment, or extract more from existing assets and resources, which would increase the operating cost of serving a customer. Assuming the latter, we propose the following cost-to-serve specification for an airline[7]:

$$\text{Cost-to-serve} = C(s) = \text{Base cost-to-serve} + f\,(\text{additional volume of services provided}) \tag{3}$$

The base cost that an airline incurs using its existing infrastructure is assumed to be 1. Extracting more out of the installed capacity of the infrastructure to serve additional customers would result in a variable cost that increases at an increasing rate. This implies that the function f(*) in expression (3) is convex. Given that *s* is the level of service offered to the customers of partner airline, we specify the cost function as:

$$C(s) = 1 + s^2 \tag{4}$$

A customer in our model travels through two sectors during the journey, the service cost in equation (4) refers to the total service cost incurred by the Alliance to serve a customer over the complete trip. Consider customer G1 travelling from city C1 to C2 by airline A1, the home airline, and from city C2 to C3 by airline A2, the partner airline. Similarly consider another customer, G2, travelling from C3 to C2 by A2, her home airline, and from C2 to C1 by A1, the partner airline. The airline A1 will incur service cost of "1" in serving G1 and "s2" in serving G2. Total cost incurred by A1 is 1+s2. Similarly, airline A2 will incur a cost of "1" in serving G2 and "s2" in additionally serving G1. Total cost incurred by A2 is 1+s2. Hence, for the Alliance that has A1 and A2 as its members, total cost to serve two customers taking opposite trips is 2*[1+s2], and hence the service cost incurred to serve one customer making one one-way trip (of two sectors) is 1+s2.

[7] We will discuss the "investment to expand service infrastructure" option later.

Given that s is a decision variable for the Alliance, the optimal service level will be a function of two opposing forces, namely, the increase in cost-to-serve and the extent of influence service has on customer satisfaction and in turn on the customers' choice of the Alliance.

An Alternative to Alliance: Within the framework of our analysis, one alternative to the Alliance is a customer having both the partner airlines as her home airlines by taking membership of the loyalty programs offered by both. For the 2-sector journey, she would then buy two separate tickets, one from airline A1 for the first sector and the other from airline A2 for the second sector. Being a member of both of the loyalty programs, she will receive maximum service from each airline, i.e. in each sector. We call this alternative "Independent-Airlines."[8]

We assume this alternative for three reasons. First, a recent IATA report by Brueckner, Lee and Singer (2010) uses this Independent Airlines option, which they call as 'non-aligned airlines', as the base case to compare the prices of various alliances. Second, in this option, each airline avoids competing directly with the partner airline, thus preserving an important economic objective of the alliance formation[9]. This helps us focus our research on the objective of finding out why customers experience non-uniform service across the member airlines in an alliance. Third, once a customer gets used to flying a particular alliance, choosing another alliance to reach the same international destination is likely to require her to travel through a different set of cities and perhaps in a different schedule. Hence we assume that the customer would prefer buying two independent tickets if she wants to receive the best service in both the sectors.

---

[8] She can also have two loyalty cards but buy the alliance ticket and use in each airline the appropriate card. We assume that this segment of customers is not of significant size.

[9] Economic benefits of the alliance as espoused in Brian and Doernhoefer (2011) are preserved in the Independent Airlines option.

Alliance Price: There are two aspects to price. First, the discount the Alliance gives with respect to the Independent-Airlines option, called 'spot-discount', and second, a notional discount arising from the loyalty program. Alliance enables a loyalty program member of one airline to add to her account the miles flown with partner airlines, and thereby helps the customer redeem her miles more *quickly* (i.e. compared to using two loyalty cards in the Independent-Airlines option), which she could use to get a free ticket, seat upgrade or some other discount in future. Since the customer is aware of the future price benefits, she can evaluate the present value of those benefits and use that value to perceive a notional 'miles-based discount.' We explain these two aspects of price through an example.

Let the prices at the Independent Airlines be p1 for sector 1 and p2 for sector 2. Without loss of generality, let p1 = p2 = p. Let the spot-discount be η, where $0 < \eta < 1$[10], and h be the miles-based discount. So, the customer pays $2p\eta$ to acquire the Alliance ticket; she further perceives a miles-based discount of 2p h in the choice of the Alliance over the Independent-Airlines option. For example, if p = USD 3000 (Business class), η = .7 and h = .05, then the ticket price at the Independent Airlines option is 2p i.e. USD 6000, the ticket price charged by the Alliance will be (6000 * .7 =) USD 4200 and the miles-based discount perceived by the customer would be (6000 * .05 =) USD 300. Although the customer flying the Alliance would pay USD 4200, she would perceive the price to be USD 3900 because of the future rewards she expects to get due to the miles she travels now.

---

[10] The alliance enables member airlines to avoid overlapping routes leading to cost saving. Hence we assume that the Alliance ticket price is lower than the sum of two independent tickets' prices. We found the same true in practice.

We use a spatial location model (Hotelling 1929) assuming a unit-length one-dimensional market where the Alliance product is at one end and the Independent-Airlines product is at the other end (see Figure 1). Since we have two classes of customers, E and H, we assume each class to be uniformly distributed along the market of unit length. Our objective is to find η and s the Alliance would choose to optimize profits.

MARKET share of alliance: First, let us consider the H-class segment. A customer at a distance x from the Alliance product will be indifferent between buying the Alliance product and the Independent-Airlines product when the net cost of purchasing either product is the same. For this customer:

$$\text{Net cost of buying the H-class Alliance ticket} = 2x + 2p\eta - 2p\,h - (1+s) \tag{5}$$

where (1+s) is the utility derived from the service –which is "1" in the first sector of the journey travelled with her home airline, and "s" in the second sector with the partner airline, 2pη is the Alliance price for the ticket, 2ph is the perceived miles-based discount explained earlier (i.e. more than what the Independent Airlines option provides) and 2x is the "travelling (or misfit) cost".

For a customer who chooses the Independent-Airlines option:

$$\text{Net cost of buying Independent-Airlines tickets} = 2(1-x)+2p-(1+1) = 2p-2x \tag{6}$$

In this case, the customer pays regular full price for each sector individually and receives the maximum service from partner airline as well because each airline treats the customer as its own customer.

Equating expressions (5) and (6), we get x_H, the market share of the Alliance in the H-class segment as:

$$x_H = \frac{1}{4}s + \frac{1}{2}p(1+h) - \frac{1}{2}\eta p + \frac{1}{4} \tag{7}$$

We now consider the E-class segment. The price of E-class ticket is a fraction of the price of an H-class ticket. We specify it as βp, where $0 < \beta < 1$. Note that we specify (see equation 2) the utility of E-class customers for service level s as $UE(s) = s\,\delta + (1 - \delta)$. Therefore,

$$\text{Net cost of buying E-class Alliance ticket} = 2x + 2p\eta\beta - 2p\beta\, h - [1 + \{s\delta + (1-\delta)\}] \tag{8}$$

where $(1+\{s\delta + (1-\delta)\})$ is the utility derived from the service – which is "1" in the first sector of the journey travelled with the home airline, and "s" in the second sector with the partner airline, $2p\eta\beta$ is the Alliance price for the E-class ticket and $2p\beta h$ is the miles- based discount.

$$\text{Net cost of buying Independent-Airlines tickets} = 2(1-x) + 2p\beta - (1+1) \tag{9}$$

Equating the two net costs (equations 8 and 9) and solving for x_E gives us the market share of the Alliance in the E-class segment (x_E) as:

$$x_E = \frac{1}{4}(1-\delta) + \frac{1}{2}\beta p(1+h) - \frac{1}{2}\eta p\beta + \frac{1}{4} + \frac{1}{4}s\delta \tag{10}$$

Let α be the size of H-class segment. Combining expressions (7) and (10), we get the market share of the Alliance, X_N, as:

$$x_N = \alpha\, x_H + (1-\alpha)\, x_E \tag{11}$$

PROFIT function of alliance**:** Assuming a unit market size, expression (11) gives the unit sales of the Alliance product per one-way trip in the 2-sector journey.

Profits for the Alliance = Profits from H-class customers + Profits from E-class customers.

$$\text{Profits from H-class customers} = \Pi_H = \alpha x_H(2\eta p - 1 - s^2), \tag{12}$$

where the variable cost of service is as defined and explained in expression (4).

It is important to note that the miles-based discount, *h*, does not influence the profit margin, i.e. the term in the parentheses on the right hand side of expression (12), because it is usually made available to customers from the unused flight capacity at the time of redemption. However, the miles-discount does affect customer choice, which is captured in the market share of the Alliance, i.e. x_H (see expressions 7 and 12). Stated differently, we assume that the airlines use their spare capacity intelligently to offer valuable rewards to customers without incurring significant cash outflow.

Similarly for the E-class segment,

$$\text{Profit from E-class customers} = \Pi_E = (1 - \alpha)x_E(2\eta p\beta - 1 - s^2). \tag{13}$$

Therefore, total profit for the Alliance is:

$$\Pi_N = \Pi_H + \Pi_E =$$

$$\alpha\left[p\eta + \frac{1}{2} + \frac{s^2}{2}\right][1 + 2p + 2hp + s - 2p\eta] + \tag{14}$$

$$\left[\beta p\eta + \frac{1}{2} + \frac{s^2}{2}\right](1 - \alpha)[2 - \delta + 2\beta p(1 + h) + s\delta - 2\beta p\eta]$$

In our model formulation, the following parameters give structure to the model.

p, the price of H-class seat: Since the cost of service is assumed to be less than 1 in the profit function (expressions 12 through 14), the parameter *p* has to be anchored in such a way that we have a positive profit margin.

α, the fraction of air-carrier seats that are H-class: $0 < \alpha < 1$.

β, the price of E-class seat as a fraction of the price of High class seat: $0 < \beta < 1$.

δ, service sensitivity of E-class travelers: A higher value of δ indicates higher service sensitivity; $0 < \delta < 1$.

h, miles- based discount: The discount a customer perceives while buying the Alliance ticket due to the expected future benefits (e.g. free ticket, seat upgrade) she would get through the miles accumulated quickly (vis-à-vis what she would get when selecting the Independent-Airlines option); $0 < h < 1$.

There are two decision variables, both decided by the Alliance as follows:

s: service level to be adopted by a member airline to serve customers of the partner airline, and

η: price discount offered on the alliance ticket with respect to the price of the ticket at the Independent-Airlines option.

Our objective is to derive the optimal values of η and s as functions of the five parameters p, α, β, δ and h. We first assume that the miles-discount, h, has no impact on customers, i.e. they don't see a significant difference between miles accumulation with the Alliance and with the Independent-Airlines options, and focus on the other four parameters. Later, we will analyze how the miles-based discount affects the findings.

OPTIMAL value of s (considering h=0): We first maximize the Alliance's profit function with respect to η and s separately to get first stage optimal η and s individually. Following that, we simultaneously solve the individual optimal functions to get the optimal pair $\{\eta^{**}, s^{**}\}$.

Note that profit function, Π_N, in expression (14) is quadratic in η and a 3rd degree polynomial in s. We adopt the following procedure to solve this:

We first differentiate the Alliance's profit function (equation 14) with respect to *s*. Since the function is 3rd degree polynomial in *s*, we get a quadratic equation as its derivative, whose solution gives two values for *s**. After some algebraic transformation we derive the following,

$$\frac{\partial \pi_N}{\partial s} = 0 \Longrightarrow s^* = \frac{1}{K1}\left[K2\,\eta + K3 \pm \sqrt{K4\,\eta^2 + K5\,\eta + K6}\right] \tag{15}$$

where the coefficients K1 through K6 are various combinations of the four parameters α, β, δ, p, and are given in the Appendix. We rearrange expression (15) and obtain the following:

$$[K1\,s^* - K2\,\eta - K3]^2 = K4\,\eta^2 + K5\,\eta + K6 \tag{16}$$

We next differentiate the Alliance's profit function (equation (14)) with respect to η separately, set it to zero, and obtain the following:

$$\frac{\partial \pi_N}{\partial \eta} = 0 \Longrightarrow \eta^* = \frac{1}{K7}[K8\,s^2 + K9\,s + K10] \tag{17}$$

where the coefficients K7 through K10 are various combinations of the four parameters $\alpha, \beta, \delta, p,$ and are given in the Appendix.

Inserting η∗ from expression (17) into expression (16), and simplifying the resulting expression gives an implicit function in optimum *s*:

$$g_2(s^*|\alpha, \beta, \delta, p) = A_0 + A_1 s^* + A_2 {s^*}^2 + A_3 {s^*}^3 = 0 \tag{18}$$

where the coefficients A_0, A_1, A_2 and A_3, are various combinations of the four parameters $\alpha, \beta, \delta, p,$ and are given in the Appendix.

Solving for s^* in expression (18) will give us the optimal value of *s*, i.e. s^{**}. However, since expression (18) is a 3rd degree polynomial in s*, we get three solutions: s_1^{**}, s_2^{**} and s_3^{**}.

Substituting each solution back in (17), we get three corresponding optimal values for η. Thus we have three optimal sets of values: $\{s_1^{**}, \eta_1^{**}\}$, $\{s_2^{**}, \eta_2^{**}\}$ and $\{s_3^{**}, \eta_3^{**}\}$.

We now analyze under what conditions would an optimal set of s and η fall within (0,1]. We derive these conditions and later check if they are realistic.

THEOREM 1**:** Existence theorem for $s^{**} < 1$

For a given value of p, if the three parameters $\{\alpha, \beta, \delta\}$ are such that $0 < \alpha < 1$, $0 < g(p) < \beta < 1$, and $0 < \delta < 1$ then the function $g_2(s)$ has exactly one root within the range [0, 1], where g(p)= .3542/(p-1)^.79. This implies the existence of a solo s^{**} that is positive and less than 1.

Proof is given in the Technical Appendix (part of the Web Appendix), following Lemma 1. Note that all the three parameters (α, β, δ) are in the bounded region [0, 1] by design. Hence, the support space specified in Theorem 1 is the whole range of α and δ, but a subset of the full range of β. This subset is (*g(p),* 1), where *g(p)* is a monotonically decreasing function in *p*, i.e. for higher values of *p*, the support given by β is larger. We next derive the conditions that support the existence of an optimal η less than 1.

THEOREM 2: Existence theorem for $\eta^{**} < 1$

For a given value of p, if the three parameters $\{\alpha, \beta, \delta\}$ are such that $(1 / (p-1)^2) < \alpha < 1$, $0 < \beta < 1$, and $0 < \delta < 1$ then for every value of s in its range [0, 1], there exists η^{**} with a positive value less than 1.

Proof is provided in the Technical Appendix (part of the Web Appendix), following Lemmas 2 and 3.

Combining Theorems 1 and 2, we have Theorem 3 concerning the conditions that support the existence of $\{s^{**}, \eta^{**}\}$ in the 2-dimensional [0, 1] space.

THEOREM 3: Existence theorem for s^{**} and η^{**}, both to be less than 1

For a given value of p, if the three parameters {α, β, δ} are such that $(1 / (p-1)^2) < \alpha < 1$, *g(p)* $< \beta < 1$, *and* $0 < \delta < 1$ *, there exists a solo optimal service level* $s^{**} \in [0, 1]$ *and a corresponding optimal Alliance-price (expressed as fraction of the full-price)* $\eta^{**} \in [0, 1]$, *where g(p) = .3542/(p-1)^.79.*

This theorem simply puts together the conditions mentioned in the Theorems 1 and 2 and hence needs no further proof[11].

CREDIBILITY and Robustness of the implications of the theorems: In Table 3, we present the solution support space (i.e. the space of parameters (α, β, δ) which support the solution "$s^{**} < 1$ and $\eta^{**} < 1$" as defined in Theorem 3 for a sample of values of *p*.[12]

Insert Table 3 about here

For example, looking at the case of p=4 (first row in Table 3), we see that for the "$s^{**} < 1$ and $\eta^{**} < 1$" solution to exist, α has to be between .1111 and 1, β has to be between .2048 and 1, and δ has to be between 0 and 1.

We collected information on the class and seat configuration of various carriers (around 300 in number) and calculated that approximately 20% of the total seats in a carrier are H-class seats. Therefore, α was estimated to be .20. As we can see, the real world α is well within the theoretically derived range (see Table 3, column 2 and its two sub-columns). We also sampled many airline tickets for H-class and E-class fares and found that E-class ticket prices are around

---

[11] A full list of all the notations used in our research is provided in the Appendix.

[12] Parameter *p* should ensure positive profit margin. It can be shown that profits are more likely to be positive and operating margins realistic if $p \geq 4$ and <10 respectively. Therefore, we anchor the parameter p in [4, 10] .

30% of the H-class ticket prices, suggesting β to be around 0.3 (see Table 4 in the Web Appendix).

Hence, the real world β also lies well within the theoretically derived range (see Table 3, column 3 and its two sub-columns). Of course, there is no need to check for δ. Therefore, we find that the solution space suggested by our model is credible with respect to the case of p=4 (first row in Table 3). Looking at the other rows of Table 3 where p > 4, one can notice that the theoretical support ranges for α and β get wider implying that our findings in case of p = 4 hold true for higher values of p as well.

We now look at optimal s and η. We chose a few parameter values randomly from the three-dimensional solution support space (i.e. α, β, δ) and find their corresponding solutions $\{s^{**}, \eta^{**}\}$, which are expected to be in the 2-dimensional [0, 1] space, at various values of p. Consider $p = 4$, $\alpha = 0.20$, $\beta = 0.3$ and $\delta = 0.5$. In this case, the optimal service level s^{**} was found to be 0.2736 and the optimal alliance discount η^{**} was found to be 0.7123, both less than 1. Similarly, for $p = 10$, $\alpha = 0.20$, $\beta = 0.3$ and $\delta = 0.5$, we find s^{**} and η^{**} to be 0.2805 and 0.5865 respectively, both less than 1. For any p between 4 and 10, using the values for (α, β, δ) as (0.2,0.3,0.5), we found s^{**} and η^{**} both less than 1. Table 5 in the Web Appendix gives the actual η-observed in a sample from the airline market. The last column of Table 5 gives the observed value of η in the market. Taking an average of these values, we get the observed average η to be .7457. The observed values of η give credibility to the theoretical range of η that support the solution space. Table 3 combined with our results here demonstrates that our model explains why airlines in an alliance provide less-than-satisfactory level of service to loyal customers of their partner airlines. Next, we show how this finding is true even when we include miles-based discount's impact.

OPTIMAL value of s (considering $h \neq 0$): As explained previously, miles-based discount reflects future free ticket or seat upgrade customers expect to get when enough miles are accrued. This discount affects customer choice towards the Alliance but not the airlines' profit margins.

Our research question concerns whether this miles-based discount affects the optimal service level offered by an airline to the customers of its partner airline in the alliance. Since we don't have an explicit function for optimal service level (see Theorems 1 through 3), we resorted to numerical analysis to explore the impact of h (i.e. miles-based discount) on optimal service level. We used the profit function of the Alliance (equation 14) to derive the optimal service level and price simultaneously for a given set of parameter values, and then repeated the process over many sets of parameter values. One set of results is given in Figure 2.

Insert Figure 2 about here

In Figure 2, we have h on the x-axis and optimal service level on the right vertical axis, and profits on the left vertical axis. It is observed that for a higher value of h, the optimal service level is higher. One plausible explanation is as follows.

With miles-based discount, the Alliance does not incur any real cash outlay because it simply makes a promise that the miles accumulated in that travel would be rewarded later. Later too, when the miles are redeemed, the airlines use their spare capacity to pay off the reward, and again actual cash outlay does not happen. Hence, the Alliance is able to influence customer choice without incurring real cash outflow for the airlines by using its spare carrier capacity intelligently. The resulting increase in the market share of the Alliance brings in more profit for the Alliance (see left vertical axis of Figure 2), which they use to improve their service level and increase their value proposition to the customers.

As mentioned before, all the four parameters α, β, δ and h lie in the (0, 1) range and hence the numerical analysis is reliable. Note that in Figure 2, we had assigned a value of .20 to α and a value of 0.3 to β, which are close to what we observe in practice (see Tables 4 and 5 in the Web Appendix). We tested several values for δ, and although we have presented only one case in Figure 2, other results are very similar. The offering of future rewards for miles out of spare capacity, in lieu of price discount at the ticket counter increases not only the profits of the Alliance but also the optimal service level. *This suggests that providing higher perceived benefits to customers by leveraging spare capacity can enhance customer service as well—another benefit of loyalty programs.*

Description of Scenario 2

In Scenario 1 (i.e. Section 2.1), the Alliance chose the optimal price for the whole trip, and also the optimal service level each member should offer to the loyal customers of the partner airline. In Scenario 2, we let the Alliance decide on the optimal price as before. However, we let each member airline choose an optimal service level to offer to customers of the partner airline. Note that each member airline always offers full service to its own loyal customers. Hence, while deciding the service level for customers of the partner airline, an airline would like to take into account how its own loyal customers would be treated by the partner airline. We will use the decision calculus approach as in Scenario 1 with a difference. In Scenario 2 it is not the Alliance that decides the optimal service level, it is each airline in the alliance that makes the decision. Further, each airline's decision takes into account the decision by the partner airline. Hence, we augment the decision calculus approach with game theoretic analysis.

The setup in Scenario 2 is similar to that of Scenario 1. We consider two groups of customers making opposite trips, where each trip is of two sectors. Consider a customer in group G1 travelling from city C1 to C2 by airline A1, G1's home airline, and from city C2 to C3 by airline A2, the partner airline. Similarly consider a customer in another group, G2, travelling in the opposite direction from C3 to C2 by A2, G2's home airline, and from C2 to C1 by A1, the partner airline. The customer group G1 will receive full service from A1 and a service of level s_2 from A2, where $0 < s_2 < 1$. The customer group G2 will receive full service from A2 and a service of level s_1 from A1, where $0 < s_1 < 1$. See the table below.

	Part of the trip served by A1 of the alliance	Part of the trip served by A2 of the alliance
G1: Loyal customers of Airline 1 (A1)	Service level = 1, the maximum	Service level = $s_2 < 1$
G2: Loyal customers of Airline 2 (A2)	Service level = $s_1 < 1$	Service level = 1, the maximum

As in Scenario 1, we assume that there are two segments of customers within each group, namely, economy class (E-class) and high class (H-class). As s_i, i = 1,2, increases from 0 to 1, the utilities obtained by H- and E-Cclass customers of group 1 respectively, are specified exactly as before, for the whole two-sector journey:

$$UH(G1) = 1 + s_2 \quad \text{and} \quad UE(G1) = 1 + s_2\,\delta + (1 - \delta)$$

where 1 is the service level offered to G1 customers by their home airline A1 in sector 1 and s_2 is the service level offered to them in their second sector by the partner airline A2, and $0 < \delta < 1$. Similarly, G2 customers will have:

$$UH(G2) = 1 + s_1 \quad \text{and} \quad UE(G2) = 1 + s_1\,\delta + (1 - \delta)$$

Where 1 is the service level offered to G2 customers by their home airline A2 in sector 1 and s_1 is the service level offered to them in their second sector by the partner airline A1, and $0 < \delta < 1$. Our specification of utilities ensures that E-class customers are less sensitive to service than H-class customers. Note that in this scenario, s_1 is a decision variable for A1 and s_2 is for A2. The cost of providing service is similar to what we had for Scenario 1, given as follows:

$$C(s_i) = 1 + s_i^2, \text{ where } i = 1, 2 \tag{19}$$

Let the Alliance price be η times the full-price a customer would pay if she chooses the Independent-Airlines option, where $0 < \eta < 1$. This means that the customer in either group pays the regular price 2p with Independent-Airlines option and a discounted price of $2p\eta$ with the Alliance option. Here, η is a decision variable for the Alliance.

Using the spatial location model as before, we assume a unit-length one-dimensional market where the Alliance product is at one end and the Independent-Airlines product is at the other end (see Figure 1). We derive the choice of the two customer groups, and thereby the market share of the Alliance. As done in Scenario 1, we derive the market share of the Alliance as follows. With respect to group G1 customers, the market shares for the Alliance in the H-class segment (x_{H1}) and E-class segment (x_{E1}), are:

$$x_{H1} = \frac{1}{4}s_2 + \frac{1}{2}p(1+h) - \frac{1}{2}\eta p + \frac{1}{4} \tag{20}$$

$$x_{E1} = \frac{1}{4}(1-\delta) + \frac{1}{4} + \frac{1}{2}\beta p(1+h) - \frac{1}{2}\eta p\beta + \frac{1}{4}\delta s_2 \tag{21}$$

Similarly, with respect to group G2 customers, the market shares for the Alliance in the H-class segment (x_{H2}) and the E-class segment (x_{E2}) are:

$$x_{H2} = \frac{1}{4}s_1 + \frac{1}{2}p(1+h) - \frac{1}{2}\eta p + \frac{1}{4} \tag{22}$$

$$x_{E2} = \frac{1}{4}(1-\delta) + \frac{1}{4} + \frac{1}{2}\beta p(1+h) - \frac{1}{2}\eta p\beta + \frac{1}{4}\delta s_1 \tag{23}$$

We now have two airlines, each set to choose its own optimal level of service to offer to customers of the partner airline taking into account that the other airline would also make the same decision. Both the choices will collectively affect the Alliance's appeal to the customers. The profit functions of the two airlines are as given below.

$$\text{Profits to Airline A1} = \Pi_{A1} = \frac{1}{2}Rev - \{\alpha x_{H1} + (1-\alpha)x_{E1}\}1 - \{\alpha x_{H2} + (1-\alpha)x_{E2}\}s_1^2, \tag{24}$$

$$\text{Profits to Airline A2} = \Pi_{A2} = \frac{1}{2}Rev - \{\alpha x_{H2} + (1-\alpha)x_{E2}\}1 - \{\alpha x_{H1} + (1-\alpha)x_{E1}\}s_2^2, \tag{25}$$

where Rev is Revenue to Alliance = $\alpha[x_{H1} + x_{H2}]2\eta p + (1-\alpha)[x_{E1} + x_{E2}]2\eta\beta p.$ (26)

Expression (26), the revenue function, recognizes the fact that although the service levels are decided independently by each airline, the price of the Alliance ticket has to be decided jointly by them because customers pay one price for the whole journey.

Expression (24) is the profit function of airline A1. The first term on the right-hand side of the expression pertains to the Alliance revenue given by expression (26). We assume that the two airlines are equal in all aspects and that they share the revenue equally. The second term on the right-hand side of the expression (24) is the expenditure incurred by airline A1 to serve its own customers (i.e. G1). Note that here the unit cost-to-serve is 1. The third term is the cost incurred by airline A1 to serve customers from group G2, i.e. loyal customers of airline A2. Here the unit cost-to-serve is, as explained before, s_1^2. Note that expression (24) is a function of all the three control variables, namely, s_1, s_2 and η, but the optimizing variable is s_1, i.e. the variable that A1 is set to control independently to maximize its profits.

A similar explanation is applicable for expression (25), which is the profit function of airline A2. The control variable is s_2, which is chosen independently by A2 to maximize its profits.

SOLVING for optimal service levels: In expression (24), we see that if airline A1 increases the service offered to group G2 (i.e. A2's loyal customers) through adopting a higher s_1, there is a negative impact, which is the higher service expenditure (third term on expression 24). There is also a positive impact, which is the increased revenue from the alliance (see expression 26) because a higher s_1 enhances the appeal of the alliance. The net result however depends on two factors. Firstly, A1 gets only a part of the increased alliance revenue (see the first term of expression 24); the other part goes to airline A2 (see the first term of expression 25). Secondly, the revenue of the alliance depends also on s_2, the service to be offered by airline A2 to the loyal customers of A1 (group G1). For example, if airline A2 chooses a very low s_2, the alliance will get low revenue resulting in airline A1 not getting enough increase in its revenue to offset its service expenditure on the loyal customers of A2. And, airline A2 may not suffer much, especially if service sensitivity is low, because it has not spent on providing higher service to loyal customers of A1. Hence, there is an incentive for A2 to offer a lower service level if it knows that A1 offers a higher service level.

Thus, when choosing a particular s_1, airline A1 would like to know what s_2 the airline A2 will choose to serve customers of A1. For every value of s_2, there will be a unique optimal s_1 chosen by A1. In other words, the optimal response of A1 will be a reaction function that finds the optimal s_1 for every value of s_2. Similarly it is easy to see that for every value of s_1, there will be a unique optimal s_2 chosen by A2, giving us the optimal s_2 as a function of s_1. The intersection point of the two reaction functions is the Nash equilibrium point that would characterize the stable optimal pair. We arrive at the intersection point of the two reaction functions through jointly maximizing the profit functions, expression (24) and expression (25), with respect to s_1 and s_2 respectively. Let us call the pair of optimal service levels obtained as $\{s_1^*, s_2^*\}$.

Note that so far we have discussed deriving optimal service levels assuming some arbitrary value for the price parameter, η. We can use the optimal pair $\{s_1^*, s_2^*\}$ in expression (26) and derive the corresponding optimal price parameter by maximizing expression (26) with respect to η. Call it η^*, which is a function $\{s_1^*, s_2^*\}$. Inserting this η^* back in expressions (24) and (26) we can derive the next updated optimal pair for the service levels, and so on, iteratively. We simplify this iterative procedure through jointly maximizing the three expressions (24), (25) and (26) with respect to s_1, s_2 and η, respectively to get the optimal set $\{s_1^{**}, s_2^{**}, \eta^{**}\}$.

OPTIMAL Service Levels and Optimal Price: We are interested in demonstrating the existence of the equilibrium service levels. First, we assume that miles-based discount is zero and choose five sample cases to evaluate jointly the optimal service levels and optimal price i.e. $\{s_1^{**}, s_2^{**}, \eta^{**}\}$ as explained in the previous section. The results are produced in Table 6.

Insert Table 6 about here

The optimal service level is less than 1 in all the five cases. Because of symmetry, both the airlines offer the same service level. For example, in Case 1, where $p = 4$, $\alpha = .20$, $\beta = .30$, $\delta = .50$, Scenario 2 would result in optimal service level, $s_1^{**} = s_2^{**} = .1928$, and the corresponding optimal discount of $\eta^{**} = .7529$. We tested with several other sets of parameter values and found optimal s to be less than 1.

Next, we relaxed the assumption of zero miles-based discount and analyzed the impact on the optimal service level. The results are provided in Figure 3. The findings are very similar to what we found in Scenario 1 (see Figure 2): The airlines offer higher optimal service level when they offer a higher miles-based discount to the alliance customers.

Insert figure 3 about here

The rationale is as follows. Rewards attached to miles-based discount incur no cash outlay for the airlines in the alliance. The airlines can intelligently use their spare capacity to pay off the reward when the miles are redeemed. But the reward does influence customer choice. By increasing the amount of reward, the airlines can enhance the value proposition to their customers, thereby improving the market share of the alliance leading to higher profits for the airlines. In turn, the airlines use the increased profits to offer a higher service level to the loyal customers of the partner airlines. However, it is to be noted that the airlines need to coordinate with respect to using their respective spare capacities to honor those loyalty rewards.

Discussion of Results

We showed analytically that when an airline in an alliance offers full service to its own loyal customers, it would offer less-than-full service to the loyal customers of its partner airline. The resulting customer dissatisfaction has been voiced on the web by many global travelers. Table 2 (in the Web Appendix) presents a sample of the complaints.

We considered two scenarios in our analysis. In Scenario 1 (i.e. Section 2.1), we let the Alliance decide an optimal service level to be provided by each member airline when serving loyal customers of the partner airline. And in Scenario 2 (i.e. Section 2.2), we let each member airline choose individually the service level for loyal customers of partner airlines. In both the Scenarios, we show that a member airline would offer less-than-full service to loyal customers of partner airline in equilibrium, implying that the observed service variation is an alliance-wide issue that cannot be solved by the airlines individually. Therefore, alliances have to consider this system-wide issue seriously and address it. In both the scenarios, miles-based discount increases both the service level and the profits for the member airlines (see Figures 2 and 3).

Miles-based discount allows airlines to use their spare carrier capacity to provide rewards to frequent travelers. This in turn enhances the attractiveness of the Alliance option for customers resulting in higher profitability for the airlines leading to higher service level in equilibrium. Higher service level would likely be translated into higher customer satisfaction for the airlines as well as for the alliance. Although the advantage of loyalty reward is well known at an individual airline level, our finding that it is useful for the alliance as well makes it all the more important. This could be an important advantage accruing to an airline in joining an alliance, but the issue needs further research.

Comparing the two scenarios, we find that profits for the airlines are lower in Scenario 2 because the intra-alliance competition between the two member airlines results in a lower service level. We confirmed the findings through extensive numerical analyses. Although both the airlines would benefit if they adopt a higher level of service (i.e. equal to that in Scenario 1), neither would offer this higher level of service because the airline offering higher service would be worse off if the other airline continues offering a comparatively lower level of service. Note that a higher service level is meant for the customers of partner airlines and hence the airlines would hesitate to offer that level unless they are certain that the partner airline would reciprocate equally. Therefore, unless the Alliance steps in and specifies the required service level, the perverse equilibrium of lower level of service would persist.

To demonstrate the higher benefit accruing in Scenario 1 compared to that in Scenario 2, we present numerical analyses using graphical presentation. Let us use α (i.e. fraction of aircraft capacity comprising H-class seats) = .20, β = .3 and p (i.e. H-class fare) = 4. We evaluate the optimal service level, optimal discount and corresponding profit for each airline for various values of δ (i.e. the service sensitivity of E-class customers) from .05 to .95 in steps of .05. We assume .30 for β. The results are given in Figure 4 in the Web Appendix. We observe that regardless of the value of δ: (a) the optimal service level is always higher in Scenario 1 than in Scenario 2, and (b) the profit to each airline is higher in Scenario 1 than in Scenario 2. One important implication of this finding is that partner airlines can improve customer service (and thus satisfaction) and profitability if the governing board of the alliance sets up and ensures uniform service standard across the member airlines. For this to happen, the alliance as an organization requires formal authority to set up and enforce service standards.

ADDRESSING CUSTOMER SERVICE VARIATION ACROSS ALLIANCE MEMBERS: SUGGESTIONS

Our analytical model shows that when airlines use their existing fixed assets to serve additional number of loyal customers of their partner airlines, the increased running cost of services result in the airlines offering lower level of services to the customers of their partner airlines as compared to their own loyal customers. This leads to complaints about poor services rendered by partner airlines. The results from our analysis clearly show that the observed service lapse is an inherent characteristic of an alliance.

What can airlines do to address the situation? Our analysis suggests the following:

Suggestion 1: More Control to Alliance

Given that Scenario 1, where the Alliance decides on the optimal service to be offered by each airline to customers of its alliance partner, yields higher service level to customers and higher profits to airlines as well, we suggest that the Alliance, instead of the member airlines, should prescribe and monitor minimum service level to be maintained by the member airlines when the airlines extend their services to loyal customers of partner airlines. They should also *clearly communicate* this to the customers. Letting the member airlines decide on the optimum service level reduces both the service level for customers and profits for the airlines. Ensuring such a service strategy, however, requires more authority to be entrusted with the Alliance, with an increase in incidental and monitoring costs.

An Alliance can also device an incentive scheme for the member airlines to improve their service level, i.e. service meant for the loyal customers of the partner airlines. For this to happen, the Alliance, as an organization, should be able to investigate the current practice of each airline setting its service level for the customers of partner airlines, measure the various parameters we have introduced in our model, evaluate how far the airlines can improve if the Alliance chooses a specific service level, and then decide what type of incentives would drive the airlines to improve their current service level.

Suggestion 2: Intelligent use of Spare Capacity and Larger Loyalty Rewards

Our analysis clearly shows that if airlines deploy their unused carrier capacity to honor loyalty rewards, they could offer a higher service level to loyal customers of partner airlines, leading to higher customer satisfaction. The Alliance should find ways to improve the loyalty reward program and spare capacity usage. As a corollary, we suggest that alliances should explore ways to cross-use the spare capacity in their respective member airlines, i.e. letting loyal customers from one airline use the spare capacity in another airline within a given alliance. However, this needs more involvement by the Alliance. Along with Suggestion 1, this implies that the Alliance taking control of the relevant services seems to be prudent. An in-depth analysis of this option may be a direction for future research.

Suggestion 3: Investment in Enhancing Service Infrastructure

A third option is the Alliance *requiring* member airlines to invest in expanding their service infrastructure. If this proves to be profitable for the airlines, then they would do it. We analyze this through extending our model as follows.

To include the impact of fixed investment on the running cost of rendering conventional services to the customers of partner airline, we change the model specification for the cost of providing service as follows. Instead of "Cost = $1 + s^2$" (current expression 4), we specify "Cost = $1 + g\, s^2$", where g, the new parameter, takes a value of 1 if there are no additional fixed investments in service infrastructure, and goes to zero if sufficient investments are made to enhance the service infrastructure.

However, it is not easy to find a function linking "g" and the "additional investments". Therefore, we ask: Would the additional investments required be lower than the additional profits generated by the reduced cost of service? We analyze the amount of additional profits that the Alliance would make if the cost-to-serve reduces, wherein we assume that with every change in cost-to-serve the Alliance would re-evaluate the optimal service level to choose. We use a simple example to demonstrate the feasibility of our suggestion.

For the analysis, we assume that the percentage of high-class seats in a plane is 20% (α = .20) and the economy class fare expressed as a fraction of the high-class fare is 0.30 (β = .30). Both these values are close to what we measured in our sample. We kept δ at .5 and analyzed the impact[13]. The results are in Table 7.

Insert Table 7 about here

Each column in the table was evaluated in our Scenario 1 model using Mathematica. See the column pertaining to g = 1: The airlines maintain status quo with no additional investment to strengthen the service infrastructure. The optimal service level they would render to customers of partner airline is .2432 and the corresponding overall profits for the Alliance are .5918.

See the column pertaining to g = .4: Recall that the new cost-to-serve is: "Cost = 1 + g s^2", where g, the new parameter takes a value of 1 if there are no additional fixed investments in service infrastructure, and goes to zero if sufficient investments are made to enhance the service infrastructure. Suppose the member airlines invest in fixed service assets so as to decrease the cost-to-serve the customers of partner airline by 60% (i.e. g = .4). As per the model, the optimal service level each member airline would render to loyal customers of its partner airline is .6036 and the corresponding profit for the Alliance would be .6358. Compared to "no additional investment" case, in the case of investment that reduces the cost-to-serve the alliance partner's customers by 60%, there is an increase of almost 150% in the level of service rendered while the

[13] We can evaluate δ using methods such as Conjoint analysis. For simplicity we assume that there is no miles-based discount (*h*). It is possible to evaluate parameter *h* as well using Conjoint analysis, and include it in the analysis.

Alliance's profits increase by around 7.43%. The higher profits are due to the ability of the airlines to increase their fare (see row marked "optimal Alliance price").

As the investment in infrastructure keeps increasing with the correspondent reduction in the service cost (i.e. g decreasing), we see that there is a monotonic increase in the level of service rendered by the Alliance, increase in the fare they charge, and increase in their profits. In fact, if g goes lower than .24, the resulting fare would be higher than what the customer would be charged at the Independent-Airlines option. We assume that this does not happen and so stop at g = .24. The increase in profits for the alliance is 16 % in this case.

IMPLEMENTING our proposed model: We now show how two airlines in an alliance can use our model to draw meaningful implications that could be implemented.

Consider an international flight from a city in Asia to a city in the US through Europe. Let the price of a round trip economy class seat in an alliance network be \$2,500. Let the round trip price of a high-class seat be \$7,500. These prices correspond to the parameter $\beta = .3$ in our model. Let the plane have 250 seats and $\alpha = .20$. Therefore, the number of high-class seats is 48, and the number of economy class seats is 202. Based on these assumptions, we calculate the total revenue for one round trip full flight as \$865,000. Let the number of round-trips the Alliance flies on this route per year be 100. Therefore, the total revenue per year per route = \$ 86.5 million. Over a five-year period, this per route revenue becomes \$ 432.5 million (assuming the Alliance contract is for 5 years).

Let the number of routes where the Alliance operates be 3. Therefore, the total revenue for the Alliance over the five years is \$ 1296.5 million or approximately \$ 1300 million. Gross margin within the scope of the proposed model is 25 to 70% (see Table 6 for example), an average of 50%. Suppose that the Alliance asks member airlines to invest \$ X million in service infrastructure to cater to the increased demand on conventional services. Following Table 7 (see the last column, last row), we see that the profits for the Alliance would increase by 16 %. Thus the increase in cash flow for the Alliance from investment is ($1300 * .5 * .16 =) $ 104 million. Now, it is up to the Alliance and the allied airlines to find if the investment in service infrastructure by all of them could be contained within $ 104 million.

Suggestion 4: Customer Education about Non-Uniform Service across Partner Airlines

Our results show that service inconsistency would remain a feature of an alliance although the level of service and the profitability can be managed through various methods (see suggestions 3.1 to 3.3 earlier). Therefore, to reduce customer dissatisfaction from inconsistent service encountered during their travel through the alliance network, in addition to the steps outlined earlier, airlines can educate their customers so as to manage expectations with respect to the service at the home and partner airlines. Once customers form right expectations, their level of satisfaction is likely to increase with the same set of issues.

On a similar note concerning customer expectation regarding airline services, we recall a recent incident that happened with United Airlines on April 9, 2017, when a passenger was forcefully removed from the flight after boarding because the airline had overbooked. Initially, the airline offered some compensation and there were no takers. Then they played a lottery and picked a person through the lottery, but he refused to leave. Quoting their rules, the airline used force to remove the person from his seat. That eviction resulted in bruises and visible wounds on the person. The other passengers were simply shocked. They took a video of the event and shared on social media. The incident went viral instantly.

Many passengers are aware that airlines handle overbooking through offering free flight or cash in return for customers relinquishing their seats. However, they are not aware that they can be forcefully evicted if they don't take those offers. Clearly, the airlines have not communicated this possibility appropriately to customers. The communication failure of what to expect from the airlines resulted in a big shock that spread far and wide, and brought out the issue of overbooking to the fore with such intensely that the US Congress stepped in and voiced its concern over the deteriorating service quality of the airlines, including the overbooking (The Wall Street Journal, April 15-16, 2017).

Overbooking is an outcome of the 'revenue management' program used by airlines to maximize their revenues. However, the way airlines are handling an overbooked flight has apparently been inconsistent and not properly communicated to customers. After the Congressional hearing, United Airlines and Delta promised to increase compensation to a passenger relinquishing his/her seat to up to $ 10,000 while the Southwest Airlines promised to do away with overbooking totally. Thus, one can see that properly managing the expectation of customers on various service aspects is critical to ensure continued customer support.

We now summarize this paper and present directions for future research.

SUMMARY AND DIRECTIONS FOR FUTURE RESEARCH

In this paper, we explore the customer service aspect of global airline alliances. Satisfactory experience of travelers is important in the evaluation of an alliance. And this satisfaction is mainly driven by the services they receive across member airlines throughout their journey. Therefore, it is reasonable to expect airlines to provide consistent service to alliance customers as they travel through the member airlines. However, it is observed that loyalty program members of one airline generally do not receive the same level of services at the partner airlines within the same journey. We study this issue to explore the reasons for the practice and discuss alternatives that can benefit both the alliance and the travelers.

Although service quality and airline alliance have been studied in-depth independently in other contexts, the service quality aspect of airline alliances has surprisingly not received much attention despite the importance of customer service in the airline business. The extant research has identified this issue of variation in airline service quality primarily using survey data. Giving an analytical structure to the problem, we develop a game theoretic framework to investigate this issue. The analytical approach has enabled us to propose a few solutions to the problem.

First, we show that the service variation is a system-wide issue that cannot be handled by individual airlines alone. Our analysis covers two opposite scenarios: (a) the alliance acts as one unified body that regulates and monitors member airlines to optimize alliance profit to be shared by member airlines; (b) each member airline in an alliance optimizes its own profit. The results show that a lower level of service for loyal customers of partner airlines cannot be avoided in either scenario implying that the service variation is inherent and system-wide in an alliance network.

Second, we show that letting the Alliance (i.e. the alliance as a decision making body) choose the optimal service level results in a level higher than what is achieved when the member airlines are allowed to choose their respective optimal service level. Therefore, airlines can achieve higher customer satisfaction and profits if the Alliance can regulate and monitor performance of the member airlines.

Third, our analysis shows new insights into the impact of loyalty rewards. We find that loyalty rewards enable airlines to utilize unused capacity to attract more customers for the alliance resulting in higher level of service and therefore customer satisfaction at partner airlines.

This link between loyalty program and customer satisfaction has not been explored in the extant literature. We suggest that alliances should find ways to improve the loyalty reward programs so that member airlines can cross-use the spare capacity of all the carriers in an alliance for the benefit of the alliance's customers.

Fourth, our analysis suggests that the member airlines can invest in fixed service infrastructure to improve services for the loyal customers of their partner airlines. Both customer satisfaction and profitability of the alliance can be increased if airlines can make suitable investment in service infrastructure. We also present a simple framework that utilizes our model and the findings to enable managers evaluate if any proposed investment would be profitable.

Finally, managing customer expectations is important for their satisfaction. Since non-uniformity of service experienced by customers travelling through an alliance network is inherent in the alliance structure, educating customers about this issue and managing their expectations would help reduce their dissatisfaction with the service inconsistency.

Although our findings explain observed service inconsistency and suggest ways for airlines to improve customer service and airline profitability, much more can be done to take this inquiry forward. One is to recognize that there are different types of alliances (limited cooperation on specific routes, code sharing, joint venture, merger-like integration) and each type has a different level of engagement between the member airlines and the corresponding degree of service support. It would be useful to study how each type influences the level of uniformity in service that a traveler experiences across member airlines when she travels as an alliance customer. A second research issue concerns how an alliance can bring about uniformity in customer service despite the asymmetry between allied airlines in their size and scope. Third, loyalty reward programs that use the spare capacity of all member airlines to reward a loyalty program member of any member airline is a fertile area for further analysis. Fourth, research is needed to analyze how the heterogeneity among passengers in terms of their service usage impacts service quality at partner airlines. Fifth, in each class of travel, some customers are likely to be travelling more often than the rest resulting in two sub-segments, namely, heavy users and light users. What implications does this have for airlines with respect to their service and pricing decisions needs research. Sixth, it will be interesting to analyze if a new airline joining an alliance could use its membership combined with service commitment as a competitive advantage. Seventh, with heterogeneity among airlines, it might be interesting to study how the choice of home airline by strategic customers impacts the alliance service and profitability. Finally, the issue of managing customer expectations through customer education and its subsequent effect on satisfaction needs investigation.

REFERENCES

Bamberger, Gustavo E, Dennis W. Carlton, and Lynette R. Neumann (2004), "An Empirical Investigation of the Competitive Effects of Domestic Airline Alliances," *Journal of Law and Economics*, 47, 195-222.

Bolton, Ruth N. (1998), "A Dynamic Model of the Duration of the Customer's Relationship with a Continuous Service Provider: The Role of Satisfaction," *Marketing Science*, 17, 45-65.

Bourdeau, Brian L., J. Joseph Cronin Jr. and Clay M. Vorhees (2007), "Modeling Service Alliances: An Exploratory Investigation of Spillover Effects in Service Partnerships," *Strategic Management Journal*, 28, 609-622.

Brueckner, Jan K. (2001), "The economics of international codesharing: an analysis of airline alliances," *International Journal of Industrial Organization*, 19, 1475-1498

Brueckner, Jan K. (2003), "International Airfares in the Age of Alliances: The Effects of Codesharing and Antitrust Immunity," *The Review of Economics and Statistics*, 85, 105-118.

Brueckner, J., Darin Lee and Ethan Singer (2010), "Revisiting alliances, codesharing, antitrust Immunity and international airfares: Findings from a new economic study," IATA report, www.iata.org/eocnomics

Brueckner, Jan K and Tom W. Whalen (2000), "The Price Effects of International Airline Alliances," *Journal of Law and Economics*, 43, 503-546.

Dowling, Grahame R. and Mark Uncles (1997), "Do customer loyalty programs really work?" *Sloan Management Review*, 38, 71-82**.**

Hotelling, Harold (1929), "Stability in Competition," Economic Journal, 39 (153): 41–57.

Pearce, Brian and Gary Doernhoefer (2011), *IATA Economics Briefing: The Economic Benefits Generated by Alliances and Joint Ventures*, IATA, 28th November.

Reichheld, Frederick F. and Thomas Teal (1996), "The Loyalty Effect: The Hidden Force Behind Growth, Profits, and Lasting Value," *Harvard Business School Press*, Boston.

Singh, Siddharth S., Dipak C. Jain and Trichy V. Krishnan (2008), "Research Note: Customer Loyalty Programs: Are They Profitable?" *Management Science*, 54, 1205-1211.

Weber, Karin (2005), "Travelers' Perceptions of Airline Alliance Benefits and Performance," *Journal of Travel Research*, 43: 257.

Weber, Karin and Beverly Sparks (2004), "Consumer attributions and behavioral responses to service failures in strategic airline alliance settings," *Journal of Air Transport Management*, 10, 361–367.

TABLE 3: SOLUTION SUPPORT SPACE DEFINED BY {α, β, δ} FOR A FEW SAMPLE VALUES OF p[14]

Full Price of H-class seat (p)	Number of H-class Seats as Fraction of Total Seats (α)		Fare of E-class Seat as Fraction of Fare of H-Class Seat (β)		Service Sensitivity of E-class Customers (δ)		s^{**}	η^{**}
	Lower limit	Upper limit	Lower limit	Upper limit	Lower limit	Upper limit		
4	.111111111	1	.204849	1	0	1	< 1	< 1
5	.0625	1	.148704	1	0	1	< 1	< 1
6	.04	1	.118473	1	0	1	< 1	< 1
7	.027778	1	.099326	1	0	1	< 1	< 1
8	.020408163	1	.086002	1	0	1	< 1	< 1
9	.015625	1	.076141	1	0	1	< 1	< 1
10	.012345679	1	.068518	1	0	1	< 1	< 1

As we can see, the feasible support range of α (2nd and 3rd columns) contains the real world value of α, which is about .20. Similarly, the feasible support range of β (4th and 5th columns) contains the real world value of β, which is about .30.

[14] For example, if $p = 10$ then any element in the {α, β, δ} three-dimensional space defined by {(.01234, 1), (.068518, 1), (0, 1}) respectively will yield an s^{**} in (0, 1) and a corresponding η^{**} in (0, 1) range.

TABLE 6: SCENARIO 2 (EXAMPLES SHOWING THE EXISTENCE OF s_1, s_2)

α = # of H-class seats as fraction of total seats, β = Fare of E-class as fraction of H-class fare, δ = Service sensitivity of E-class customers, η = Alliance ticket price as fraction of regular price

Case #	s_1**	s_2**	η^{**}	Profits to each airline
1	p=4; $\alpha = .20$; $\beta = .30$; $\delta = .50$			
	.1928	.1928	.7529	1.0920
2	p=4; $\alpha = .20$; $\beta = .30$; $\delta = .25$			
	.1510	.1510	.7606	1.1212
3	p=5; $\alpha = .20$; $\beta = .30$; $\delta = .50$			
	.1908	.1908	.7021	1.7246
4	p=5; $\alpha = .20$; $\beta = .30$; $\delta = .25$			
	.1501	.1501	.7084	1.7652
5	p=8; $\alpha = .20$; $\beta = .30$; $\delta = .50$			
	.1874	.1874	.6261	4.4110
6	p=8; $\alpha = .20$; $\beta = .30$; $\delta = .25$			
	.1485	.1485	.6302	4.4857
7	p=10; $\alpha = .20$; $\beta = .30$; $\delta = .50$			
	.1861	.1861	.6008	6.8590
8	p=10; $\alpha = .20$; $\beta = .30$; $\delta = .25$			
	.1478	.1478	.6041	6.9566

TABLE 7: INVESTING IN ENHANCING SERVICE INFRASTRUCTURE

	g, Level of reduction on cost-to-serve					
	Low (g=1)	.8	.6	.4	.3	High (g=.24)
Optimum Service Level to customers of partner airline (Max = 1)	.24318	.303594	.403965	.603601	.801887	.998955
Optimum Alliance Price as a fraction of Full price	.84514	.853112	.866341	.892616	.918669	.944522
Alliance's share in High class segment	.54308	.546231	.55148	.561977	.572468	.582956
Alliance's share in Economy class segment	.47508	.479049	.485642	.498773	.511835	.524835
Alliance's overall market share	.48800	.491814	.498152	.510782	.523355	.535878
Alliance Overall Profits	.59178	.599017	.611157	.635758	.660784	.686238
Profit Increase over "g=1" case profits		1.2 %	3.3 %	7.4 %	11.7 %	16.0 %

FIGURE 1: MODELING FRAMEWORK

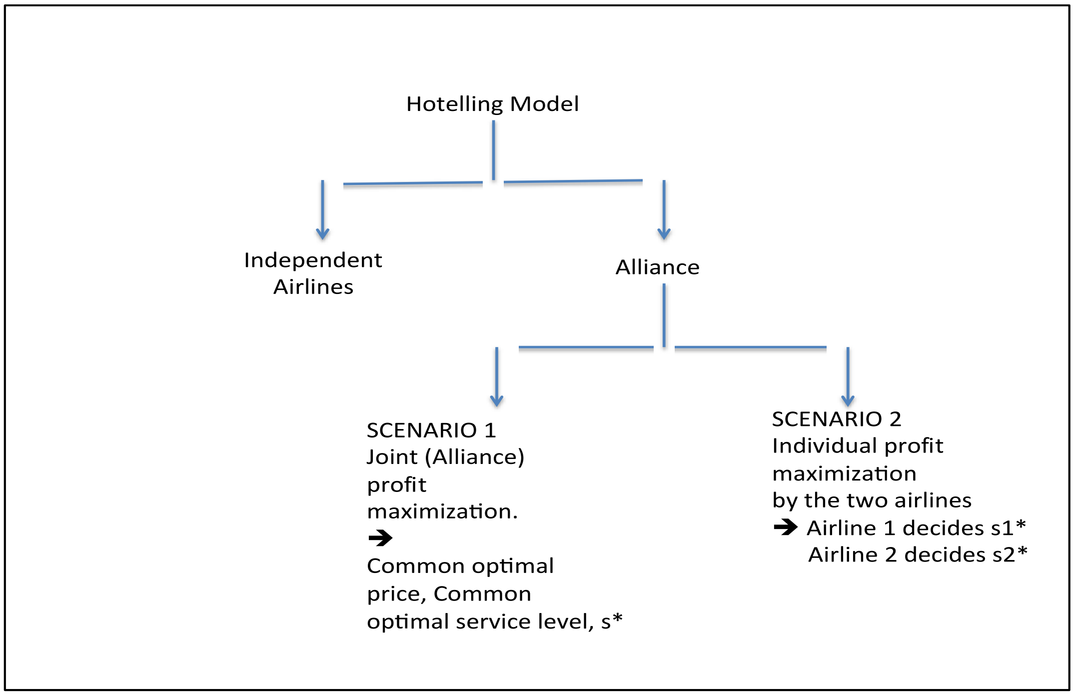


FIGURE 2: IMPACT OF MILES-BASED DISCOUNT ON OPTIMAL SERVICE (Scenario 1)

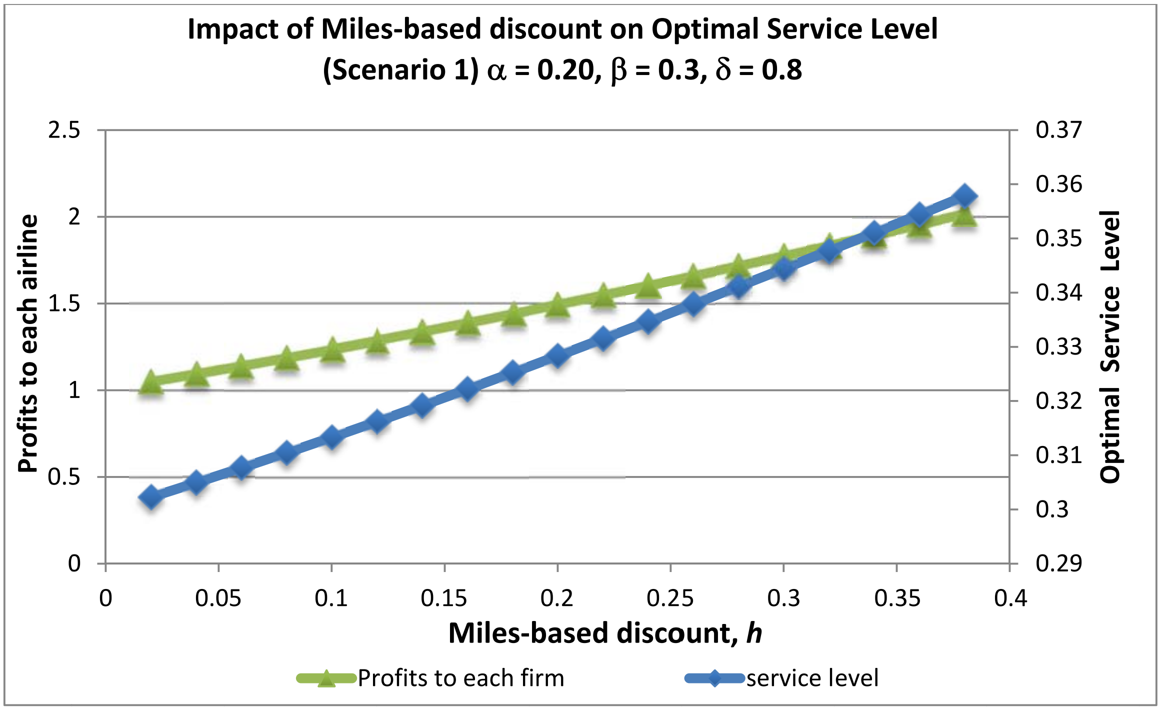
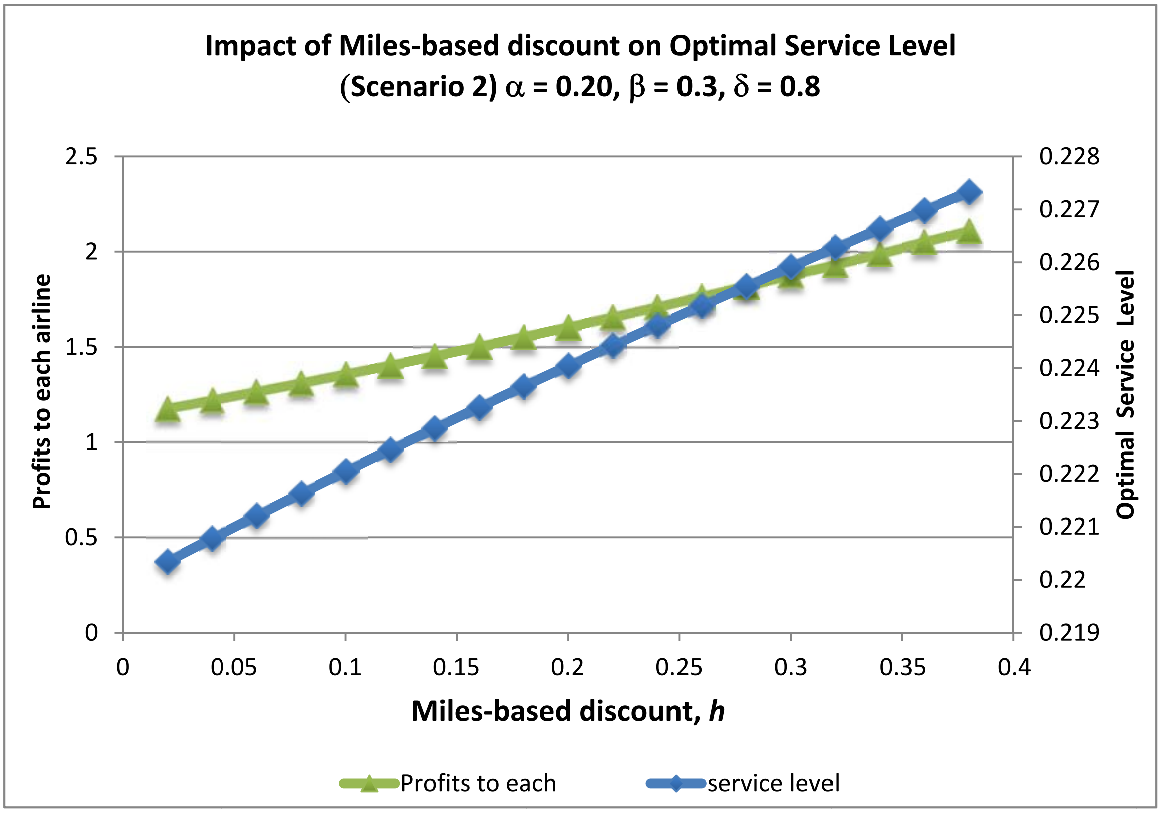


FIGURE 3: IMPACT OF MILES-BASED DISCOUNT ON OPTIMAL SERVICE (Scenario2)



APPENDIX

Terms pertaining to expressions (11) through (14) in the text and notation used:

$K1 = 3(\alpha(1-\delta)+\delta)$
$K2 = 2\beta p + 2\alpha p - 2\alpha\beta p$
$K3 = \alpha(1-\delta) - 2\beta p + 2\alpha\beta p - 2\alpha p - (1-\delta) - 1$
$K4 = 8p^2\beta\alpha - 8p^2\beta^2\alpha + 4p^2\beta^2 + 4\alpha^2p^2 - 8\alpha^2p^2\beta + 4\alpha^2p^2\beta^2$
$K5 = 2\alpha p + 2\beta p + 26\alpha(1-\delta)\beta p + 16\alpha^2p^2\beta - 8\alpha^2\beta^2p^2 - 16\delta\beta p - 2\alpha\beta p + 16p^2\beta^2\alpha$ $-16p^2\beta\alpha + 10\alpha^2(1-\delta)p - 10\alpha\delta p - 10\alpha^2(1-\delta)\beta p - 12\alpha(1-\delta)^2p\beta +$ $6\alpha^2(1-\delta)^2p\beta - 8p^2\beta^2 - 8\alpha^2p^2 + 6(1-\delta)^2p\beta$
$K6 = -2 + 8\delta + 4\beta p + 4(1-\delta)p\beta + 4\alpha^2(1-\delta)\beta p - 4\alpha\beta p - 8\alpha(1-\delta) + 4\alpha p - 8\alpha(1$ $-\delta)p\beta - 2\alpha^2(1-\delta)^2 + 4\alpha(1-\delta)^2 + 4\beta^2p^2 + 4\alpha^2p^2 - 2(1-\delta)^2 - 4\alpha^2(1$ $-\delta)p - 8\beta^2p^2\alpha + 8\beta p^2\alpha + 4\alpha^2\beta^2p^2 - 8\alpha^2\beta p^2 + 4\alpha p(1-\delta)$
$K7 = 4p(-\alpha - \beta^2 + \beta^2\alpha)$
$K8 = -\alpha - \beta + \alpha\beta$
$K9 = -\alpha - \beta + \alpha\beta + \beta(1-\delta) - \alpha\beta(1-\delta)$
$K10 = -2\alpha - 2\alpha p - 2\beta + 2\alpha\beta - \beta(1-\delta) - 2\beta^2p + \alpha(1-\delta)\beta + 2\beta^2p\alpha$
B0 = $K3^2$ – K6 + {K10 (2 K2 K3 – K5)} / K7 + $K10^2$ ($K2^2$ – K4) / $K7^2$
B1 = - 2 K1 K3 + K9 (2 K2 K3 – K5) / K7 – 2 K1 K2 K10 / K7 + 2 K9 K10 ($K2^2$ – K4) / $K7^2$
B2 = $K1^2$ + k8 (2 K2 K3 – K5) / K7 – 2 K1 K2 K9 / K7 + ($K2^2$ – K4) ($K9^2$ + 2 K8 K10) / $K7^2$
B3 = - 2 K1 K2 K8 / K7 + 2 ($K2^2$ – K4) K8 K9 / $K7^2$
B4 = ($K2^2$ – K4) $K8^2$ / $K7^2$
A0 = K32 – K6 + {K10 (2 K2 K3 – K5)} / K7
A1 = - 2 K1 K3 + K9 (2 K2 K3 – K5) / K7 – 2 K1 K2 K10 / K7
A2 = K12 + k8 (2 K2 K3 – K5) / K7 – 2 K1 K2 K9 / K7
A3 = - 2 K1 K2 K8 / K7
NOTATION
H-class seat: High or Business Class seat
E-class seat: Economy Class seat
α: Fraction of air-carrier seats that are of H-class, $0 < \alpha < 1$
p: Price of H-class seat
β: Price of E-class seat as a fraction of the price of H-class seat, $0 < \beta < 1$
δ: Service sensitivity of E-class travelers, $0<\delta<1$
H: Miles-based discount, i.e. the discount perceived by a frequent-flyer customer, $0 < h < 1$
g: Degree of impact of investment in service assets on the marginal cost of service provision
DECISION VARIABLES
s: Service level to be adopted by either member airline to serve customers of the partner airline
s_1: Service level to be adopted by Airline 1 to serve customers of the partner airline A2
s_2: Service level to be adopted by Airline 2 to serve customers of the partner airline A1
η: Price discount on the alliance ticket with respect to the price at the Independent-Airlines option

WEB APPENDIX: TABLE 1

TABLE 1: THE THREE MAJOR INTERNATIONAL ALLIANCES AS OF NOVEMBER 11, 2016 [http://en.wikipedia.org/wiki/Airline_alliance]

Star Alliance Members*	Sky Team Alliances Members#	One World Alliances Members~
Adria Airways JP	Aeroflot	Air-berlin
Aegean Airlines A3	Aerolineas Agentinas	American Airlines
Air Canada AC	Aeromexico	British Airways
Air China CA	Air Europa	Cathay Pacific
Air India AI	Air France	Finn-air
Air New Zealand NZ	Alitalia	Iberia
ANA NH	China Airlines	Japan Airlines
Asiana Airlines OZ	China Eastern Airlines	LATAM
Austrian OS	China Southern Airlines	Malaysia Airlines
Avianca AV	Czech Airlines	Qantas
Brussels Airlines SN	Delta	Qatar Airways
Copa Airlines CM	Garuda Indonesia	Royal Jordanian
Croatia Airlines OU	Kenya Airways	S7 Airlines
EGYPTAIR MS	KLM	Sri-Lankan Airlines
Ethiopian Airlines ET	Korean Air	
EVA Air BR	Middle East Airlines MEA	
LOT Polish Airlines LO	Saudia	
Lufthansa LH	TAROM Romanian Air Transport	
Scandinavian Airlines SK	Vietnam Airlines	
Shenzhen Airlines ZH	Xiamen Airlines	
Singapore Airlines SQ		
South African Airways SA		
SWISS LX		
TAP Portugal TP		
THAI TG		
Turkish Airlines TK		
United UA		

*http://www.staralliance.com/en/member-airlines ; #http://www.skyteam.com/en/about/ ; ~https://www.oneworld.com/member-airlines/overview

WEB APPENDIX: TABLE 2

TABLE 2: SUMMARY OF SOME CUSTOMER COMPLAINTS AS OF 2013 - 2015

Airlines	Alliance Affiliation	Problem Summary
Alaska and Delta	Skyteam	Delta not crediting partner airline miles
Skyteam	Skyteam	Shorting on miles with partner airlines
Oneworld	Oneworld	No alliance benefits for customers
Air Canada	Oneworld	Air Canada not crediting partner airline miles
American Airline and Iberia	Oneworld	Partner airlines not recognizing other's tickets
Copa and Lufthansa	Star	Copa not communicating with partner airline
American	Oneworld	Inability to book upgrades on other Oneworld carriers
United and Lufthansa	Star	Baggage lost in transit b/w partner airlines
Lufthansa and Air Canada	Star	Partner airlines not booking return tickets and not recognizing each other tickets
Skyteam	Skyteam	Not allowing business class (or first class) tickets to be booked 'freely' as award tickets with partners
BA and Iberia	Oneworld	Iberia charging for luggage from BA
BMI	Star	No business class tickets using airmiles
Air France and Northwest	Skyteam	No seat assignment until departure
Lufthansa and Spanair	Star	Baggage lost in transit b/w partner airlines
United	Star	United not allowing its miles to redeem through partner airlines
TAM and Lufthansa	Star	No check in for connecting partner airline
Star	Star	Poor upgrade services from Star Allaince
Thai and Lufthansa	Star	No ticket cooperation b/w partner airlines
Swiss and United	Star	Baggage lost in transit b/w partner airlines
Lufthansa and United	Star	Customer service problem
Singapore and Thai	Star	Partner airlines not cooperating and issuing boarding passes

Air Canada and Swiss	Star	Poor upgrade services from Star Allaince airlines
Lufthansa	Star	Miles award usage possible only with original carrier
United and Turkish	Star	Reservation issue
American Airline and BA	Oneworld	Baggage lost in transit b/w partner airlines
Alitalia	Skyteam	Connection missed
US Airways	Star	Missed connection, poor customer and lounge
US Airways and United	Star	Poor customer services and missed connection
TAP Portungal	Star	Not punctual and missed connections
American and Cathay Pacific	Oneworld	Poor customer services when travelling in partners
United and Continental	Star	Partner airlines lacking cooperation
Alitalia	Skyteam	No transit assistance and missed connections
Air France and Delta	Skyteam	Baggage lost in transit b/w partner airlines

Sources:
http://www.airlinecomplaints.org/
http://www.airlinequality.com/Forum/copa.htm
http://www.tripadvisor.ca/ShowTopic-g1-i10702-k5778200-Lost_baggage-Air_Travel.html
http://www.tripadvisor.ca/ShowTopic-g1-i10702-k5778200-Lost_baggage-Air_Travel.html

TABLE 4: TICKET PRICES FOR "ECONOMY" AND "HIGH" CLASS SEATS AND β FROM A RANDOMLY SELECTED SAMPLE OF INTERNATIONAL FLIGHT ROUTES AS OF JANUARY 2013: A part of the Sample
(AVERAGE β= .272656729; STANDARD DEVIATION OF β= .147940674)

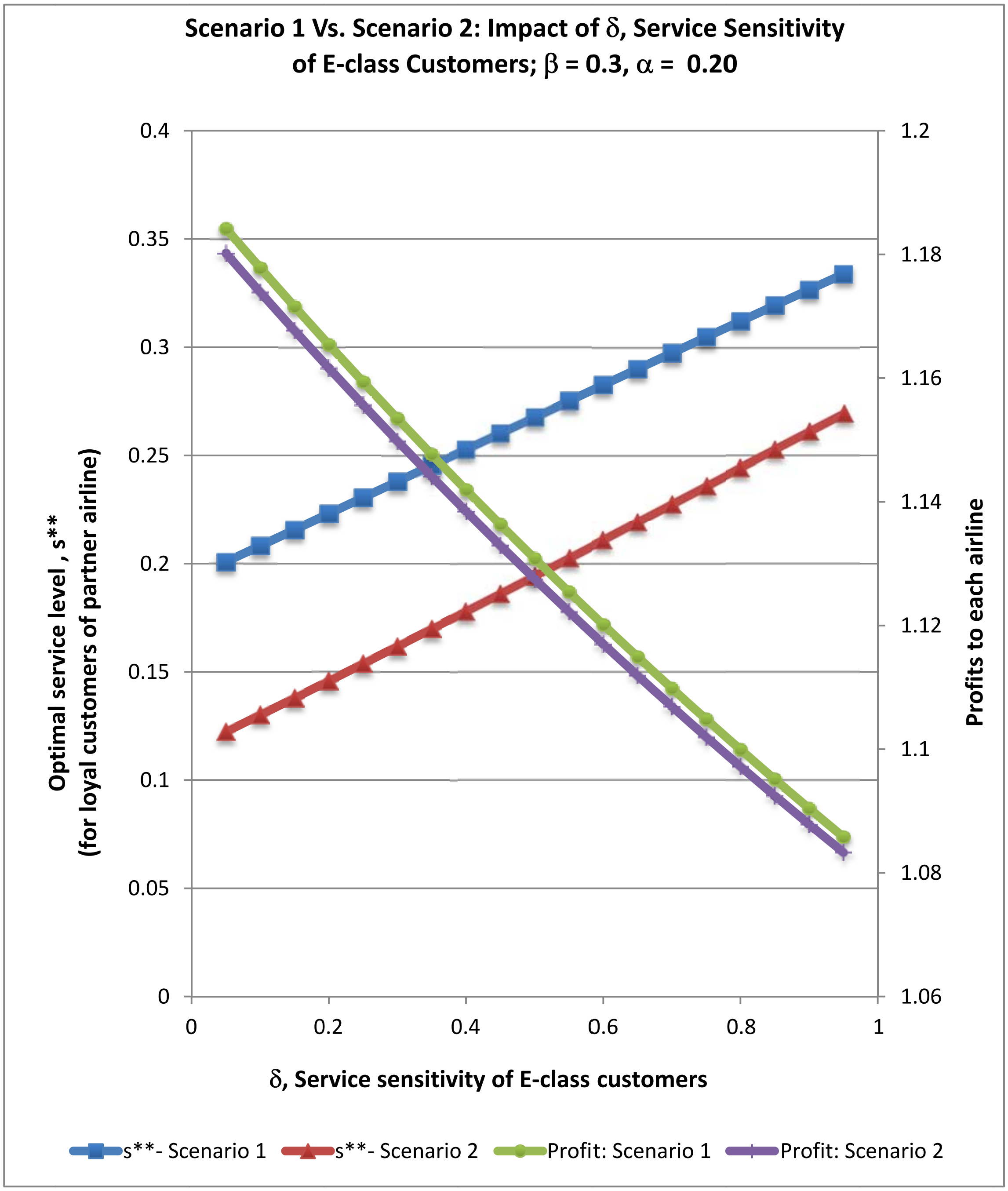
Airlines	City-Pair	Economy Class	Premium Economy	Business Class	First Class	β
KLM	London Heathrow (LHR) to Delhi(DEL)	89079		104887		.849285421
Brussels Airlines	London Heathrow (LHR) to Delhi(DEL)	66377	94385			.703257933
Malaysia Airlines	Delhi(DEL) to Singapore Changi (SIN)	26167		41323		.633230888
Srilankan Airlines	Delhi(DEL) to Singapore Changi (SIN)	32896		55619		.591452561

TABLE 5: TICKET PRICES FOR "ALLIANCE" AND "INDEPENDENT-AIRLINES" OPTIONS AND η FROM A RANDOMLY SELECTED SAMPLE OF INTERNATIONAL FLIGHT ROUTES (2013 JAN): **A part of the sample**
(AVERAGE $\eta = .74568758$; STANDARD DEVIATION OF $\eta = .27608015$)

City-Pair	**Airlines**	**Class**	**Date of Booking**	**Date of Journey**	**ALLIANCE**	**Cost A**	**Cost B**	**INDEPENDENT**	η
			(dd/mm/yyyy)	**(dd/mm/yyyy)**	**Cost (A+B)**	**(First Sector)**	**(Second Sector)**	**Cost A + Cost B**	
Washington - Delhi (Via New York)	Delta + Air India	Economy	26/1/13	29/1/13	44018.19	4643	40590	45233	**.9731**
Singapore - New York (Via Mumbai)	Jet + Air India	Economy	26/1/13	29/1/13	106132	10764	56736	67500	**1.5723**
Singapore - Los Angeles (Via London)	Singapore + American	Economy	26/1/13	29/1/13	118170	72455	50097	122552	**.9642**
Singapore - New York (Via London)	Qantas + British	Economy	26/1/13	29/1/13	68267	42007	88206	130213	**.5243**
Beijing - New York (Via London)	Virgin Atlantic + United	Business	31/1/13	3/2/13	569124	239528	327847	567375	**1.0031**
Singapore - New York (Via London)	Singapore + British	First	31/1/13	3/2/13	842320	586319	619972	1206291	**.6983**

FIGURE 4

SCENARIO 1 VS. SCENARIO 2: IMPACT OF δ, SERVICE SENSITIVITY OF E-CLASS CUSTOMERS; β = .3, α = .20



WEB APPENDIX: TECHNICAL APPENDIX

TECHNICAL APPENDIX

Notations used in our research:

H-class seat: High or Business Class seat

E-class seat: Economy Class seat

α: Fraction of air-carrier seats that are of H-class, $0 < \alpha < 1$.

p: Price of H-class seat

β: Price of E-class seat as a fraction of the price of H-class seat, $0 < \beta < 1$.

δ: Service sensitivity of E-class travelers, $0<\delta<1$.

H: Miles-based discount, which is the discount perceived by a frequent-flyer customer, $0 < h < 1$.

g: Degree of impact of investment in service assets on the marginal cost of service provision.

Decision Variables

s: Service level to be adopted by either member airline to serve customers of the partner airline.

s_1: Service level to be adopted by Airline 1 to serve customers of the partner airline A2.

s_2: Service level to be adopted by Airline 2 to serve customers of the partner airline A1.

η: Price discount on the alliance ticket with respect to the price at the Independent-Airlines option.

PROOFS FOR LEMMAS AND THEOREMS

Lemma 1: For a given value of p, if the other three parameters are such that $0 < \alpha < 1$, $(1/4p) < \beta < 1$, and $0 < \delta < 1$ then the function $g_2(s)$ is monotonic in s in the range [0, 1].

Proof: The function $g_2(s)$ is: $g_2(s|\alpha,\beta,\delta,p) = A_0 + A_1 s + A_2 s^2 + A_3 s^3$

Taking the first derivative: $g_2'(s|\alpha,\beta,\delta,p) = A_1 + 2A_2 s + 3A_3 s^2$. Setting this derivative to zero and solving for the two roots of this quadratic equation, we get: $\underline{s} = s|_{g_2'=0} = \frac{-2A_2 - \sqrt{4A_2^2 - 12A_1A_3}}{6A_3}$ and $\overline{s} = s|_{g_2'=0} = \frac{-2A_2 + \sqrt{4A_2^2 - 12A_1A_3}}{6A_3}$. The full expanded versions of A1, A2 and A3 as functions of the four parameters, namely, α, β, δ, p are given in the Appendix. Through algebraic manipulation and using "ForAll" procedure in the Mathematica[15], it can be shown that for a given value of p,

$$\forall \alpha \in (0,1), \beta \in \left(\frac{1}{4p}, 1\right), \delta \in (0,1),$$

$$\underline{s} = s|_{g_2'=0} < 0, and\ \overline{s} = s|_{g_2'=0} > 1.$$

Since there can be only two roots for the expression $g_2'(s|\alpha,\beta,\delta,p) = 0$, the finding that one root is less than 0 and the other root is greater than 1 implies that over the interval [0, 1] the function $g_2(s)$ is monotonic, either increasing all the way or decreasing all the way. ◊

Theorem 1: For a given value of p, if the other three parameters are such that $0 < \alpha < 1$, $0 < g(p) < \beta < 1$, and $0 < \delta < 1$ then the function $g_2(s)$ has exactly one root within the range [0, 1], where g(p)= .3542/(p-1)^0.79.

Proof: Let us evaluate the function g2(s) at s=0 and at s=1, the two boundary points of s.

$g_{2(s=0|\alpha,\beta,\delta,p)} = A_0$ and $g_{2(s=1|\alpha,\beta,\delta,p)} = A_0 + A_1 + A_2 + A_3$. Using the "ForAll" procedure in the Mathematica, it can be shown that $A_0 < 0$ for all values of α in the (0, 1) range, δ in the (0, 1)

---

[15] Since the three parameters α, β, δ are bounded in the interval [0, 1] the "ForAll" procedure in Mathematica can be applied.

range and β in the (g(p), 1) range, where g(p) is given by .3542/(p-1)^.79. Let us explain g(p), the lower limit of β. We checked the lower limit of β with many different values of p (from 2 to 10) and traced the resultant function. This turned out to be .3542/ p ^.79. In order to be conservative, we increased the lower limit by replacing p by p-1. See the following table for a sample of p values we tested, the actual lower limit of β, and the lower limit expressed by the function. We need the g(p) to be higher than the actual lower limit.

A function for the Lower Limit of β

p		2	3	4	5	6	7	8	9	10
Lower limit of β	Actual	.2	.142857	.111111	.1	.090909	.076923	.071429	.0625	.058824
	g(p)	.3542	.204849	.148704	.118473	.099326	.086002	.076141	.068518	.062431

Using the "ForAll" procedure in the Mathematica, it can be shown that [A_0+A_1+A_2+A_3] > 1 for all values of α in the (0, 1) range, δ in the (0, 1) range and β in the (0, 1) range. Thus, g2(s = 0) < 0 and g2(s = 1) > 1 for all values of α in the (0, 1) range, δ in the (0, 1) range and β in the (g(p), 1) range. From Lemma 1, we know that for all values of α in the (0, 1) range, δ in the (0, 1) range and β in the ((1/4p), 1) range the function g_2(s) is monotonic in s in the range [0, 1]. Since it can be easily shown that g(p) > 1/(4p) for all positive values of p, we have the result that for all values of α in the (0, 1) range, δ in the (0, 1) range and β in the (g(p), 1) range there is exactly one root of g_2(s) in the [0, 1] range of s. ◊

Lemma 2: For every value of s in its range [0, 1], there exists a positive valued η*.

*Proof***:** Consider the function that maximizes the profit function using η as the control variable (expression 15). $\frac{\partial \pi_N}{\partial \eta} = 0 \Longrightarrow \eta^* = f(s, s^2 | \alpha, \beta, \delta, p)$. Expressed fully, this becomes: $\eta^* =$

$H1\ s^2 + H2\ s + H3$, where H1=K8/K7, H2=K9/K7 and H3=K10/K7. Here, K7, K8 and K9 are various combinations of the four parameters α, β, δ and p as given in the Appendix. When simplified, we get: $1 = \frac{\alpha+\beta-\alpha\beta}{4p(\alpha+\beta^2-\alpha\beta^2)}$; $H2 = \frac{\alpha+\beta-\beta(1-\delta)-\alpha\beta+\alpha\beta(1-\delta)}{4p(\alpha+\beta^2-\alpha\beta^2)}$;

and $H3 = \frac{2\alpha+2\alpha p+2\beta-2\alpha\beta+\beta(1-\delta)+2\beta^2 p-\alpha\beta(1-\delta)-2\beta^2 p\alpha}{4p(\alpha+\beta^2-\alpha\beta^2)}$.

Differentiating η* with respect to s, and treating s as an independent variable, we get, $\frac{\partial\eta^*}{\partial s} = 2\ H1\ s + H2$. Note that H1 and H2 are both positive given that α, β and δ all lie in (0, 1) range. Hence the right hand side of the above expression is positive, and so is the left hand side. Evaluating η* at s = 0 we get:

$$\eta^*_{(s=0)} = H3 = \frac{2\alpha + 2\alpha p + 2\beta - 2\alpha\beta + \beta(1-\delta) + 2\beta^2 p - \alpha\beta\delta - 2\beta^2 p\alpha}{4p(\alpha + \beta^2 - \alpha\beta^2)}$$

$$= \frac{2\alpha + 2\alpha p + 2\beta(1-\alpha) + \beta(1-\delta)(1-\alpha) + 2\beta^2 p(1-\alpha)}{4p(\alpha + \beta^2 - \alpha\beta^2)}$$

which is positive valued because α, β and δ all lie in (0, 1) range. Since $\frac{\partial\eta^*}{\partial s} > 0\ \ \forall s$, and $\eta^*(s = 0) > 0$, we have the result that η* is positive valued for every s in the range [0, 1]. ◊

Lemma 3: For a given p, if $\alpha > 1 / (p-1)^2$ then η* at s = 1 is less than 1.

Proof: Let us evaluate η* at s = 1. Then, $\eta^*_{(s=1)} = H1 + H2\ + H3$, where H1, H2 and H3 are given in Lemma 2. This is algebraically reduced to: $\eta^*_{(s=1)} = \frac{1}{2} + \frac{\alpha+\beta(1-\alpha)}{p(\alpha+\beta^2(1-\alpha))}$. This follows that, $\frac{1}{2} + \frac{\alpha+\beta(1-\alpha)}{p(\alpha+\beta^2(1-\alpha))} < 1 \implies \eta^*_{(s=1)} < 1$. Manipulating this further, we get:

$$p > \frac{2(\alpha + \beta(1-\alpha))}{(\alpha + \beta^2(1-\alpha))} \implies \eta^*_{(s=1)} < 1$$

Let $\frac{2(\alpha+\beta(1-\alpha))}{(\alpha+\beta^2(1-\alpha))} = \underline{p}$. Thus: p $> \underline{p} \Rightarrow \eta^*{}_{(s=1)} < 1$

Let us analyze $\underline{p}$. What is the maximum value this can take? To find this, we need to find the values of α and β that would give the highest value. We first take the derivate with respect to β, and set it to zero to get the β* that maximizes $\underline{p}$: $\frac{\partial p}{\partial \beta} = 0 \Rightarrow \beta^* = \frac{\sqrt{\alpha}-\alpha}{1-\alpha}$

Substituting the optimal β* in the expression for $\underline{p}$ we get, after simplification,

$$\underline{p}_{|\beta=\beta*} = 1 + \frac{1}{\sqrt{\alpha}}$$

Hence, we get: $p > 1 + \frac{1}{\sqrt{\alpha}} \Rightarrow \eta^*{}_{(s=1)} < 1$. This can be rephrased as:

$$\alpha > \frac{1}{(p-1)^2} \Rightarrow \eta^*{}_{(s=1)} < 1.$$

This proves the lemma. ◊

Theorem 2: For a given value of p, if the three parameters {α, β, δ} are such that $(1 / (p-1)^2) < \alpha < 1$, $0 < \beta < 1$, and $0 < \delta < 1$ then for every value of s in its range [0, 1], there exists a positive valued η^{**} whose value is less than 1.

Proof: Lemma 2 shows that η* is positive valued in the range [0, 1] of s and that it monotonically increases in s, and Lemma 3 shows that its value at s = 1 is less than 1 under certain condition. These two lemmas imply together that η* is less than 1 in the whole [0, 1] range of s for all the values of α in $(1 / (p-1)^2, 1)$ range, all values of β in (0, 1) range and all values of δ in (0, 1) range. ◊