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Assessing the Price Effects of Airline Alliances on Complementary Routes

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Abstracts

This paper investigates the impacts of complementary alliance on airfares. The conventional wisdom argues that complementary airline alliances reduce airfares for passengers on the flow-through routes as a result of the elimination of double marginalization and efficiency gain. On the other hand, complementary alliances help improve connecting services through one-stop check-in, better schedule coordination, etc., such that passengers are willing to pay higher prices for the enhanced services. That is, complementary alliances have both positive and negative effects on airfares for flow-through tickets that counteract each other. The net impact, therefore, is uncertain, *a priori*. Our theoretical model shows that the overall effects of complementary alliances on airfares depend on the relative strengths of the airfare reducing effects due to cooperative pricing setting and the increased willingness to pay for services improvements. Our empirical analysis based on data from the North trans-Pacific markets in October 2007 finds that member airlines of Star Alliance and Skyteam Alliance appear to charge significantly higher prices for through-tickets than the sum of segment fares on complementary routes, whereas for oneworld Alliance members, the upward and downward effects on airfares seem to counterbalance each other. Moreover, the price markup for through ticket is higher for business passengers than for leisure passengers.

Keywords: Complementary Alliances, Airfare, Double Marginalization

1. Introduction

Airlines form international alliances in order to expand their network and achieve global coverage while circumventing the regulatory and legal barriers that preclude airlines from actually operating in or between foreign countries (Oum et al., 1996). Alliances can and do take many different shapes and forms, but are generally classified into complementary and parallel alliances. Complementary alliances refer to those where two airlines link up their existing networks so as to feed traffic to each other, whereas parallel alliances refer to the collaborations between two airlines that, prior to their alliance, are competitors on some routes.

A fundamental concern about alliances is how alliances affect airfares and vitality of competition in the affected markets. The conventional wisdom argues that alliances may lead to the elimination of competition on parallel routes if carriers cooperate, rather than compete, on price. Such cooperative efforts may contribute to higher prices for passengers traveling with alliance carriers. However, if the alliance increases flow-through passengers, economies of density may lead to lower operating costs and lower airfares (Brueckner, 2001, 2003; Brueckner and Zhang, 2001, Park, 1997, Youssef and Hansen, 1994, Park and Zhang, 2000, Chen and Gayle 2006, and Gayle 2007). The net effects depend on the relative strengths of the offsetting forces from cooperative pricing and efficiency gains. Wan et al. (2009) investigated the effects of alliances on parallel, hub-to-hub routes, and found that the airfare effects of Star Alliances and Skyteam on transatlantic hub-to-hub routes are insignificant, whereas business airfares between oneworld hubs are significantly lower than those on other routes.

The conventional wisdom also argues that complementary alliances may reduce airfares for passengers on the flow-through routes as a result of the elimination of double marginalization (Brueckner and Whalen, 2000). In addition, the efficiency gains through the cooperation between the allied airlines would reduce carriers' costs, contributing to lower fares. On the other hand, complementary alliances provide connecting passengers with improved transfer services and greater convenience, such as shorter layover time, one-stop check-in, more flexible scheduling, shared frequent flyer programs, etc. These enhanced services would lead to an increased willingness for passengers to pay higher fares.

The objective of this paper is to explore the effects of airline alliances on airfares in the markets served by complementary alliances. We first develop an analytical model to examine how the potential airfare reductions from the elimination of double marginalization through complementary alliances may be offset by the higher willingness of passengers to pay for enhanced services. The analytical model is then empirically tested based on the data from the North trans-Pacific markets. The rest of the paper is organized as following: Section 2 provides a brief review of key studies on the effects of alliances; Section 3 develops our research propositions based on analytical modeling; and Section 4 describes the data and presents the empirical results, followed by the final conclusion and discussion section.

2. The Effects of Alliances on Airfares

When airfares are determined independently by carriers, each carrier chooses a "sub-fare" or segment fare for its own portion of an interline trip, and the sum of sub-fares will be the overall airfare paid by interline passengers. Under such so-called non-cooperative price setting, each carrier sets the sub-fare to maximize its own profit, taking other carriers' sub-fares as given. That is, without cooperation, each carrier charges a sub-fare exceeding its marginal cost for profit maximization while ignoring the fact that an increase in its own sub-fare may have a negative impact on the traffic of other carriers, which is known as double marginalization.

When carriers adopt a cooperative pricing mechanism in an alliance, they share the revenue arising from interline traffic, and through-ticket fares are set to maximize their joint profits. As a result, double marginalization would be eliminated, which would lead to lower interline fares. This argument has been supported by a number of empirical studies on international alliances. For example, Oum et al (1996) showed that code-sharing agreements resulted in lower fares and more passengers for partner airlines. Brueckner and Whalen (2000) found that interline airfares on international routes served by alliance partners were 25% lower than those provided by non-allied airlines. Furthermore, Park and Zhang (2000) found that complementary alliances led to lower fares in North Atlantic markets. Similarly, Brueckner (2003) concluded that code-sharing agreements would reduce interline fares by 8%-17% on international routes, antitrust immunity would reduce interline fares by 13% - 21%, and the combined effects would be 17% - 30% fare reduction.

Recent studies, however, have started to question the extent of fare-reducing effects from complementary alliances. For example, Bilotkach (2007) showed that airline alliances might hurt interline passengers if allied airlines only coordinate in scheduling but not in pricing. In this case, the interline fare would be increased because passengers could end up paying too much for service improvement. Czerny (2009) argued that allied airlines may use code-sharing agreements to implement price discrimination between interline passengers and non-interline passengers. Without code-sharing agreements, airlines cannot identify the interline passengers, and therefore, interline passengers are charged at the same price as other passengers. On the other hand, code-sharing agreements allow the allied airlines to market interline trips as enhanced services, thus at higher prices. As such, the welfare benefits from code-sharing agreements are questionable.

There is also anecdotal evidence supporting the arguments against the fare reduction effects of complementary alliances. For example, an article titled “Huddling Together” in The Economist[1] used the booking experience of Mr. Adam Pilarski, a former chair of economics and forecasting unit at McDonnell Douglas, to show strong skepticism towards the fare-reducing effects of complementary alliances. Mr. Pilarski was to travel from Washington D.C. to Oslo via London. He was told that the through-ticket fare was $1,500 by United Airlines with SAS operating the London-Oslo segment under code-share agreement. However, if he booked the flights separately, that is, Washington DC to London with United, and London to Oslo with SAS, the total price would be only $1,000. This implies a $500 price premium with the single through-ticket.

The above discussions indicate that complementary alliances have two counteracting effects on through-ticket fare: fare-reducing effects from the elimination of double marginalization and the increased willingness of passengers to pay for enhanced connecting services. Thus, the overall effects of complementary alliances on through-ticket fares are unknown, a priori. In the next section, an analytical model is developed to assess the above two countervailing forces. Then, some empirical evidence is provided based on the data from the North trans-Pacific markets.

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[1] The Economist, March 8, 2001

3. Theoretical Modeling

As discussed earlier, complementary alliance refers to the case where two airlines combine their existing networks and jointly provide improved services for connecting passengers. Figure 1 shows a simplified network served by two airlines. Airports A and H are located in Country I, and Airport B is located in Country II. Suppose that Airline 1 operates the domestic network in Country I (i.e., Airports A and H), while Airline 2 is supposed to be based in Country II and operate flights between B and H.

There are three origin-destination markets in Figure 1: AH, BH, and AB. Airline 1 is assumed to be a monopolist in the AH market and Airline 2 is a monopolist in the HB market. Hence, passengers traveling between A and B must take interline services: AH on Airline 1; and HB on Airline 2.

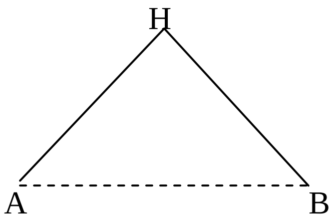

Figure 1: A Three-node Route Network across Two Countries

Model Setup:

To simplify the analysis, it is assumed that the route distance is identical on the flight segments AH and BH. Moreover, passenger demands are assumed to be symmetrical in the local origin-destination markets AH and BH. Following Park (1997) and Brueckner (2001), we assume that both demand and marginal cost functions are linear. Specifically, travel demands in markets AH, BH and AB are determined by the following:

$$q_{AH} = \alpha - p_{AH} \quad (1)$$

$$q_{BH} = \alpha - p_{BH} \quad (2)$$

$$q_{AB} = \alpha - (s_{AH} + s_{BH}) \quad (3)$$

where α is a constant parameter representing passenger demand, while p_{AH} and p_{BH} represent the monopolistic prices that Airlines 1 and 2 set in the AH market and the BH market, respectively. In the interline market AB, we assume, following Brueckner (2003), that Airlines 1 and 2 choose sub-fares s_{AH} and s_{BH} independently. Thus, travel demand in the AB market will depend on the sum of the two sub-fares (i.e., $s_{AH} + s_{BH}$). As for the cost function, we assume that airline operation is characterized by economies of density; that is, the greater the traffic density on a route, the lower the unit operating costs. Thus, the marginal cost function can be specified as follows:

$$c'_{(q)} = 1 - \theta \times q \qquad (4)$$

where q represents the traffic density on a given route, and the positive constant parameter θ reflects the presence and extent of cost reduction as a result of increased traffic density.

Given the above assumptions on market demand and marginal cost functions, we analyze the through-ticket fares under five scenarios. Scenario I is the base case where there is no alliance between the two airlines. In Scenario II, the two airlines jointly set through-ticket fares. Further, the two airlines in Scenario III are able to reduce their costs from increased traffic density. Given that alliances facilitate cooperation and coordination between the two airlines, the connecting services are improved in Scenario IV. The final scenario (Scenario V) combines all the potential effects of complementary alliances to derive its overall impact on through ticket fares.

Scenario I: Double-Marginalization Effects

This is the base case where there is no alliance between the two airlines. The profits for Airlines 1 and 2 can be expressed as follows:

$$\pi_1 = p_{AH} q_{AH} + s_{AH} q_{AB} - c(q_{AH} + q_{AB}) \qquad (5)$$

$$\pi_2 = p_{BH} q_{BH} + s_{HB} q_{AB} - c(q_{BH} + q_{AB}) \qquad (6)$$

To derive the monopolistic prices p_{AH} and p_{BH}, and the optimal sub-fares s_{AH} and s_{BH}, we substitute Equations (1)-(3) into the profit functions (5) and (6), and take the first derivative of the profits for Airlines 1 and 2 with respect to their respective airfares. Given the assumed marginal-cost specifications in Equation 4, the first-order conditions for Airline 1 can be expressed as follows:

$$\alpha - 2p_{AH} = \theta(2\alpha - p_{AH} - s_{AH} - s_{BH}) - 1 \qquad (7)$$

$$\alpha - 2s_{AH} - s_{BH} = \theta(2\alpha - p_{AH} - s_{AH} - s_{BH}) - 1 \qquad (8)$$

Equations (9) and (10) represent the first-order conditions for Airline 2:

$$\alpha - 2p_{BH} = \theta(2\alpha - p_{BH} - s_{AH} - s_{BH}) - 1 \qquad (9)$$

$$\alpha - s_{AH} - 2s_{BH} = \theta(2\alpha - p_{BH} - s_{AH} - s_{BH}) - 1 \qquad (10)$$

Solving the set of equations from (7) to (10), we obtain the optimal monopolistic airfares p_{AH}^{*}, p_{BH}^{*} and the optimal sub-fares s_{AH}^{*}, s_{BH}^{*} as follows:

$p_{AH}^{*} = p_{BH}^{*} = \frac{3+3\alpha-6\alpha\theta}{6-7\theta}$; and $s_{AH}^{*} = s_{BH}^{*} = \frac{2+2\alpha-4\alpha\theta}{6-7\theta}$.

Thus, the sum of sub-fares paid by passengers traveling between AB via H is:

$s_{AH}^{*} + s_{BH}^{*} = \frac{4+4\alpha-8\alpha\theta}{6-7\theta}$.

The second-order conditions for the profit maximization problems require the following inequality condition to hold: $\theta < 2$. In addition, the value of α must satisfy the following conditions: $\alpha > \max[\frac{4}{2+\theta}, \frac{3}{3-\theta}]$ when $\theta < \frac{6}{7}$; and $\alpha < \min[\frac{4}{2+\theta}, \frac{3}{3-\theta}]$ when $\frac{6}{7} < \theta < 2$, so that both optimal outputs and airfares have positive signs.

Scenario II: Elimination of Double-Marginalization through Complementary Alliances

When Airlines 1 and 2 jointly set through-ticket fare p_{AB} for the connecting flights in the AB market, they split the through ticket fare evenly since the route distances for AH and BH are assumed to be identical. Hence, Airline 1 will get the revenue of $P_{AB}/2$ per passenger from the AH segment, and Airline 2 will get the revenue of $P_{AB}/2$ per passenger in the HB segment. Thus, the profit functions for airlines can be expressed as follows:

$$\pi_1 = p_{AH}q_{AH} + \frac{p_{AB}}{2}q_{AB} - c(q_{AH} + q_{AB}) \qquad (11)$$

$$\pi_2 = p_{BH}q_{BH} + \frac{p_{AB}}{2}q_{AB} - c(q_{BH} + q_{AB}) \qquad (12)$$

where $q_{AB} = \alpha - p_{AB}$, $q_{AH} = \alpha - p_{AH}$, and $q_{BH} = \alpha - p_{BH}$.

Below, Equations (13) and (14) represent the first-order conditions for Airline 1, and Equations (15) and (16) represent the first-order conditions for Airline 2:

$$\alpha - 2p_{AH} = \theta(2\alpha - p_{AH} - p_{AB}) - 1 \qquad (13)$$

$$\frac{\alpha}{2} - p_{AB} = \theta(2\alpha - p_{AH} - p_{AB}) - 1 \qquad (14)$$

$$\alpha - 2p_{BH} = \theta(2\alpha - p_{BH} - p_{AB}) - 1 \qquad (15)$$

$$\frac{\alpha}{2} - p_{AB} = \theta(2\alpha - p_{BH} - p_{AB}) - 1 \qquad (16)$$

Given the symmetrical assumption on travel demands in the AH market and the BH market, the equilibrium price p_{AH} is equal to p_{BH} , as implied by Equations (14) and (16). Solving Equations (13), (14), and (15) yields the following optimal airfare solutions:

$$p_{AH}^{**} = p_{BH}^{**} = \frac{2+2\alpha-5\alpha\theta}{4-6\theta}; \text{ and } p_{AB}^{**} = \frac{4+2\alpha-7\alpha\theta}{4-6\theta}.$$

The second-order conditions for the profit maximization problems require $\theta < \frac{2}{3}$. In addition, the value of α must satisfy the following conditions: $\frac{2}{5\theta-2} < \alpha < \frac{4}{7\theta-2}$ when $\frac{2}{7} < \theta < \frac{2}{5}$; $\alpha < \frac{2}{5\theta-2}$ when $\frac{2}{5} < \theta < \frac{2}{3}$; and $\alpha > \frac{4}{7\theta-2}$ when $\theta < \frac{2}{7}$, so that both optimal outputs and airfares have positive signs.

Table 1 compares the respective equilibrium airfares for Scenario I and Scenario II.

Table 1: Comparison of Equilibrium Airfares between Scenario I and Scenario II

	Airfare in Market AB
Scenario 1: Non-cooperative setting	$\frac{4+4\alpha-8\alpha\theta}{6-7\theta}$
Scenario II: Cooperative-setting	$\frac{4+2\alpha-7\alpha\theta}{4-6\theta}$

Proposition 1:
The through ticket fare in the cooperative setting (i.e., the scenario with alliance) is less than the sum of sub-fares in the non-cooperative setting (i.e., the scenario without alliance).
(See Appendix I for the proof for Proposition 1).

Scenario III: Cost Reduction through Complementary Alliances

When θ equals zero, there is no economy of traffic density. The greater the value for θ, the greater the extent of increasing return to traffic density. That is, any increase in traffic density would reduce the unit operating costs of airlines (Oum, et al, 1996), thus lowering airfares.

Proposition 2*:*
The reduction in the through-ticket fare through the formation of alliance will be greater when there are stronger economies of traffic density. (See Appendix II for the proof for Proposition 2.)

Scenario IV: Service Improvement through Complementary Alliances

The complementary alliance between Airlines 1 and 2 in the flow-through market AB facilitates operation coordination between the two carriers, thereby enabling them to provide passengers with improved connecting services, such as reduced layover time, shared ground service facilities, closer gates, more flexible flight schedules, one-stop check-in, etc. These service improvements may stimulate additional demand for travel in the AB market. Let δ[2] represent such stimulated demand, then total demand in the AB market will have the following expression: $q_{AB} = \alpha + \delta - p_{AB}$. Assuming that the demands in the AH and BH markets remain the same, the profits for Airlines 1 and 2 can be expressed as follows:

$$\pi_1 = p_{AH} q_{AH} + \frac{p_{AB}}{2} q_{AB} - c(q_{AH} + q_{AB}) \qquad (17)$$

$$\pi_2 = p_{BH} q_{BH} + \frac{p_{AB}}{2} q_{AB} - c(q_{BH} + q_{AB}) \qquad (18)$$

where $q_{AB} = \alpha + \delta - p_{AB}$, $q_{AH} = \alpha - p_{AH}$, and $q_{BH} = \alpha - p_{BH}$.

Based on the profit equations (17) and (18), the first-order conditions for Airlines 1 and 2 can be derived as follows:

$$\alpha - 2p_{AH} = \theta(2\alpha + \delta - p_{AH} - p_{AB}) - 1 \qquad (19)$$

$$\frac{\alpha + \delta}{2} - p_{AB} = \theta(2\alpha + \delta - p_{AH} - p_{AB}) - 1 \qquad (20)$$

$$\alpha - 2p_{BH} = \theta(2\alpha + \delta - p_{BH} - p_{AB}) - 1 \qquad (21)$$

$$\frac{\alpha + \delta}{2} - p_{AB} = \theta(2\alpha + \delta - p_{BH} - p_{AB}) - 1 \qquad (22)$$

With the symmetrical assumptions on travel demands in the AH and BH market, the equilibrium price p_{AH} is identical to p_{BH}, as indicated by Equations (20) and (22). Solving Equations (19)-(21) yields the optimal airfare solutions as follows:

$$p_{AH}^{****} = p_{BH}^{****} = \frac{2 + 2\alpha - 5\alpha\theta - \delta\theta}{4 - 6\theta}; \text{ and } p_{AB}^{****} = \frac{4 + 2\alpha - 7\alpha\theta + 2\delta - 5\delta\theta}{4 - 6\theta}.$$

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[2] An alternative explanation for this parameter is as follows. In the AB market P_{AB}' represents the "full price" paid by passengers for flying with allied airlines, and δ reflects service improvements resulting from alliance-based, "online" connections. Thus, the full price can be expressed as the difference between the monetary cost paid by passengers P_{AB} and the quality benefits due to "online" connections δ; i.e., $P_{AB}' = P_{AB} - \delta$. Using the "full price" expression, the demand function in the AB market is derived as: $q_{AB} = \alpha - P_{AB}' = \alpha + \delta - P_{AB}$.

As in Scenario II, the second-order conditions for the profit maximization problems require the inequality $\theta < \frac{2}{3}$ to hold. Furthermore, to ensure the positive values for the optimal airfares and outputs, α and δ must satisfy the following three conditions:
(1) $-2\alpha + 5\alpha\theta + \delta\theta < 2 < 2\alpha - \alpha\theta - \delta\theta$; (2) $\alpha > \frac{\delta\theta}{2 - 3\theta}$; and
(3) $7\alpha\theta + 5\delta\theta - 2\alpha < 4 + 2\delta < 2\alpha + \alpha\theta + 5\delta\theta$.

Table 2 compares the equilibrium airfares between the base case and Scenario IV. The parameter δ represents the amount of increased flow through traffic demand in the AB market as a result of service improvements due to the formation of alliance.

Table 2: Comparison of Airfares between Scenario I and Scenario IV

	Airfare in Market AB
Scenario I: Non-cooperative setting	$\frac{4 + 4\alpha - 8\alpha\theta}{6 - 7\theta}$
Scenario IV: Cooperative-setting with Service Improvements	$\frac{4 + 2\alpha - 7\alpha\theta + 2\delta - 5\delta\theta}{4 - 6\theta}$

***Proposition 3*:**
The fare-reducing effects of complementary alliances are offset by the increased willingness of passengers to pay for service improvements, leading to higher through-ticket fare.

Scenario V: The Combined Effects of Complementary Alliances on Airfare

The equilibrium airfares under Scenario IV in Table 2 are in fact the combined effects of the elimination of double marginalization through cooperative price setting, the cost reduction from increased traffic density, and the higher willingness to pay for improved services.

The difference in airfares in the AB market before and after alliance can be expressed as:

$$\Delta p_{AB} = p_{AB}^{****} - (s_{AH}^{*} + s_{BH}^{*}) = \frac{(2-\theta)(4 - 2\alpha - \alpha\theta) + \delta(12 - 44\theta + 35\theta^2)}{42\theta^2 - 64\theta + 24}$$

Then Proposition 4 is developed discussing the various conditions under which Δp_{AB} might have positive or negative values.

***Proposition 4*:**
Complementary alliances have double-edged effects on airfares in the flow through market. The net effect is uncertain, depending on the values of δ (i.e., stimulated demand or service

improvement) in relation to α and θ: When θ is less than $2/5$, through-ticket fare will be greater (lower) than the aggregated sub-fares if δ is greater (less) than $\frac{(2-\theta)(2\alpha+\alpha\theta-4)}{12-44\theta+35\theta^2}$; when θ is greater than $2/5$, but less than $2/3$, through-ticket fare will be greater (lower) than the sum of sub-fares if δ is less (greater) than $\frac{(2-\theta)(2\alpha+\alpha\theta-4)}{12-44\theta+35\theta^2}$.[3]

It is noted that the theoretical model developed in this section considers the most simplified case where the route distance, local market demand, and cost parameters are all assumed to be symmetric for Airline 1 and 2. Moreover, the model does not take into account price discrimination and product differentiation, which are common practices among airlines in segmenting business and leisure travelers. To relax any of the underlying assumptions, the model needs to be modified in various aspects. For example, the constant parameter α in Equation (1) – (3) should be allowed to vary among the three markets AH, BH, and AB to accommodate the differences in market characteristics. Second, the current demand functions assume that the price elasticity of passenger demand is homogeneous within and across markets. This assumption could be relaxed by using separate demand functions for business and leisure traveler segments in each market. Finally, asymmetric route distances could be accommodated by adopting IATA's multilateral proration rules. That is, the through-ticket revenue could be allocated based on ratio of modified distances[4] between the two flight segments.

The aforementioned modifications of the theoretical model allow us to conduct a more comprehensive investigation of the effects of complementary alliances on airfares. However, the main findings from the original model will hold; that is, the overall effects from complementary alliances on airfare in the flow-through market are uncertain, depending on the relative strength

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[3] It can also be shown that when the value of $\frac{2\delta-5\delta\theta}{4-6\theta}$ is sufficiently large, through-ticket fare in Scenario IV will always be more than the sum of sub-fares in Scenario I.

[4] Airlines' unit costs for long distance flights are generally lower than those on short distance flights due to the presence of economies of distance. Consequently, in allocating the through-ticket revenues, we need to assign a higher weight to the route distance in the shorter flight segment than that in the longer flight segment.

between potential fare reductions from efficiency gain and elimination of double marginalization effects, and higher willingness to pay for improved services.

4. Empirical Analysis

As discussed in the previous section, complementary alliances have three major countervailing effects on airfare: fare reduction effects due to the elimination of double marginalization; fare reduction effects resulting from economies of traffic density; and fare increasing effects reflecting the price premium for improved connecting services. As a result, complementary alliances may have positive, negative, or insignificant impacts on airfares in flow-through markets. Moreover, since leisure travelers are more price-conscious than business passengers, we expect that the airfare effects for leisure passengers may be different from those for business passengers.

Because the direction and magnitude of the effects of complementary alliances on airfare cannot be clearly defined a priori, it is necessary to conduct an empirical investigation to estimate how alliances might impact airfares on complementary routes. In this section, we conduct an empirical study based on data from the North trans-Pacific markets

4.1 The Data

Our empirical analysis is based on two major databases. The primary data source is a sub-set of the MIDT (Marketing Information Data Transfer) database, which contains actual origin-destination bookings by itinerary and average airfares for travels between Northeast Asia and the United States in October 2007. The second group of data for our analysis is gathered from the OD1B database provided by the US Department of Transport (DOT). Other supplemental data are collected from OAG (Official Airline Guide), U.S. Censors of Bureau, etc. The MIDT dataset used in our study has a total of 20,553 observations[5] representing 4,407 itineraries for trips originating in an Asian airport and arriving at a US destination. An itinerary refers to a carrier-specific routing choice between an origin and a destination. The number of bookings with an itinerary can be used as a proxy measure for passenger traffic volume based on that particular itinerary.

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[5] Airlines with less than 10 observations on any flight segment are excluded.

Star Alliance accounts for 35.5% of the sample bookings, oneworld 13.8%, and SkyTeam 30.7%, which are similar to their worldwide market shares as shown in Table 3.

Table 3: The Market Shares of the Three Major Global Alliances

	Market Shares* in North Pacific October. 2007	**Worldwide Market Shares** August 2007**
Star Alliance	35.5%	36.8%
oneworld Alliance	13.8%	19.4%
SkyTeam Alliance	30.7%	32.3%
Others	20.0%	20.7%
Total	100%	100%

* In terms of number of bookings

** In terms of ASK as reported by Alliance Survey from Airline Business (August, 2007)

To examine the difference between through-ticket fares and the sums of segment fares, we focus our analysis on multi-segment itineraries and classify them into three major categories: pure online, allied interline, and non-allied interline.

- *Pure Online*: multi-segment itineraries operated and marketed by a single carrier from the origin to the destination. For example, the three-segment itinerary from Incheon International Airport (ICN) in S. Korea to Gerald R. Ford International (GRR) in Grand Rapids via San Francisco (SFO) and Chicago (ORD) operated and marketed by United Airlines is a Pure-Online itinerary.
- *Allied Interline*: multi-segment itineraries with interline transfers between airlines in the same alliance group. A good example will be the two-segment itinerary from Hong Kong International Airport (HKG) to Boston Logan International Airport (BOS) via New York JFK (JFK) with Cathay Pacific (CX) operating the first segment (HKG-JFK) and American Airlines operating the second segment (JFK-BOS). Cathay Pacific and American Airlines are both members of oneworld alliance.
- *Non-Allied Interline*: multi-segment itineraries with interline transfers between airlines that do not belong to the same alliance. For example, the two-segment itinerary from Tokyo Narita Airport (NRT) to Boston Logan International Airport (BOS) via New York JFK (JFK) with Japan Airlines operating the first segment (NRT-JFK) and Delta Air Lines operating the second segment (JFK-BOS) is a Non-Allied Interline itinerary. Japan Airlines (JL) is a member of oneworld alliance, whereas Delta is a member of SkyTeam alliance.

Table 4: Overall Summary of Itineraries

		Number of observations	Number of O-D Pairs	Total No. of Bookings
Non-stop Itinerary		177	67	296,533
Pure Online (1)		5,894	1,972	108,130
Allied Interline (2)	**Star**	3,656	1,689	37,092
	oneworld	1,533	831	19,525
	SkyTeam	1,419	813	18,168
Non-allied Interline (3)		7,874	2,876	52,345
Total for Multi-Segment Itinerary: (1)+ (2)+(3)		20,376	4,340	235,260

Table 4 provides a summary of the four types of itineraries. It is shown that although non-stop services are only available in 67 origin-destination markets, they carry more passengers than all the multi-segment flights combined.

Since airfare data for domestic flights behind Asian gateway airports are not available, Our empirical analysis is limited to multi-segment trips originating from a Northeast Asian gateway and arriving at a US destination. The first segments of our sample trips are between an Asian gateway airport and a US gateway airport and the final destinations are behind the US gateway airports. The MIDT dataset contains average through-ticket fares and average fares for the first segments (Asian gateway to US gateway) by airline and by booking class, but it does not have US domestic segment fares. The domestic segment fares are obtained from the OD1B database. While the MIDT data is for October 2007, OD1B data is only available on quarterly basis. Therefore, the 3rd quarter 2007 airfares are used.

For the simplicity of analysis, we limit our empirical tests to one-stop itineraries that originate from an Asian gateway airport, connect at a U.S. gateway airport to reach their U.S. destinations. Our sample data includes 9 Asian gateway airports: NRT, ICN, HKG, PVG, PEK, KIX, NGO, CAN, and SHE, and a total of 3,100 itinerary observations representing 864 O&D markets.

4.2 Exploratory Analysis

We start with an exploratory analysis comparing through-ticket fares and the sums of the two segment fares. Table 5 presents the paired t-test results when all the itineraries are pooled together. The results suggest that, collectively, there is no significant difference between the average through-ticket airfares and the sums of segment airfares.

Table 5: The Overall Paired t-test Results (All itineraries are included)

	Observations	Mean $	Std. Err.	Std. Dev.	95% Conf. Interval
Through-ticket Fare	2,584	1498.55	17.08	868.28	1465.06 1532.05
Sum of Segment Fares	2,584	1495.75	8.99	457.14	1478.12 1513.38
Difference	2,584	2.80	16.40	833.64	-29.36 34.96

Ho: Mean (Through-ticket Fare- Sum of Segment Fares) = 0
Ha: mean(diff) < 0 Ha: mean(diff) != 0 Ha: mean(diff) > 0
t = 0.1708 t = 0.1708 t = 0.1708
P < t = 0.5678 P > |t| = 0.8644 P > t = 0.4322

We then conduct separate tests for each of the three itinerary groups. Table 6 lists the average airfares by itinerary type, and Table 7 presents the results of the three separate paired t-tests.

Table 6: The Average Airfare by Itinerary Type

Pure-online Itinerary					
	Observations	Mean $	Std. Dev.	Min $	Max $
Through-ticket Fare	1671	1439.23	891.55	248.76	7280.77
Fare on Segment 1	1977	1337.65	459.72	175.01	3250.13
Fare on Segment 2	1956	189.20	80.98	27.44	724.14
Allied-Interline Itinerary					
	Observations	Mean $	Std. Dev.	Min $	Max $
Through-ticket Fare	551	1703.14	782.47	526.17	5770.54
Fare on Segment 1	671	1354.47	479.53	528.44	2915.45
Fare on Segment 2	444	184.03	86.81	38.05	541.65
Non-allied Interline Itinerary					
	Observations	Mean $	Std. Dev.	Min $	Max $
Through-ticket Fare	586	1557.33	833.46	268.89	5785.67
Fare on Segment 1	701	1257.46	467.38	204.03	3250.13
Fare on Segment 2	684	177.47	74.24	28.59	724.14

The results indicate that the difference between through-ticket fares and the sums of segment fares varies depending on the type of itinerary. More specifically, it is shown that the through ticket fares are significantly lower than the sums of segment fares for Pure-Online itineraries. This result does not imply that there is no “service premium” charged by airlines operating pure-online itineraries. Instead, as compared to other two types of itineraries, the connecting service and schedule coordination are expected to be the best for an online itinerary since it is provided by a single airline. Nevertheless, the through-ticket fare is found to be lower than the sum of segment fares, suggesting that the “service premium” effects are outweighed by fare reduction due to elimination of double marginalization or efficiency gain. In fact, it is reasonable to presume that for a single airline operating Pure-Online itineraries, the problem of double marginalization can be eliminated completely. It appears that passengers benefit from pure-online itineraries in terms of not only having the smoothest connecting services but also paying lower through-ticket fares as compared to the option of buying separate segment tickets. However, only US carriers are able to provide Pure-Online services in our sample markets because the *cabotage* restriction does not allow foreign carriers to operate “domestic flights” between two US points.

Table 7: The Paired t-test Results by Itinerary Type

<table>
<tr><th colspan="7">Pure-online Itinerary</th></tr>
<tr><th></th><th>Observations</th><th>Mean $</th><th>Std. Error</th><th>Std. Dev.</th><th colspan="2">95% Confidence Interval</th></tr>
<tr><td>Through-ticket Fare</td><td>1646</td><td>1437.73</td><td>21.92</td><td>889.33</td><td>1394.73</td><td>1480.72</td></tr>
<tr><td>Sum of Segment Fares</td><td>1646</td><td>1508.74</td><td>11.05</td><td>448.45</td><td>1487.06</td><td>1530.42</td></tr>
<tr><td>Difference</td><td>1646</td><td>-71.02</td><td>21.00</td><td>852.03</td><td>-112.21</td><td>-29.83</td></tr>
<tr><td colspan="7">Ho: mean (Through-ticket Fare – Sum of Segment Fares) = 0
Ha: mean(difference) < 0 Ha: mean(difference) != 0 Ha: mean(difference) > 0
t = -3.3816 t = -3.3816 t = -3.3816
P < t = 0.0004 P > |t| = 0.0007 P > t = 0.9996</td></tr>
<tr><th colspan="7">Allied-Interline Itinerary</th></tr>
<tr><th></th><th>Observations</th><th>Mean $</th><th>Std. Error</th><th>Std. Dev.</th><th colspan="2">95% Confidence Interval</th></tr>
<tr><td>Through-ticket Fare</td><td>366</td><td>1687.78</td><td>42.25</td><td>808.37</td><td>1604.69</td><td>1770.87</td></tr>
<tr><td>Sum of Segment Fares</td><td>366</td><td>1523.74</td><td>24.38</td><td>466.37</td><td>1475.80</td><td>1571.67</td></tr>
<tr><td>Difference</td><td>366</td><td>164.04</td><td>41.04</td><td>785.15</td><td>83.34</td><td>244.75</td></tr>
<tr><td colspan="7">Ho: mean(Through-ticket Fare – Sum of Segment Fares) = 0
Ha: mean(difference) < 0 Ha: mean(difference) != 0 Ha: mean(difference) > 0
t = 3.9971 t = 3.9971 t = 3.9971
P < t = 1.0000 P > |t| = 0.0001 P > t = 0.0000</td></tr>
<tr><th colspan="7">Non-allied Interline Itinerary</th></tr>
<tr><th></th><th>Observations</th><th>Mean $</th><th>Std. Error</th><th>Std. Dev.</th><th colspan="2">95% Confidence Interval</th></tr>
<tr><td>Through-ticket Fare</td><td>572</td><td>1552.51</td><td>34.42</td><td>823.16</td><td>1484.90</td><td>1620.11</td></tr>
<tr><td>Sum of Segment Fares</td><td>572</td><td>1440.45</td><td>19.74</td><td>472.10</td><td>1401.68</td><td>1479.22</td></tr>
<tr><td>Difference</td><td>572</td><td>112.05</td><td>32.76</td><td>783.55</td><td>47.70</td><td>176.40</td></tr>
<tr><td colspan="7">Ho: mean(Through-ticket Fare – Sum of Segment Fares) = 0
Ha: mean(difference) < 0 Ha: mean(difference) != 0 Ha: mean (difference) > 0
t = 3.4202 t = 3.4202 t = 3.4202
P < t = 0.9997 P > |t| = 0.0007 P > t = 0.0003</td></tr>
</table>

As shown in Table 7, the through ticket fares for interline connections, both Allied and Non-allied, are significantly higher than the sums of segment fares. The higher through-ticket fare for Allied-Interline itineraries is probably because the presence of “service premiums” for enhanced connection dominates the potential fare reduction from elimination of double marginalization or efficiency gain. The higher through ticket fares for Non-Allied interline itineraries, however, are likely to be the combined result of double marginalization effects and higher costs due to lack of integration and coordination.

Overall, the above paired t-test results imply that Pure-Online services are the most favorable choice for connecting passengers, followed by allied-interline services, and non-allied interline itineraries are the most undesirable option for passengers.

Further analysis is conducted to examine whether there is any difference among the three alliance groups in the through-ticket fare vs. the sums of segment fares. Table 8 summarizes the average airfares by itinerary type within each of the alliance groups. The results from corresponding paired t-tests are presented in Table 9. These results indicate that through-ticket fares are significantly higher than the sums of segment fares on interline itineraries for member airlines within Star and Skyteam Alliance, implying that the "service premium" effects most likely outweigh the fare reduction due to elimination of double marginalization or efficiency gain. However, the upward and downward effects on through-ticket fares appear to offset each other for oneworld members. Reasons for such differential airfare effects among the three major global alliances are not obvious. One explanation might be the fact that oneworld alliance has the smaller market share in the North trans-Pacific market, and therefore, its member airlines have somewhat limited power to impose any substantial "service premium" on the interline tickets. Another explanation for the differential airfare effects is that there might be differences among the three alliances in the extent of implementing fully-integrated operations and well-coordinated pricing and capacity decisions between allied airlines. The results provide some indication that the member airlines of Star and Skyteam alliances may have neither achieved the full potential of cost savings as a result of operation integration nor completely eliminated double marginalization under a cooperative price setting.

Table 8: The Average Interline Airfares by Alliance Group

Allied-Interline Itinerary: Star Alliance					
	Observations	Mean $	Std. Dev.	Min $	Max $
Through-ticket Fare	298	1680.87	825.11	526.17	5770.54
Fare on Segment 1	346	1320.05	530.39	528.44	2915.45
Fare on Segment 2	236	191.26	97.75	38.05	541.65
Allied-Interline Itinerary: oneworld Alliance					
	Observations	Mean $	Std. Dev.	Min $	Max $
Through-ticket Fare	139	1708.97	660.66	573.11	3375.01

<table>
<tr><td>Fare on Segment 1</td><td>157</td><td>1450.44</td><td>430.85</td><td>800.72</td><td>2779.41</td></tr>
<tr><td>Fare on Segment 2</td><td>94</td><td>177.21</td><td>83.47</td><td>55</td><td>494</td></tr>
<tr><td colspan="6">Allied-Interline Itinerary: Skyteam Alliance</td></tr>
<tr><td></td><td>Observations</td><td>Mean $</td><td>Std. Dev.</td><td>Min $</td><td>Max $</td></tr>
<tr><td>Through-ticket Fare</td><td>114</td><td>1754.28</td><td>808.48</td><td>662.85</td><td>3890.63</td></tr>
<tr><td>Fare on Segment 1</td><td>168</td><td>1335.66</td><td>395.61</td><td>662.85</td><td>2669.10</td></tr>
<tr><td>Fare on Segment 2</td><td>114</td><td>174.70</td><td>60.88</td><td>50.92</td><td>379.02</td></tr>
</table>

Table 9: The Paired t-test Results for Allied Interline Services by Alliance Group

<table>
<tr><td colspan="7">Allied-Interline Itinerary: Star Alliance</td></tr>
<tr><td></td><td>Observations</td><td>Mean $</td><td>Std. Error</td><td>Std. Dev.</td><td colspan="2">95% Confidence Interval</td></tr>
<tr><td>Through-ticket Fare</td><td>204</td><td>1683.13</td><td>60.78</td><td>868.18</td><td>1563.28</td><td>1802.98</td></tr>
<tr><td>Sum of Segment Fares</td><td>204</td><td>1516.82</td><td>34.60</td><td>494.16</td><td>1448.60</td><td>1585.04</td></tr>
<tr><td>Difference</td><td>204</td><td>166.31</td><td>57.14</td><td>816.08</td><td>53.65</td><td>278.97</td></tr>
<tr><td colspan="7">Ho: mean(Through-ticket Fare – Sum of Segment Fares) = 0
Ha: mean(diff) < 0 Ha: mean(diff) != 0 Ha: mean(diff) > 0
t = 2.9107 t = 2.9107 t = 2.9107
P < t = 0.9980 P > |t| = 0.0040 P > t = 0.0020</td></tr>
<tr><td colspan="7">Allied-Interline Itinerary: oneworld Alliance</td></tr>
<tr><td></td><td>Observations</td><td>Mean $</td><td>Std. Error</td><td>Std. Dev.</td><td colspan="2">95% Confidence Interval</td></tr>
<tr><td>Through-ticket Fare</td><td>85</td><td>1650.02</td><td>70.59</td><td>650.83</td><td>1509.64</td><td>1790.40</td></tr>
<tr><td>Sum of Segment Fares</td><td>85</td><td>1599.18</td><td>46.82</td><td>431.63</td><td>1506.08</td><td>1692.28</td></tr>
<tr><td>Difference</td><td>85</td><td>50.84</td><td>69.02</td><td>636.34</td><td>-86.42</td><td>188.09</td></tr>
<tr><td colspan="7">Ho: mean(Through-ticket Fare – Sum of Segment Fares) = 0
Ha: mean(diff) < 0 Ha: mean(diff) != 0 Ha: mean(diff) > 0
t = 0.7366 t = 0.7366 t = 0.7366
P < t = 0.7683 P > |t| = 0.4634 P > t = 0.2317</td></tr>
<tr><td colspan="7">Allied-Interline Itinerary: Skyteam Alliance</td></tr>
<tr><td></td><td>Observations</td><td>Mean $</td><td>Std. Error</td><td>Std. Dev.</td><td colspan="2">95% Confidence Interval</td></tr>
<tr><td>Through-ticket Fare</td><td>77</td><td>1741.78</td><td>92.04</td><td>807.64</td><td>1558.47</td><td>1925.09</td></tr>
<tr><td>Sum of Segment Fares</td><td>77</td><td>1458.78</td><td>47.76</td><td>419.08</td><td>1363.66</td><td>1553.9</td></tr>
<tr><td>Difference</td><td>77</td><td>283.00</td><td>95.72</td><td>839.92</td><td>92.36</td><td>473.64</td></tr>
<tr><td colspan="7">Ho: mean(Through-ticket Fare – Sum of Segment Fares) = 0
Ha: mean(diff) < 0 Ha: mean(diff) != 0 Ha: mean(diff) > 0
t = 2.9566 t = 2.9566 t = 2.9566
P < t = 0.9979 P > |t| = 0.0041 P > t = 0.0021</td></tr>
</table>

In sum, the preliminary results from our exploratory analysis suggest that through ticket fares offered by airlines in complementary alliances are generally higher than the sum of segment fares. This implies that the "service premium" added by alliance partners in their through ticket fares for improved connecting services is more than the extent of fare reduction, which could result from elimination of double marginalization, or efficiency gain for allied airlines.

4.3 Empirical Models

Based on our exploratory analysis, we construct two regression models to further examine factors that may affect the differences between the through ticket fare and the sum of segment fares. Both models use the ratio of through-ticket fare to the sum of segment fares as the dependent variable. The explanatory variables include demand characteristics, market concentration, route characteristics, itinerary type, and market size. The main regression model (Model 1) is specified as:

Model (1) Fare Ratio = *f* (Dummies for types of itinerary; Route characteristics; Demand characteristics; Market Competition; and Number of passenger bookings by various fare classes)

To investigate whether there is any difference among the three alliance groups, Model (2) attempts to distinguish the allied interline itineraries by alliance group:

Model (2) Fare Ratio = *f* (Dummies for allied interline itineraries by alliances; Dummy for non-allied interline, Route characteristics; Demand characteristics; Market Competition; and Number of passenger bookings by various fare classes)

The following provides a description of the variables included in regression analysis:

Type of Itinerary:

- *Pure Online:* The base case, thus the default in the regressions**.**
- *Allied Interline***:** A dummy variable for allied interline itineraries
- *Non-Allied Interline***:** A dummy variable for non-allied interline itineraries

Route Characteristics:

- V*acation Destination*: A dummy variable for itineraries destined for airports in popular "vacation states" including California, Florida, Hawaii, Nevada, Arizona, New Mexico, Texas, Louisiana, Mississippi, Alabama, Puerto Rico and Virgin Islands (Ito and Lee, 2007). Leisure travelers tend to be more price-sensitive compared to business passengers. Thus, the ratio of through-ticket fare to the sum of segment fares is expected to be less on vacation routes, *ceteris paribus*.
- *Itinerary Distance:* The actual flight distance from origin airport to destination airport.

- *Gateway Destination*: A dummy variable for itineraries with US gateway airports as final destinations. Since non-stop services might be available for those OD pairs, the actual or potential competition would lead to a smaller gap between through-ticket fare and segment fares, *ceteris paribus*.

Demand Characteristics:

- *Number of itineraries:* The total number of alternative routings for a given OD pair. It is used as a proxy for the potential market demand, as there is a high correlation between log(Number of Itineraries) and log(Total Number of Bookings). We expect the fare-ratio to be higher on routes with more itineraries.
- A*verage population* and *Average per capital GDP:* The traditional indicators for potential market size for a given OD market.

Market Competition:

- *Number of Alliances*: The number of major alliances competing on a given route. Competition among the major alliances is expected to have a negative impact on the fare ratio. Thus, the fare ratio is expected to be lower in the presence of inter-alliance competition, *ceteris paribus*.
- *Market shares of Pure Online*: The collective share of Pure-Online itineraries on a given route in terms of number of bookings. Since Pure-Online services provide passengers with the most convenient connecting services, the presence of Pure-Online services is expected to intensify competition, leading to lower fare ratio.
- *Non-Stop:* A dummy variable for the presence of non-stop services. The presence of non-stop services is expected to force interline carriers to reduce through ticket fares to stay competitive.
- *Booking based HHI:* The Herfindahl-Hirschman index for market concentration in terms of bookings. This variable reflects the degree of concentration of passenger bookings across alternative itineraries for a given route. It ranges between 0 and 1. A higher HHI value indicates that passenger bookings are concentrated on a small number of itineraries on a given route. On the other hand, a lower value indicates that passenger bookings are widely distributed across a large number of alternative routings. We expect the fare ratio to be higher on the routes having greater booking-based itinerary concentration, *ceteris paribus*.

- *Alliance based HHI*: The Herfindahl-Hirschman index for market concentration based on bookings with the three major global alliances. It reflects the degree of concentration among the major alliances. We expect the fare ratio to be higher with a higher Alliance HHI value, *ceteris paribus*.

Number of bookings by fare classes

- The numbers of bookings by fare classes are used as weights in calculating the overall average through-ticket fare on an itinerary. We include them as control variables in the fare ratio regressions.

Table 10a presents the summary statistics for the key variables, and their pair-wise correlations are provided in Table 10b.

Table 10a: Summary Statistics for Key Variables

Variables	Obs	Mean	Std. Dev.	Min	Max
Through-ticket airfare ($)	2808	1,515.66	865.09	248.76	7,280.77
Airfare on Segment One ($)	3349	1,324.23	466.53	175.01	3,250.13
Airfare on Segment Two ($)	3084	185.86	80.53	27.44	724.14
Pure-Online	3359	0.59	0.49	0	1
Allied Interline	3359	0.20	0.40	0	1
Non-Allied Interline	3359	0.21	0.41	0	1
Allied Interline with Star Alliance	3359	0.10	0.30	0	1
Allied Interline with oneworld Alliance	3359	0.05	0.21	0	1
Allied Interline with Skyteam Alliance	3359	0.05	0.22	0	1
Itinerary Distance	3359	7,287	848	5,186	9,850
Vacation Destination	3359	0.32	0.47	0	1
Gateway Destination	3359	0.38	0.48	0	1
Average Population (‘000)	3359	13,400	5,130	3,468	26,800
Average per Capita GDP ($)	3359	34,482	8,408	14,993	58,184
Number of Alliances	3359	2.38	0.67	1	3
Market share of Pure-Online	3359	0.61	0.28	0	1
Non-Stop	3359	0.22	0.41	0	1
Number of Itineraries	3359	25.24	16.63	1	79
Booking-based HHI	3359	0.31	0.22	0.0634	1
Alliance-based HHI	3359	0.46	0.22	0	1
Number of first class bookings	3359	0.50	5.08	0	236
Number of business class bookings	3359	4.28	9.87	0	137
Number of full economy bookings	3359	1.24	4.12	0	79
Number of premium coach bookings	3359	5.79	18.88	0	422
Number of discount coach bookings	3359	15.78	44.69	0	1310

Table 10b: Correlation Coefficients

	Fare Ratio	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25
Fare Ratio	1.00																						
4 Itinerary dummy for pure-online	-0.13 (0.00)	1.00																					
5 Itinerary dummy for allied interline	0.09 (0.00)	-0.60 (0.00)	1.00																				
6 Itinerary dummy for non-allied interline	0.08 (0.00)	-0.62 (0.00)	-0.26 (0.00)	1.00																			
7 Allied interline dummy for Star Alliance	0.06 (0.00)	-0.41 (0.00)	0.68 (0.00)	-0.17 (0.00)	1.00																		
8 Allied interline dummy for oneworld Alliance	0.01 (0.61)	-0.27 (0.00)	0.44 (0.00)	-0.11 (0.00)	-0.08 (0.00)	1.00																	
9 Allied interline dummy for Skyteam Alliance	0.07 (0.00)	-0.28 (0.00)	0.46 (0.00)	-0.12 (0.00)	-0.08 (0.00)	-0.05 (0.00)	1.00																
10 Itinerary distance	0.16 (0.00)	0.00 (0.97)	-0.05 (0.00)	0.05 (0.00)	-0.13 (0.00)	0.02 (0.21)	0.07 (0.00)	1.00															
11 Vacation destination dummy	-0.16 (0.00)	-0.04 (0.01)	0.04 (0.02)	0.01 (0.53)	0.03 (0.10)	0.02 (0.19)	0.01 (0.41)	-0.12 (0.00)	1.00														
12 Gateway destination dummy	0.13 (0.00)	-0.25 (0.00)	0.16 (0.00)	0.14 (0.00)	0.16 (0.00)	-0.01 (0.59)	0.08 (0.00)	0.07 (0.00)	-0.01 (0.66)	1.00													
13 Average Population	-0.09 (0.00)	-0.20 (0.00)	0.19 (0.00)	0.06 (0.00)	0.18 (0.00)	0.09 (0.00)	0.01 (0.49)	-0.44 (0.00)	0.02 (0.34)	0.09 (0.00)	1.00												
14 Average per Capita GDP	0.03 (0.19)	-0.06 (0.00)	0.07 (0.00)	0.01 (0.63)	0.08 (0.00)	0.18 (0.00)	-0.16 (0.00)	0.13 (0.00)	-0.06 (0.00)	0.18 (0.00)	0.05 (0.00)	1.00											
15 Number of alliances	-0.04 (0.05)	-0.13 (0.00)	0.10 (0.00)	0.07 (0.00)	0.09 (0.00)	0.20 (0.00)	-0.13 (0.00)	0.10 (0.00)	-0.09 (0.00)	0.09 (0.00)	0.33 (0.00)	0.44 (0.00)	1.00										
16 Market share of pure-online itineraries on route	-0.08 (0.00)	0.35 (0.00)	-0.19 (0.00)	-0.24 (0.00)	-0.13 (0.00)	-0.06 (0.00)	-0.11 (0.00)	-0.04 (0.01)	-0.09 (0.00)	-0.5 (0.00)	-0.30 (0.00)	-0.17 (0.00)	-0.08 (0.00)	1.00									
17 Non-stop dummy	0.03 (0.08)	-0.22 (0.00)	0.11 (0.00)	0.16 (0.00)	0.13 (0.00)	0.07 (0.00)	-0.04 (0.05)	0.05 (0.00)	-0.02 (0.18)	0.44 (0.00)	0.27 (0.00)	0.25 (0.00)	0.15 (0.00)	-0.70 (0.00)	1.00								
18 Number of itineraries	0.10 (0.00)	-0.44 (0.00)	0.22 (0.00)	0.31 (0.00)	0.15 (0.00)	0.11 (0.00)	0.10 (0.00)	0.25 (0.00)	0.08 (0.00)	0.49 (0.00)	0.19 (0.00)	0.25 (0.00)	0.30 (0.00)	-0.65 (0.00)	0.52 (0.00)	1.00							
19 Booking-based HHI	0.05 (0.01)	0.23 (0.00)	-0.14 (0.00)	-0.15 (0.00)	-0.06 (0.00)	-0.09 (0.00)	-0.08 (0.00)	-0.08 (0.00)	-0.02 (0.16)	-0.01 (0.40)	-0.23 (0.00)	-0.10 (0.00)	-0.43 (0.00)	0.15 (0.00)	0.11 (0.00)	-0.38 (0.00)	1.00						
20 Alliance-based HHI	0.06 (0.00)	0.11 (0.00)	-0.02 (0.38)	-0.12 (0.00)	-0.01 (0.42)	-0.06 (0.00)	0.05 (0.00)	-0.08 (0.00)	0.01 (0.65)	0.03 (0.09)	-0.09 (0.00)	-0.11 (0.00)	-0.37 (0.00)	0.13 (0.00)	0.14 (0.00)	-0.22 (0.00)	0.72 (0.00)	1.00					
21 Number of bookings with first-class tickets	0.02 (0.40)	-0.03 (0.12)	-0.01 (0.69)	0.04 (0.02)	-0.02 (0.37)	0.02 (0.19)	-0.01 (0.46)	-0.05 (0.00)	0.05 (0.01)	0.04 (0.04)	0.04 (0.03)	0.04 (0.02)	0.05 (0.00)	-0.02 (0.19)	0.01 (0.70)	0.08 (0.00)	-0.05 (0.00)	-0.05 (0.00)	1.00				
22 Number of bookings with business class tickets	0.03 (0.19)	0.09 (0.00)	0.02 (0.34)	-0.13 (0.00)	-0.05 (0.00)	0.14 (0.00)	-0.04 (0.02)	-0.04 (0.01)	-0.02 (0.31)	0.05 (0.01)	-0.00 (0.80)	0.13 (0.00)	0.11 (0.00)	0.00 (0.80)	0.04 (0.01)	0.12 (0.00)	-0.03 (0.09)	-0.03 (0.05)	0.24 (0.00)	1.00			
23 Number of bookings with full economy class tickets	-0.07 (0.00)	0.13 (0.00)	-0.04 (0.02)	-0.12 (0.00)	-0.01 (0.77)	-0.00 (0.83)	-0.06 (0.00)	-0.11 (0.00)	0.02 (0.26)	-0.03 (0.06)	0.08 (0.00)	0.05 (0.00)	0.03 (0.12)	0.02 (0.31)	0.01 (0.45)	0.02 (0.19)	-0.03 (0.10)	-0.01 (0.61)	0.03 (0.08)	0.33 (0.00)	1.00		
24 Number of bookings with premium coach tickets	-0.07 (0.00)	0.21 (0.00)	-0.11 (0.00)	-0.15 (0.00)	-0.06 (0.00)	-0.06 (0.00)	-0.05 (0.00)	-0.08 (0.00)	0.05 (0.00)	0.06 (0.00)	-0.02 (0.32)	0.03 (0.12)	0.02 (0.30)	0.02 (0.16)	0.02 (0.30)	0.07 (0.00)	-0.01 (0.67)	-0.02 (0.16)	0.09 (0.00)	0.47 (0.00)	0.25 (0.00)	1.00	
25 Number of bookings with discount coach tickets	-0.06 (0.00)	0.14 (0.00)	-0.05 (0.01)	-0.12 (0.00)	-0.05 (0.00)	0.01 (0.59)	-0.02 (0.15)	-0.06 (0.00)	0.06 (0.00)	0.02 (0.19)	-0.01 (0.72)	0.06 (0.00)	0.05 (0.00)	0.04 (0.01)	-0.02 (0.33)	0.09 (0.00)	-0.01 (0.71)	-0.01 (0.55)	0.19 (0.00)	0.56 (0.00)	0.33 (0.00)	0.41 (0.00)	1.00

Significance levels are in parenthesis.

4.4. Results

The estimation results for Model (1) are presented in Table 11, and they validate the findings from our exploratory analysis.

Table 11: Estimation Results for Model (1)

	Coefficient	t-statistic	p-value
Non-allied interline itinerary	0.0649	2.21	0.027
Allied interline itinerary	0.1002	3.19	0.001
Vacation Destination	-0.1632	-7.80	0.000
Log (Flight Distance)	0.1713	1.65	0.100
Log (Average Population)	-0.0542	-2.07	0.039
Log (Average Per Capita GDP)	0.0306	0.69	0.488
Log (Number of Alliances)	-0.0972	-2.42	0.015
Market Share of Pure-Online	-0.2605	-4.11	0.000
Non-Stop Dummy	-0.1781	-4.81	0.000
Log (Number of Itineraries)	0.0735	3.34	0.001
Booking-based Itinerary HHI	0.1334	1.63	0.104
Alliance HHI	0.1910	2.77	0.006
Log (Number of First-class Bookings.)	0.0483	2.17	0.030
Log (Number of Business-class Bookings.)	0.1292	9.96	0.000
Log (Number of Full Economy Bookings.)	-0.0310	-2.01	0.044
Log (Number of Premium-coach Bookings.)	-0.0387	-3.69	0.000
Log (Number of Discount-coach Bookings.)	-0.0607	-5.93	0.000
Constant	-1.0780	-0.81	0.420
Number of observations	2584		
R-square	0.1365		
Adjusted R-square	0.1308		

Note: (1) Dependent Variable: log (Ratio of through ticket fare over sum of segment fares)
(2) Pure Online is the default case

The regression results can be summarized as follows:

- The significantly positive coefficient for Allied Interline suggests that the ratio of through-ticket fare to the sum of segment fares is about 10% higher for Allied Interline itineraries than that for Pure-Online itineraries. This result implies that the formation of alliances would lead to an increase in airfares on complementary routes. Proposition 1 states that through-ticket fare charged by allied airlines may be less than the sum of segment fares due to elimination of double marginalization and efficiency consideration, whereas Proposition 3 states that improved connecting services and schedule coordination could lead to higher willingness to pay for the through-tickets by passenger. Our empirical results indicate that the fare reduction effects from complementary alliances are not sufficient to offset the price markup for service improvement. This may suggest that some allied airlines do not fully cooperate in their pricing and capacity decisions for joint optimization.

- *Vacation Destination* has a significant and negative coefficient, which indicates that airlines are generally constrained in their ability to charge high "service premium" for vacation-oriented itineraries as passengers are more price sensitive on those routes, and also there are more competitors such as charter services.
- Both *First-Class Bookings* and *Business-Class Bookings* have positive coefficients, whereas the three variables for economy class bookings all have negative coefficients, which suggest business passengers are charged at a significantly higher price markup for through tickets than that charged on other passengers. Since business passengers are less price-conscious, we expect that the spread between through-ticket fares and the sum of segment fares would be greater for the segment of business passengers. This proposition finds support from the empirical results.
- *Average Population* has a negative coefficient. This result suggests that routes with large population at endpoint cities tend to have higher traffic density, and thus lower unit operating costs for airlines, which allows them to charge lower prices.
- The negative coefficient for *Number of Alliances* supports the argument that the inter-alliance competition can restrain the price colluding effects within an alliance and the price premium charged by allied airlines for improved connecting services.
- *Market Share of Pure-Online* has a negative coefficient supporting the argument that the presence of pure-online competition can impose substantial pressures on allied and non-allied interline carriers to lower their though-ticket fares.
- The negative coefficient for the *Non-Stop* dummy variable suggests that the presence of direct non-stop services also add great pressures on both allied and non-allied interline carriers to lower their through-ticket fares.
- The positive coefficient for *Number of Itineraries* suggests that higher demand on those routes lead to greater price markup for through-tickets.

- *Alliance HHI* has a positive coefficient, which confirms the presumption that greater market concentration among the three major alliances would lead to higher price markup for through-tickets.

Table 12 presents the results for Model (2) which includes three dummy variables for allied-interline itineraries by each of the three major alliances. The Pure-Online is again considered as the default case in the regression. It is shown that for member airlines of Star and SkyTeam alliances, the fare ratios between through-tickets and combined segment tickets appear to be 14% higher than those of Pure Online itineraries. This result may suggest that member airlines within both Star and SkyTeam alliances tend to charge "service premiums" for their allied interline services, which more than off-set the potential fare reduction from alliances. Without well-coordinated integration and full cooperation, it would be difficult for allied airlines to reduce through-ticket fares through elimination of double marginalization or efficiency gain. Therefore, the price markup for improved services could easily dominate the countervailing fare reduction effects. Complementary alliances, on the other hand, do not appear to have any significant impact on the through-ticket fares for oneworld member airlines.

The estimated coefficients for other explanatory variables are generally consistency between Model (1) and Model (2). Since there is significant correlation between some of the explanatory variables, such as "Number of itineraries" and "Market share of pure-online", multicollinearity may become a problem. To test whether multicollinearity could cause any serious concern for escalating variance estimation, we compute variance inflation factors (VIF) for all the predictors in both Model (1) and (2). The VIF values are found to be within the range of 1.11 and 4.74[6], indicating that multicollinearity is not likely a problem.[7]

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[6] The general rules states that if the VIF value is less than 10, multicollinearity would not be a major concern for causing inflated variance estimation.

[7] We also run three alternative regressions for both Model (1) and (2) excluding the variables "Number of alliances", "Market share of pure-online" and "Number of itineraries" respectively. The estimation results for the main explanatory variables are rather similar to those from the original regressions. The results for these alternative regressions are available from the authors upon request.

Table 12: Estimation Results for Model (2)

	Coefficient	t-statistic	p-value
Non-allied Interline	0.0650	2.22	0.026
Allied Interline with Star Alliance	0.1369	3.56	0.000
Allied Interline with oneworld Alliance	-0.0395	-0.69	0.491
Allied Interline with Skyteam Alliance	0.1443	2.48	0.013
Vacation Destination	-0.1603	-7.66	0.000
Log (Flight Distance)	0.1796	1.72	0.085
Log (Average Population)	-0.0541	-2.07	0.039
Log (Average Per Capita GDP)	0.0390	0.88	0.379
Log (Number of Alliances)	-0.0901	-2.24	0.025
Market Share of Pure-Online	-0.2601	-4.10	0.000
Non-Stop Dummy	-0.1746	-4.70	0.000
Log (Number of Itineraries)	0.0689	3.13	0.002
Booking-based Itinerary HHI	0.1286	1.57	0.117
Alliance HHI	0.1879	2.72	0.007
Log (Number of First-class Bookings.)	0.0506	2.28	0.023
Log (Number of Business-class Bookings.).	0.1353	10.30	0.000
Log (Number of Full Economy Bookings.)	-0.0321	-2.08	0.038
Log (Number of Premium-coach Bookings.)	-0.0434	-4.10	0.000
Log (Number of Discount-coach Bookings.)	-0.0594	-5.80	0.000
Constant	-1.2381	-0.93	0.354
Number of observations	2584		
R-square	0.1394		
Adjusted R-square	0.1330		

To further investigate how the presence of non-stop flights may influence the decision of allied airlines in setting the through-ticket fares for interline services, we re-estimate Model (1) using two different sub-samples: Routes with the presence of non-stop flights and routes without the presence of non-stop flights. Similarly, Model (2) is re-estimated using the two sub-sample sets. Tables 13 and 14 report the regression results based on these sub-sample sets for Model (1) and Model (2), respectively.

As shown in Table 13, the coefficient for *Allied Interline* are significant and positive in both cases, suggesting alliance partners charge higher through-ticket fares for allied interline services with or without the presence of non-stop services. Similarly, *Vacation Destination* has a significant and negative coefficient in both cases, indicating that regardless of the presence of non-stop flights, the markup for through tickets is lower for vacation oriented itineraries than those on other routes. Overall, the results in Table 13 are consistent with the results from the full sample.

Table 13: Estimation Results for Model (1) with and without Non-stop Flights

	With the presence of non-stop flights			Without the presence of non-stop flights		
	Coefficient	t-statistic	p-value	Coefficient	t-statistic	p-value
Non-allied Interline	0.1153	2.80	0.005	0.0372	0.98	0.329
Allied Interline	0.1260	2.84	0.005	0.0875	2.17	0.030
Vacation Destination	-0.1858	-4.97	0.000	-0.1550	-6.16	0.000
Log (Flight Distance)	0.3968	2.50	0.013	0.0748	0.56	0.574
Log (Average Population)	-0.0787	-1.52	0.130	-0.0509	-1.63	0.103
Log (Average Per Capita GDP)	0.0890	0.73	0.467	0.0086	0.17	0.864
Log (Number of Alliances)	-0.0280	-0.27	0.785	-0.0908	-1.83	0.068
Market Share of Pure-Online	-0.2528	-2.09	0.037	-0.3054	-3.25	0.001
Log (Number of Itineraries)	-0.0023	-0.04	0.968	0.0829	3.24	0.001
Booking-based Itinerary HHI	0.1630	1.23	0.220	0.1383	1.15	0.249
Alliance HHI	0.0780	0.79	0.431	0.2544	2.80	0.005
Log (Number of First-class Bookings.)	0.0149	0.42	0.673	0.0580	2.13	0.033
Log (Number of Business-class Bookings.)	0.0753	3.39	0.001	0.1432	9.25	0.000
Log (Number of Full Economy Bookings.)	-0.0220	-0.78	0.433	-0.0342	-1.89	0.059
Log (Number of Premium-coach Bookings.)	-0.0119	-0.63	0.527	-0.0449	-3.63	0.000
Log (Number of Discount-coach Bookings.)	-0.0309	-1.85	0.065	-0.0710	-5.70	0.000
Constant	-3.2345	-1.37	0.170	-0.0586	-0.03	0.972
Number of obs. R-square Adjusted R-square	605 0.2055 0.1838			1979 0.1239 0.1167		

Table 14: Estimation Results for Model (2) with and without Non-stop Flights

	With the presence of non-stop flights			Without the presence of non-stop flights		
	Coefficient	t-statistic	p-value	Coefficient	t-statistic	p-value
Non-allied Interline	0.1149	2.78	0.006	0.0384	1.01	0.312
Allied Interline With Star Alliance	0.1332	2.60	0.009	0.1393	2.75	0.006
Allied Interline with oneworld Alliance	0.1064	1.36	0.175	-0.1108	-1.47	0.141
Allied Interline with Skyteam Alliance	0.1238	1.31	0.190	0.1422	2.00	0.046
Vacation Destination	-0.1850	-4.92	0.000	-0.1509	-5.99	0.000
Log (Flight Distance)	0.3972	2.50	0.013	0.0833	0.62	0.533
Log (Average Population)	-0.0797	-1.53	0.127	-0.050	-1.60	0.111
Log (Average Per Capita GDP)	0.0916	0.74	0.460	0.0171	0.34	0.734
Log (Number of Alliances)	-0.0272	-0.26	0.792	-0.0826	-1.66	0.096
Market Share of Pure-Online	-0.2538	-2.10	0.037	-0.3003	-3.18	0.002
Log (Number of Itineraries)	-0.0026	-0.04	0.965	0.0765	2.98	0.003
Booking-based Itinerary HHI	0.1627	1.22	0.222	0.1218	1.02	0.310
Alliance HHI	0.0776	0.78	0.436	0.2531	2.78	0.005
Log (Number of First-class Bookings.)	0.0152	0.43	0.666	0.0604	2.22	0.027
Log (Number of Business-class Bookings.)	0.0771	3.36	0.001	0.1499	9.61	0.000
Log (Number of Full Economy Bookings.)	-0.0221	-0.79	0.432	-0.0360	-1.98	0.047
Log (Number of Premium-coach Bookings.)	-0.0135	-0.69	0.488	-0.0500	-4.01	0.000
Log (Number of Discount-coach Bookings.)	-0.0306	-1.82	0.069	-0.0694	-5.57	0.000
Constant	-3.2505	-1.37	0.171	-0.2360	-0.14	0.888
Number of obs. R-square Adjusted R-square	605 0.2056 0.1812			1979 0.1282 0.1202		

The presence of non-stop flights, however, appears to have different effects among the three alliance groups. Although *Allied Interline with Star Alliance* has significant and positive coefficients in both cases, the coefficient for *Allied Interline with Skyteam* is not significant in the presence of non-stop flights. This suggests that the presence of non-stop flights intensifies competition faced by Skyteam member airlines, which leaves the member airlines little room to impose price markup on through-ticket fares. Similar to the results in Table 13, the coefficient for Allied Interline with oneworld is not significant in either case, re-confirming our earlier findings that the upward and downward airfare effects are counterbalancing for oneworld member airlines.

5. Summary and Conclusions

The main question this paper attempts to address is: Do complementary alliances contribute to higher through-ticket fares for allied interline services? On one hand, complementary alliances facilitate the elimination of double marginalization effects through cooperative price setting, which would reduce through-ticket fares. In addition, the capacity coordination by allied airlines would increase traffic density, thereby reducing unit operating costs. On the other hand, complementary alliances help improve connecting services through one-stop check-in, better schedule coordination, more convenient connection, etc, such that passengers are willing to pay higher prices for the enhanced services. Therefore, complementary alliances have both positive and negative effects on through-ticket fares that counteract against each other, and the net result is uncertain *a priori*.

Our analytical models show that (1) if allied airlines are only engaged in a cooperative price setting with no service improvement, through-ticket fares would be less than the sum of segment fares; (2) the reduction in through-ticket fare would be larger when economy of traffic density becomes stronger; however, (3) when complementary alliances improve connecting services and consequently generate more demand, the equilibrium through-ticket fare would be greater than the sum of segment fares; and (4) the overall effect of complementary alliances on through-ticket fares, therefore, is uncertain depending on the relative strengths of these offsetting impacts.

Based on the data for the North trans-Pacific market in October 2007, our empirical analysis validates the theoretical propositions and finds that the airfare reduction from the pricing cooperation by allied airlines on complementary routes is generally outweighed by passengers' higher willingness to pay for service improvements. Moreover, our empirical results provide evidence to support the presumption that partner airlines in a complementary alliance are more likely to impose higher price markup on through-ticket fares for business passengers than for leisure travelers.

Since our empirical model only estimates the overall effects from complementary alliances on through-ticket fares relative to the sums of segment fares, one must be cautious in interpreting the differential effects among the three major global alliances including Star, Skyteam, and oneworld. Assume that all three major alliances have similar capabilities to fully integrate their operation and implement the cooperative price-setting mechanism for joint profit maximization. If we further assume that the fare reduction effects among the three alliances are the same, then our results would imply that the level of price markup on flow-through ticket is different among the three major alliances. Specifically, member airlines of Star Alliance and Skyteam Alliance tend to charge significantly higher fares for flow-through tickets than the sum of segment fares on complementary routes. However, oneworld Alliance members do not appear to impose any significant price markup for their interline services, which might be explained by the fact that oneworld Alliance has a considerably smaller market share in the North trans-Pacific market. As such, their lack of competitive strength may serve to restrain their ability to impose higher prices for through-tickets.

There are several other interesting results from our empirical investigation. First, we find that the presence of non-stop and pure-online flights creates substantial pressure on both allied and non-allied airlines to lower their through-ticket fares. We also find that the competition among alliances can effectively restrain the extent to which allied airlines may charge price markup on through-tickets for improved connecting services. By contrast, higher concentration among the major alliances tends to lead to higher through-ticket fares. From the policy perspective, this result suggests that there is still a necessity for adopting government oversights to prevent or deter the dominance of any single alliance on flow-through routes so as to protect the interests of passengers affected by complementary alliances.

A key contribution of the paper is that it provides both theoretical and empirical evidence against the conventional wisdom that complementary alliances would certainly benefit passengers through their fare reduction effects. It is well known that allied airlines provide connecting passengers with greater convenience and enhanced transferring services such as shorter layover time, one-stop check-in, more flexible scheduling, etc. However, the effects of complementary alliances on airfare are not so straightforward. It is true that complementary alliances may reduce airfares on flow-through routes as a result of the elimination of double marginalization or the efficiency gains through better cooperation and traffic consolidation between allied airlines. However, the conventional argument has ignored an important counteracting factor. That is, service improvements may stimulate more passenger demand and induce passengers to be more willing to pay higher fares. Our empirical analysis suggests that allied airlines in fact charge considerably higher prices for through tickets than the sum of segment tickets purchased separately, and such fare distortions are more significant for business passengers.

In summary, it should not be taken for granted that complementary alliances always benefit passengers in terms of providing both service improvement and fare reduction. To better evaluate the welfare impacts of airline alliances on complementary routes, we need to identify to what extent passengers may benefit from improved services, whether the price markup for service improvements could be justified, and whether such price increasing effects will dominate the potential fare reduction due to either elimination of double marginalization or efficiency gain. The answers to all these questions would be impossible without explicitly and separately estimating the two countervailing effects of complementary alliances on through-ticket fares. It is evident that more empirical investigations are needed in future research.

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Appendix I – Proof of Proposition 1

Proof:

Based on the airfare comparison results as shown in Table 1, we can calculate the changes in the airfare paid by passengers in the through-travel market AB with and without alliances:

$$\Delta p_{AB} = p_{AB}^{**} - (s_{AH}^{*} + s_{BH}^{*}) = \frac{(\theta - 2)(2\alpha + \alpha\theta - 4)}{42\theta^2 - 64\theta + 24}$$

From the constraints on the values of θ and α in Scenarios 1 and 2, we know that it is required that $\theta < \frac{2}{3}$. Hence, it can be shown that $\theta - 2 < 2$, while $42\theta^2 - 64\theta + 24 > 0$. Furthermore, it is required in Scenario 1 that when $\theta < \frac{6}{7}$, the following inequality $2\alpha + \alpha\theta - 4 > 0$ holds. Thus, it can be simply proved that $\Delta p_{AB} < 0$, indicating that the airfare for the through-ticket is lower in the alliance setting than the aggregated subfares in the non-alliance setting.

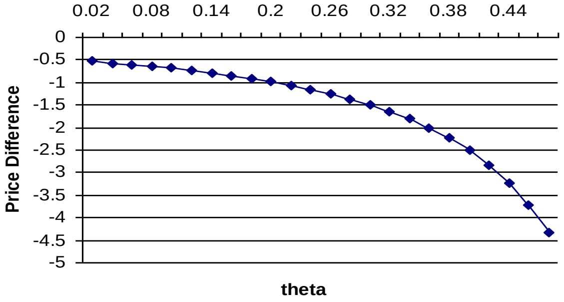
Appendix II - Proof of Proposition 2

Proof:

For a given α level, let us examine how the value for Δp_{AB} changes with θ. The validity of Proposition 2 can be illustrated be using the following numerical examples.

Numerical Example I:

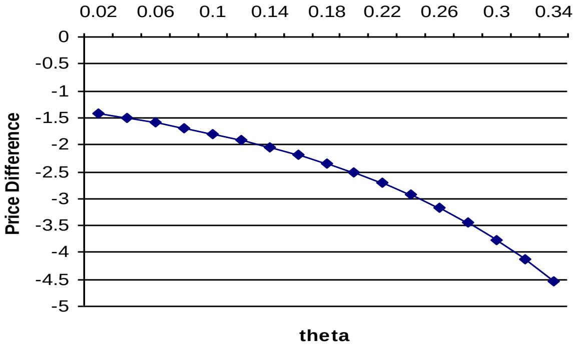
Let $\alpha = 5$. The feasible range for θ is [0.02, 0.48]. Calculate the values for Δp_{AB} at different levels for θ.



As shown in the above graph, the price difference Δp_{AB} is getting larger in the absolute value as the level for θ increases.

Numerical Example II:

Let $\alpha = 10$. The feasible ranges for θ is [0.02, 0.34], and [0.42, 0.44].



As shown in the above graph, the price reduction is greater as the value for θ increases. This finding is consistent with the case when $\alpha = 5$. Moreover, the comparison in the price reduction for the case when $\alpha = 5$ and for the case when $\alpha = 10$ indicates that the extent of price reduction as a result of alliance is also affected by the size of market demand α. That is, the greater the market demand, the greater the price reduction effects from the alliance, holding other factors constant.