ESSAYS ON ALLIANCES, ANTITRUST IMMUNITY, AND CARVE-OUT POLICY IN INTERNATIONAL AIR TRAVEL MARKETS

by

TYSON THOMAS

B.S., Southern Illinois University Edwardsville, 2007
M.S., Southern Illinois University Edwardsville, 2009

AN ABSTRACT OF A DISSERTATION

submitted in partial fulfillment of the requirements for the degree

DOCTOR OF PHILOSOPHY

Department of Economics
College of Arts and Sciences

KANSAS STATE UNIVERSITY
Manhattan, Kansas

2015

Abstract

This dissertation seeks to answer questions regarding changes in the competitive environment in international air travel markets which has undergone rapid changes since the early 1990s. Specifically, the research in this dissertation examines policies regarding cooperation among airlines in international air travel markets as well as how cooperation affects an airline's product quality. These issues are explored in two essays which comprise my dissertation.

The first essay explores the efficacy of a policy known as a carve-out. Airlines wanting to cooperatively set prices for their international air travel service must apply to the relevant authorities for antitrust immunity (ATI). While cooperation may yield benefits, it can also have anti-competitive effects in markets where partners competed prior to receiving ATI. A carve-out policy forbids ATI partners from cooperating in markets policymakers believe will be most harmed by anti-competitive effects. We examine carve-out policy applications to three ATI partner pairings, and find evidence of tacit collusion in carve-out markets in spite of the policy, calling into question whether consumers benefited from application of the policy in the cases studied.

The second essay examines the relationship between product quality and airline cooperation. Much of the literature on airline cooperation focuses on the price effects of cooperation. The key contribution of our paper is to empirically examine the product quality effects of airline cooperation. Two common types of cooperation among airlines involve international alliances and antitrust immunity (ATI), where ATI allows for more extensive cooperation. The results suggest that increases in the membership of a carrier's alliance or ATI partners are associated with the carrier's own products having more travel-convenient routing quality. Therefore, a complete welfare evaluation of airline cooperation must account for both price and product quality effects.

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Chapter 1 - Assessing Firm Behavior in Carve-out Markets: Evidence on the Impact of Carve-out Policy

1.1 Introduction

Since the early 1990's, there has been an increasing trend in cooperation among international carriers in the airline industry. This is in part due to international restrictions that limit foreign carriers' service in domestic markets. Cooperation can effectively allow carriers entry into foreign markets. International carriers can establish a type of cooperation referred to as a codeshare agreement. A codeshare agreement allows a carrier to operate a flight under the guise of a partner carrier. Carriers in a codeshare agreement can sell tickets for flights on an itinerary in which a partner carrier operates at least one coupon segment on the itinerary. The result is a passenger may fly with at least one carrier on the trip itinerary that is different from the carrier that sold the ticket for the entire trip to the passenger. Additionally, international alliances allow for the carriers in the alliance to coordinate flight schedules (to decrease layover times), streamline luggage checking, share frequent flier programs and decrease gate proximity at airports, all of which improve travel conveniences for passengers.

There are three major international alliances: Skyteam, Star and Oneworld. Carriers in each of these alliances may have codeshare agreements with other carriers within that alliance. It should be noted, however, that carriers within an alliance may also have codeshare agreements with carriers outside of the alliance.

International carriers within an alliance may also apply to the antitrust enforcement authority of a country for antitrust immunity (ATI), which if granted would exempt certain cooperative actions between the carriers from being the basis of prosecution under the country's antitrust laws. Codesharing and ATI differ in the extent of cooperation allowed. Specifically, in addition to all of the cooperation associated with codesharing, if a carrier has ATI with another carrier then the ATI partners can cooperate with respect to setting fares. In the U.S., it is the Department of Transportation (DOT) that is tasked with reviewing applications from airlines for ATI. The DOT can deny the carriers ATI, grant the carriers ATI or grant the carriers ATI along with a carve-out. A carve-out is a legal restriction that forbids collusive behavior between ATI partners in certain markets.[1]

There has been an extensive amount of research regarding the market effects of varying forms of cooperation between carriers in international air travel markets; however, research regarding carve-outs is limited. There has been no previous empirical research regarding the market effects of policymakers imposing carve-outs, which is the primary contribution of this study. To understand why a carve-out may be put in place, we must first understand the effects of granting carriers ATI.

Brueckner (2001) uses a theoretical model to analyze what may happen to prices and welfare as a result of price cooperation. The results suggest the effects depend on the type of market being considered. In other words, ATI will have different effects in interline markets versus interhub markets. Interline markets are markets in which a passenger must switch operating carriers at some point on their journey. Interhub markets are markets between the carriers' hubs in which a passenger is not required to transfer across operating carriers to complete their journey. The key distinction between these two types of markets is that the partner carriers' transportation services are complementary in interline markets, but substitutable in the interhub markets. Brueckner's (2001) results suggest that ATI will lead to lower prices in the interline markets. The author argues that this occurs as a result of elimination of double marginalization in the interline markets. However, the findings show that in interhub markets, where the carriers directly compete, cooperation will have an anticompetitive effect (raise fares). Brueckner (2001) notes the cooperation by the carriers may induce some cost efficiencies in all markets (interline as well as interhub) due to the impact of economies of passenger-traffic density.[2] These cost efficiencies have a countervailing effect to the anticompetitive effect in the interhub markets. Thus, if the cost efficiencies in the interhub market are sufficiently large, prices may fall in the interhub market and passenger traffic may rise.

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[1] In the European Union, the European Commission (EC) is tasked with granting carriers ATI. Note that the DOT only has jurisdiction over international itineraries originating in the United States. For a more thorough discussion of the process and rulings regarding ATI and carve-outs, see Bilotkach and Huschelrath (2011 and 2012).

[2] Economies of passenger-traffic density is the phrase given to the situation in which an airline is able to lower the marginal cost of transporting a given passenger on a route the larger the volume of passengers it transports through the route.

Brueckner and Whalen (2000) attempt to empirically determine the effects of different degrees of cooperation on prices in interline markets and interhub markets. Using reduced-form linear regression analysis, the researchers examine the effects of both codesharing and ATI. The results are consistent with the theory that prices will fall in interline markets with greater degrees of cooperation. Codesharing works to lower prices, but ATI has a greater effect on lowering prices. The argument is that codesharing does not fully eliminate the double marginalization. Brueckner and Whalen (2000) also attempt to determine the effect of changes in competition in interhub markets. When carriers are granted ATI, there will effectively be less competition in the interhub markets. Contrary to what the theory suggests, the findings show that there is no statistically significant effect on prices as a result of lower competition.

Brueckner (2003b) builds on the literature by empirically investigating the effects of codesharing and ATI for interline markets. The empirical analysis controls for the endogeneity of codesharing. The estimates provide evidence that cooperation lowers prices for passengers in the interline markets. Specifically, codesharing and ATI each have the effect of lowering prices, but ATI has a much larger effect on prices than codesharing. The findings support the argument that greater degrees of cooperation will further diminish double marginalization.

Whalen (2007) estimates a model that examines the impact that codeshare agreements and ATI have on prices as well as passenger traffic in interline markets. The contribution here was the use of panel data in the econometric model. Whalen (2007) used data spanning from 1990 through 2000. Using panel data for the analysis is very useful as these data provide relevant information before and after some alliances are formed as well as after an alliance is eliminated. The estimates support the theory that prices will fall in interline markets with codesharing and ATI. ATI has a larger impact on prices versus codesharing. Likewise, consistent with the theory, the estimates suggest that passenger traffic will increase with cooperation.

Brueckner, Lee and Singer (2011) using data spanning from 1998 through 2009, attempt to determine if the results from previous studies continue to be valid. The researchers examine the effects of codesharing and ATI for different types of passengers. The findings provide further support for the theoretical conclusions. The results suggest that a greater degree of cooperation lowers prices for interline passengers.[3]

Although there are numerous studies examining the effects of ATI, the literature regarding carve-outs is limited. Brueckner and Proost (2010) theoretically examine the effects of a carve-out. The purpose is to understand when a carve-out is beneficial or harmful to consumers. The theory suggests that ATI will be anticompetitive in the interhub markets serving to increase prices for passengers. However, in the presence of economies of passenger-traffic density, ATI will bring cost efficiencies to the carriers. Only in the case of a joint venture alliance will the carriers be able to fully achieve the cost efficiencies. These cost efficiencies can be passed on to the passengers in the form of lower prices. Depending on which effect is greater, prices may rise or fall in the interhub markets. Should potential economies of passenger-traffic density be pronounced, imposing a carve-out in principle limits cooperation, which in turn limits the ability to exploit economies of passenger-traffic densities potentially resulting in higher prices versus the alternative of no carve-out.

Brueckner and Picard (2012) theoretically explore the incentives of carriers that have been given ATI to tacitly cooperate in the interhub markets when faced with a carve-out in that market. More specifically, the question asked is whether greater cooperation in the interline markets increases the incentive to collude in the interhub. The idea here is that although the carriers are forbidden from jointly setting prices in the interhub markets, there may be an incentive for tacit collusion. For instance, one of the carriers raises the prices for their flights in the market and, likewise, the other carrier raises their prices without any prior discussion between the carriers. Should this occur, this would impose a problem for regulators in implementing an effective carve-out, as the carve-out may not influence the outcome resulting from cooperative behavior of partner carriers. However, the theoretical predictions suggest that under certain circumstances typically assumed in the literature there exists no incentive for tacit collusion.

The main purpose of this paper is to empirically determine the impact a carve-out has on prices, marginal costs and markups. The goal here is to provide insights into how ATI partner

[3] Numerous additional studies relating cooperation in international markets to prices include, but are not limited to: Bilotkach (2005), Brueckner (2003a), Flores-Fillol and Moner-Colonques (2007), Gayle and Xie (2014), Hassin and Shy (2004) and Park and Zhang (2000).

carriers behave in the carve-out markets relative to non-carve-out markets. In other words, do the carriers act in accordance with the carve-out or is there evidence of collusion in the carve-out markets? The following is a brief description of the research methodology we use to investigate these issues.

We begin by specifying and estimating a discrete choice demand model of international air travel. We then assume that multiproduct carriers set travel product prices according to a Nash equilibrium. Conditional on the demand parameter estimates, the Nash equilibrium assumption allows us to compute markups and recover marginal costs of the products offered by the carriers. The structural model affords us the opportunity to compute markups and recover marginal costs under two alternative scenarios: (1) where we assume the carriers that are given ATI jointly set their product prices in all markets, even markets designated as carve-outs; and (2) where we assume the ATI partner carriers jointly set their product prices in all markets except the carve-out markets, as required by a carve-out policy. Based on Vuong (1989), we then employ a Vuong-type non-nested likelihood ratio test to determine under which price-setting assumption the data provides a better goodness of fit.[4] In the combined subsamples of the American (AA)/LAN-Chile (LA), Delta (DL)/Air France (AF) and United (UA)/Air Canada (AC) ATI pairings, the non-nested test result suggests that the model in which these partner carriers jointly set their product prices in all markets, including the carve-out markets, has better statistical support from systematic patterns in the data. This is an important result as it indicates there may be some tacit collusion occurring between the ATI partners in the carve-out markets.

Given our product-level computations of markups and marginal costs, we subsequently specify and estimate markup and marginal cost functions. We also specify a reduced-form price regression that allows us to estimate the effect a carve-out has on overall prices. The regression estimates provide some intriguing results. For instance, estimates from the markup regressions suggest that each ATI pairing in question may be engaged in some tacit collusion. This is evident from the result that markups on the ATI partners' products relative to competitors' products are at least as great in the carve-out markets relative to the non-carve-out markets for each ATI pairing examined. However, in the case of the AA/LA ATI pairing, the evidence does

[4] Gasmi, Laffont and Vuong (1992) similarly use non-nested likelihood ratio tests to examine cooperative behavior of Coca-Cola and Pepsi in the soft drink market. For a more complete survey of applications of this type of statistical test, see Kadiyali, Sudhir and Rao (2001).

not suggest that potential efficiencies of cooperation are being realized in their carve-out markets. This does not bode well for consumers. The tacit collusion coupled with unrealized efficiencies of cooperation each act to raise prices for consumers. AA/LA prices relative to competitors' prices are on average $506 greater in their carve-out markets versus their non-carve-out markets. The findings regarding DL and AF suggest relative product marginal costs are no different between their carve-out and non-carve-out markets. However, their products' prices relative to competitors' prices are on average $174 greater in their carve-out markets. In the case of the UA/AC ATI pairing, there is some indication that tacit cooperation may be taking place, however, there is also evidence of realized cost efficiencies in their carve-out markets. Overall, the realized cost efficiencies seem to be sufficient to result in lower relative prices on average for UA and AC products in their carve-out markets on the order of approximately $193.

The paper proceeds as follows. In section 1.2 we provide discussion of examples in which the DOT granted carriers ATI with carve-outs. In section 1.3 we discuss the data and define the variables used in the analysis. Section 1.4 discusses the econometric model used in the analysis. Section 1.5 discusses estimates from the demand model, Section 1.6 discusses the empirical results regarding the outcomes of partner carriers' behavior in their carve-out markets, and Section 1.7 provides a brief discussion and some concluding comments.

1.2 Examples of ATI Decisions and Associated Carve-outs

Given the benefits that cooperation has been found to convey, ATI has been granted to numerous airline partnerships since the DOT's first approval in 1993 of the partnership between Northwest and KLM.[5] However, theory suggests cooperation between partner carriers will result in anticompetitive effects in interhub markets, which harm passengers in these markets. As a result, the DOT may impose a carve-out in the interhub market, which effectively forbids collusion between ATI partner carriers in markets the policymaker designate as carve-out. The carve-out is meant to eliminate the anticompetitive effects. However, in the case that ATI allows the partner carriers to achieve cost efficiencies (even in the interhub markets), the carve-out may negate some of these cost efficiencies. The DOT must weigh these potential costs and benefits when deciding to impose a carve-out.

[5] There were no carve-outs given in this first ATI ruling by the DOT

The DOT's first approval of ATI with a carve-out was in the case of United Airlines and Lufthansa in 1996. The DOT imposed a carve-out in the Chicago-Frankfurt and Washington D.C.-Frankfurt markets. United Airlines was also given ATI with Air Canada in 1997 where carve-outs in two markets were imposed. Similarly, United Airlines was given ATI with Air New Zealand in 2001 where carve-outs in two markets were imposed. United Airlines is currently involved in five separate ATI agreements where three are subject to carve-outs.[6]

American Airlines was first given ATI with Canadian Airlines in 1996 with carve-outs in the New York-Toronto market; although, this particular ATI agreement ceased in 2007. As of this writing, American Airlines has three separate ATI agreements: one with LAN and LAN-Peru (two carve-outs), one with British Airways, Iberia, Finnair and Royal Jordanian (no carve-outs) as well as one with Japan Airlines (no carve-outs).

In 1996 the DOT granted ATI to Delta and three foreign carriers (Austrian Airlines, Sabena and Swissair). There were numerous carve-outs in this ruling by the DOT. Additionally, in 2002 there was another ATI ruling regarding Delta that included three different foreign carriers: Air France, Alitalia and Czech Airlines (this was expanded later in 2002 to include a fourth foreign carrier, Korean Air Lines). With this ruling, two carve-outs were implemented. The carve-outs were in the Atlanta-Paris and Cincinnati-Paris markets. In the case of the latter ATI decision regarding Delta, the ATI partnership was expanded to include Northwest in 2008. However, in this expansion, the previously implemented carve-outs were removed. The rationale posited is that a joint-venture among Delta, Northwest, Air France and KLM would allow the carriers to exploit potential cost efficiencies and provide an overall benefit to passengers. Additionally, it is believed that granting the carriers ATI would not significantly lessen competition in those markets.[7]

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[6] For a complete history of ATI decisions and associated carve-outs, see Table A.1 and Table A.2 in the appendix.

[7] See U.S. Department of Transportation Office of the Secretary, Final Order 2008-5-32, May 22, 2008.

1.3 Data, Definitions and Descriptive Statistics

Data and Sample Selection

The data used in the study are from the International Passenger Origin and Destination Survey obtained from the U.S. Department of Transportation. The survey is taken quarterly and contains a 10% sample of itineraries for international air travel where at least one segment on the itinerary is operated by a U.S. carrier. Within the dataset, each observation contains information regarding the price of the itinerary, origin airport, destination airport, intermediate airport stops, number of passengers that purchased the particular itinerary, flight distance between each intermediate stop, ticketing carrier(s) for each coupon segment and operating carrier(s) for each coupon segment. The data used in the study span from the first quarter of 2005 through the fourth quarter of 2010.

Our sample is restricted to itineraries that meet the following criteria. First, we keep only itineraries that are roundtrip. Itineraries that involve multiple ticketing carriers are also eliminated. Additionally, itineraries that include the origin or destination as an intermediate stop or where the destination is another U.S. location are dropped. Itineraries where an intermediate stop is stopped at multiple times on the going or coming portion of the itinerary are also discarded. Finally, we eliminate itineraries with a price less than $100 or greater than $10,000.

We define a market as an origin airport and destination airport combination at a particular time period. For instance, travel from ORD (O'Hare International Airport in Chicago, U.S.) to FRA (Frankfurt Airport in Frankfurt, Germany) is a separate market than ORD to CDG (Charles de Gaulle Airport in Paris, France). Likewise, travel from ORD to FRA in the first quarter of 2005 is a separate market than ORD to FRA in the second quarter of 2005. A product offered within a market is defined by the unique combination of ticketing carrier, group of operating carriers, and sequence of airports on the travel itinerary.

The number of itineraries in the dataset are very large and in many cases repeated multiple times. Thus, to further simplify our analysis we collapse the itineraries in each market based on defined products. We obtain the price of a product by the mean price for which the product was purchased, and the quantity sold, q, as the number of passengers that purchased the itinerary. All prices are converted to 2005 dollars using the consumer price index. In our final sample, there are a total of 1,791,108 observations/products and 475,639 different markets.

To fully examine the effect that a carve-out has on prices, markups and marginal costs for carriers that have been granted ATI, one must identify the markets in which the ATI partner carriers each offer products, i.e. markets in which the ATI partners service overlap, where a subset of these markets are designated as carve-out for the carriers. This allows us to compare the prices, markups and marginal costs for carriers with ATI in non-carve-out markets versus carve-out markets. In the dataset, there were three such instances in which carriers with ATI each offered products in carve-out markets as well as other markets. This is the case with the UA/AC, DL/AF and AA/LA ATI partner pairings. For instance, UA and AC are subject to carve-outs in the Chicago/Toronto and San Francisco/Toronto markets. UA and AC each offered products in these two carve-out markets. It is also the case that UA and AC each offered products in other markets including, but not limited to the following: Denver/Toronto and Newark/Vancouver. As a result, we focus our attention to the three aforementioned ATI partner pairings and their respective carve-outs. Table 1.1 illustrates the defined carve-out markets in our sample that we analyze.

Table 1.1 Carve-out Markets in the Data Sample that we Ananalyze

Carriers	Carve-out markets	Sample date begin (Q/YR)	Sample date end (Q/YR)
United/Air Canada	Chicago-Toronto	1/2005	4/2010
	San Francisco-Toronto	1/2005	4/2010
Delta/Air France	Atlanta-Paris	1/2005	3/2008
	Cincinnati-Paris	1/2005	3/2008
American/LAN-Chile	Miami-Santiago	1/2005	4/2010

*Note the carve-outs markets are defined using the respective carrier's hub in the city.

Variable Definitions

Codesharing is defined as a situation in which the carrier that sells the travel ticket to the passenger (the ticketing carrier), differs from the carrier that owns the plane that transports the passenger (the operating carrier). The first step in creating a codeshare variable is to account for regional carriers in the sample. We make the assumption that the regional carriers operate for a major carrier. For example, consider the case of the domestic regional carrier SkyWest Airlines (OO). In our sample the assumption is made that SkyWest Airlines is operating local routes within the US for the major US ticketing carrier, where the major US ticketing carrier often transports passengers internationally using its own planes. Therefore, in the sample the ticketing carrier/operating carrier, UA/OO, would be converted to UA/UA and not classified as codesharing between these carriers. As such, following much of the literature on airline codesharing, our study focuses on codesharing between major carriers.

Codeshare variables are created regarding the type of codesharing between carriers on certain portions of a given itinerary. We construct variables that correspond to three types of codesharing. One type of codeshare variable is defined as *Trad_1_going*. *Trad_1_going* is a zero-one dummy variable that takes a value of one only if at least one coupon segment of the going portion of the product is operated by the ticketing carrier, and at least one coupon segment is operated by a carrier other than the ticketing carrier. Likewise, *Trad_1_coming*, accounts for this type of codesharing on the coming portion of the product. *Trad_2_going* (*Trad_2_coming*) is a zero-one dummy variable that takes a value of one only if the ticketing carrier is not an operating carrier on the going (coming) portion of the product, and there are multiple operating carriers on this going(coming) portion of the product. *Virtual_going* (*Virtual_coming*) is a zero-one dummy variable that takes a value of one only if the ticketing carrier is different than the operating carrier, and all coupon segments on the going (coming) portion are operated by the same carrier. Last, certain portions of a given itinerary may not involve any codesharing and are classified as online. *Online_going* (*Online_coming*) is a zero-one dummy variable that takes a value of one only if the ticketing carrier is the operating carrier for all coupon segments on the going (coming) portion of the product.

Other variables used in the analysis include, *Opres*, a measure of the size of an airline's presence at the origin airport. Variable *Opres* takes a value equal to the number of destination airports that a carrier has non-stop flights to leaving from the specific origin airport. In contrast, variable *MC_opres* takes on a value equal to the number of airports that a carrier offers non-stop flights from that goes to the origin airport. Given that the origin airport for each itinerary is located in the U.S., *MC_opres* is calculated using the Domestic Passenger Origin and Destination Survey. This dataset is maintained by the U.S. Department of Transportation and is the domestic equivalent to the international dataset.

The idea for two different presence variables is that *Opres* is more appropriate for partly explaining variations in demand across airlines, while *MC_opres* is more appropriate for partly explaining variations in marginal cost across airlines. *Opres* is more appropriate for partly explaining variations in demand as consumers likely care about how many different destinations to which an airline flies non-stop from the passenger's origin airport. *MC_opres* is more appropriate for explaining variations in marginal cost across airlines since a larger *MC_opres* value for an airline at an airport indicates that the airline can channel larger volumes of passengers through the airport, which may facilitate the airline being better able to exploit economies of passenger-traffic density. Economies of passenger-traffic density is the phrase given to the situation in which an airline is able to lower the marginal cost of transporting a given passenger on a route the larger the volume of passengers it transports through the route.

Nonstop_going (*Nonstop_coming*) is a zero-one dummy variable that takes a value of one only if the going (coming) portion of the product is a non-stop flight between the origin and destination. *Itinerary_dist_going* (*Itinerary_dist_coming*) is a variable that measures the flying distance of the going (coming) portion of the product. *Route_qual_going* (*Route_qual_coming*) is a measure of the routing quality of the going (coming) portion of the product. It is defined as the minimum flying distance going to (coming from) the destination airport in the origin-destination market as a percentage of the actual flying distance on the going (coming) portion of the itinerary for the product for which the routing quality is being measured. If *Route_qual_going* (*Route_qual_coming*) takes on the maximum value of 100, then in terms of flying distance this is the most travel-convenient routing offered in the market for the going (coming) portion of the trip.[8]

Close_comp_going (*Close_comp_coming*) is a variable that indicates the number of other products in the market with the same number of coupon segments on the going (coming) portion of the product, where these other competing products are not offered by the airline that offers the product for which the *Close_comp_going* (*Close_comp_coming*) measure is computed. Finally, the observed product share, denoted by S_{jmt}, is the market share of product j in origin-destination pair, m, at time t. S_{jmt} is calculated as the quantity sold of the product, q_{jmt}, divided by the number of potential consumers for the market, POP_{mt}, (measured by the population size of the origin city).[9] Table 1.2 shows summary statistics for the aforementioned variables.

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[8] See Chen and Gayle (2014) for a detailed discussion of this distance-based measure of routing quality.

[9] Since product shares are extremely small values when using population size to measure potential market size, product shares are scaled up by a factor of 100.

Table 1.2 Descriptive Statistics

(2005Q1 - 2010Q4)				
Variable	Mean	Std. Dev	Min	Max
Real_price[1]	979.28	901.90	89.55	9,992
Quantity	5.62	39.12	1	5,812
S_{jmt}	1.72e-3	0.01	1.18e-5	0.95
Opres	26.48	40.56	0	265
MC_opres	24.08	31.15	0	182
Nonstop_going	0.04	0.20	0	1
Nonstop_coming	0.04	0.20	0	1
Itinerary_dist_going	3,949.23	2,485.02	96	17,801
Itinerary_dist_coming	3,952.83	2,488.72	96	17,586
Route_qual_going	94.07	9.28	35.71	100
Route_qual_coming	94.00	9.36	28.28	100
Close_comp_going	6.02	9.68	0	116
Close_comp_coming	5.97	9.62	0	112
Trad_1_going	0.16	0.36	0	1
Trad_1_coming	0.16	0.37	0	1
Trad_2_going	1.57e-3	0.04	0	1
Trad_2_coming	2.09e-3	0.05	0	1
Virtual_going	0.02	0.14	0	1
Virtual_coming	0.02	0.15	0	1
Observations	1,791,108			
Markets	475,639			

1. Measured in constant year 2005 dollars

1.4 Model

Demand

A nested logit model is used to capture consumer's choice behavior among differentiated air travel products sold in international air travel markets. In each market we assume the number of potential consumers is equal to the population size in the originating city, *POP*. Each consumer, denoted by *c*, can choose any one of $J + 1$ options, $j = 0,1,\ldots,J$. The outside option/good ($j = 0$) represents the consumer's choice to not purchase any of the $j = 1,\ldots,J$ differentiated air travel products in the market, which effectively represents the consumer's choice not to fly internationally.

The products within each market are organized into $G + 1$ mutually exclusive groups, $g = 0,1,\ldots,G$. The products within each group are closer substitutes than the substitutability of products across groups. Groups are defined based on products offered by the same ticketing carrier.

Given this information, each consumers' discrete choice optimization problem is to choose the alternative that yields them the highest utility:

$$\max_{j\in\{0,1,\ldots,J_{mt}\}}\{u_{cjmt} = \mu_{jmt} + \delta\zeta_{cgmt} + (1-\delta)\varepsilon^{d}_{cjmt}\}. \tag{1}$$

The term μ_{jmt} represents the mean utility across all consumers that purchase product j. Here, *m* indexes an origin airport and destination airport combination, and *t* indexes the time period. ζ_{cgmt}, is a random compenent of utility common to all products in group g. ε^{d}_{cjmt} is a random component of utility specific to consumer *c* from consuming product *j*. δ is a parameter that lies within the range of 0 to 1 and measures the consumer's correlation of preference across products within the same group. As δ approaches 1, consumers view products within the same group as closer substitutes. The random components ζ_{cgmt} and ε^{d}_{cjmt} have distributions such that $\delta\zeta_{cgmt} + (1-\delta)\varepsilon^{d}_{cjmt}$ has type 1 extreme value distribution.

The mean utility, μ_{jmt}, is specified as a linear function of product characteristics:

$$\mu_{jmt} = x_{jmt}\phi^{x} - \phi^{p}p_{jmt} + \xi_{jmt}. \tag{2}$$

Thus, the mean utility from consuming product *j* is a function of the price of product j, p_{jmt}, a vector of observed non-price product characteristics, x_{jmt}, and an error term, ξ_{jmt}, representing the unobserved (by the researchers) product characteristics. ϕ^{x} and $\phi^{p}$are parameters to be estimated in the demand model.

The nested logit model yields the following predicted share function for product *j*:

$$s_j(p,x,\xi;\phi^{x},\phi^{p},\delta) = \frac{\exp\left[\frac{\mu_j}{(1-\delta)}\right]}{D_g} \times \frac{D_g^{1-\delta}}{1+\sum_{g=1}^{G} D_g^{1-\delta}} \tag{3}$$

where $D_g = \Sigma_{k\in G_g}\exp[\frac{\mu_k}{1-\delta}]$, and the specification of μ_j is given in equation (2). The subscript notations for market have been dropped only for convenience. The demand for product *j* is given by the following:

$$d_j = s_j(p, x, \xi;\ \phi^x, \phi^p, \delta) \times POP \tag{4}$$

where ϕ^x, ϕ^p and δ are the parameters to be estimated in the demand model.

4.2 Supply

To facilitate modeling supply of air travel products that involve codesharing, we assume that the ticketing carrier of the product markets and sets the final price for the round-trip ticket and compensates operating carrier(s) for operating services provided. Unfortunately for researchers, partner airlines do not publicize details of how they compensate each other on their codeshare flights, so we face the challenge of specifying a modeling approach that captures our basic understanding of what is commonly known about how a codeshare agreement works without imposing too much structure on a contracting process about which we have few facts. The approach we use to model supply of products that involve codesharing is also used by Chen and Gayle (2007) and Gayle (2013).

A codeshare agreement can be thought of as a privately negotiated pricing contract between partners (w, Γ), where w is a per-passenger price the ticketing carrier pays over to an operating carrier for transporting the passenger, while Γ represents a potential lump-sum transfer between partners that determines how the joint surplus is distributed. For the purposes of this paper it is not necessary to econometrically identify an equilibrium value of Γ.

Let the final price of a product that involves codesharing be determined within a sequential price-setting game, where in the first stage of the sequential process an operating carrier sets price, w, for transporting a passenger using its own plane(s), and privately makes this price known to its partner ticketing carrier. In the second stage, conditional on the agreed-upon price w for services supplied by the operating carrier, the ticketing carrier sets the final round-trip price p for the product. The final subgame in this sequential price-setting game is played between ticketing carriers, and produces the final ticket prices observed by consumers and us the researchers.

Let each ticketing carrier, denoted by f, offer to consumers a set of products, denoted by F_f. Thus, ticketing carrier f in market m sets final prices for these products according to the following optimization problem:

$$max_{p_j\,\forall j\in F_f}\left[\sum_{j\in F_f}(p_j - mc_j)q_j\right] \quad (5)$$

where $\left[\sum_{j\in F_f}(p_j - mc_j)q_j\right]$ is variable profit carrier *f* obtains in the market by offering the set of products F_f to consumers, p_j is the price of product *j*, mc_j is the effective combined marginal cost ticketing carrier *f* incurs by offering product *j* and q_j is the quantity sold of product *j*.

Let r indexes operating carriers, and R_j be the set of operating carriers that use their own planes to provide transportation services to product *j*. The effective combined marginal cost of product *j* is given by $mc_j = c_j^f + \sum_{r\in R_j} w_j^r$. c_j^f is the part of the effective combined marginal cost that ticketing carrier f incurs by using its own plane to provide transportation services on some segment(s) of the trip needed for product j. If ticketing carrier f does not provide transportation service on any segment of the trip, then $c_j^f = 0$. w_j^r is the price ticketing carrier f pays to operating carrier r for its transportation service on the trip segment(s) that use(s) plane(s) owned by operating carrier r.

Since in equilibrium quantity of product *j* demanded is equal to quantity supplied, i.e. $d_j = q_j$, then we can replace q_j in the optimization in (5) with the expression on the right-hand-side of the demand equation in (4). Therefore, across all carriers indexed by *f* in a given market, the optimization problem in (5) yields the following *J* first-order conditions:

$$\sum_{k\in F_f}(p_k - mc_k)\frac{\partial s_k}{\partial p_j} + s_j = 0 \qquad \text{for all } j = 1,\ldots,J \quad (6)$$

where F_f is the subset of products in the market that are offered to consumers by airline *f*. The system of first-order conditions represented by equation (6) can be rewritten in matrix notation as the following:

$$s + (\Omega .* \Delta) \times (p - mc) = 0 \quad (7)$$

where p is a $J \times 1$ vector of product prices, mc is a $J \times 1$ vector of marginal costs, s is a $J \times 1$ vector of predicted product shares, Ω is a $J \times J$ matrix of zeros and ones appropriately positioned to capture ticketing carriers' "ownership" structure of the *J* products in a market, and Δ is a $J \times J$

matrix of first-order own-price and cross-price effects, where element $\Delta_{jk} = \frac{\partial s_k}{\partial p_j}$. Note, the operator $.*$ represents element-by-element multiplication of two matrices.

A convenient feature of representing the first-order conditions using matrix notion is that the structure of matrix Ω in equation (7) effectively determines groups of products in a market that are jointly priced. For example, if the distinct ticketing carriers that offer products to consumers in a market non-cooperatively set their product prices, then the structure of Ω is simply determined by F_f for all *f* in the market. On the other hand, if subsets of these ticketing carriers are ATI partners and therefore jointly/cooperatively set prices in a given market, then the structure of Ω is based on product-groupings according to subsets of ATI partners instead of F_f. We will subsequently exploit this convenient feature of matrix Ω to analyze price-setting behavior of ATI partner carriers in their carve-out markets.

Equation (7) can be used to calculate a $J \times 1$ vector of product markups as follows:

$$markup(p, x, \xi;\ \phi^x, \phi^p, \delta) = \ p - mc = -(\Omega .* \Delta)^{-1} \ \times s \tag{8}$$

Additionally, with computed product markups in hand, product marginal costs can subsequently be recovered simply by subtracting computed markup from price, i.e. $\widehat{mc} = p - markup$.

1.5 Estimation and Results

Demand Estimation

As shown in Berry (1994), the following linear equation specification can be used to estimate the parameters in the nested logit demand model:

$$\ln(S_{jmt}) - \ln(S_{0mt}) = x_{jmt}\phi^x - \phi^p p_{jmt} + \delta \ln(S_{jmt/g}) + \xi_{jmt}, \tag{9}$$

where S_{jmt} is the observed market share of the product, S_{0mt} is the observed market share of the outside good, and $S_{jmt/g}$ is the observed within group share of the product. The estimation of equation (9) needs to take into account the potential endogeneity of p_{jmt} and $S_{jmt/g}$.

Instruments

Valid instruments will be correlated with p_{jmt} and $S_{jmt/g}$, but uncorrelated with ξ_{jmt}. The instruments used in demand estimation are: (1) the number of other products in the market with an equivalent number of coupon segments on the going (coming) portion of the itinerary, where these other competing products are not offered by the airline that offers the product for which the instrument variable value is computed; (2) the total number of miles flown on the going (coming) portion of the itinerary; and (3) the deviation of a product's itinerary flying distance-based routing quality measure from the mean routing quality measure across the set of products offered by the ticketing carrier.[10] (1) and (2) instrument for price, while (3) instruments for the within group share.

The instruments for price stem from the fact that price is composed of a markup and marginal cost component. Instrument (1) serves as a measure of the level of competition a product faces in the market; thus, affecting the product's markup. Instrument (2) follows from the idea that flying distance is likely to be correlated with the product's marginal cost. Following arguments in Chen and Gayle (2014), the use of instrument (3) stems from the idea that, all else equal, consumers prefer the product with the most direct routing, i.e. highest routing quality measure, between the origin and destination. Since the demand model groups products by airlines, which defines how within group product shares are computed, the rationale for the instrument is that the lower (greater) the product's routing quality relative to the mean routing quality across products offered by the airline in the market, then the lower (greater) will be the product's within group share. Thus, the instrument is likely to be correlated with the product's within group share.

The arguments made in the previous two paragraphs provide reasons to believe that our instruments are likely correlated with the endogenous variables. However, it is also important that the instruments are unlikely to be correlated with the shocks to demand captured by ξ_{jmt}. For the latter property of our instruments we rely on the fact that the menu of products offered by

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[10] For cases in which the routing quality is equal to the mean routing quality of all products offered by the carrier, the deviation of routing quality instrument variable is constructed to take the maximum value of the routing quality measure of 100.

airlines in a market is predetermined at the time of shocks to demand. Furthermore, unlike price and within group product share, the menu of products offered and their associated non-price characteristics are not routinely and easily changed during a short period of time, which mitigates the influence of demand shocks on the menu of products offered and their non-price characteristics. Therefore, a product's itinerary flying distance and its routing quality measure are predetermined during the short-run period of price-setting by airlines and product choice by passengers, which makes these valid non-price product characteristics to use for constructing instruments.

Results from Demand Estimation

Table 1.3 reports ordinary least squares (OLS) and two-stage least squares (2SLS) methods of estimating coefficients in the demand model. The coefficient estimates on p_{jmt} and $\ln(S_{jmt/g})$ are consistent with economic theory, but are very different in magnitude across the two methods of estimation. A Wu-Hausman test is performed to examine the endogeneity of p_{jmt} and $\ln(S_{jmt/g})$. The Wu-Hausman test result is reported in the last row of Table 1.3 and provides strong evidence of the endogeneity of p_{jmt} and $\ln(S_{jmt/g})$. Thus, instruments must be used.

As a check on the statistical power of instruments to explain variations in the endogenous variables, we perform nested likelihood ratio tests. Using OLS, each endogenous variable is first regressed against the exogenous variables, which serve as the restricted specifications in the nested likelihood ratio tests. Second, for the unrestricted specifications in the nested likelihood ratio tests, each endogenous variable is regressed against the exogenous variables and the instruments. The χ^2 test statistics regarding the joint significance of the instruments in explaining variations in p_{jmt} and $\ln(S_{jmt/g})$ are 7,777.92 and 477,883.53, respectively, where each is statistically significant at the 1% level. Thus, the instruments do have power in explaining variations in the endogenous variables.

In light of the Wu-Hausman test results, we focus subsequent discussion on the 2SLS regression estimates. Consistent with economic theory, the coefficient estimate on price is negative. An increase in price lowers the utility of consumers, all else constant. Additionally, note the statistical significance of coefficient estimate on $\ln(S_{jmt/g})$ suggests that consumers have greater preference for the set of products offered by a given carrier. This provides evidence that consumers exhibit some brand loyalty to a particular carrier.

The coefficient estimate on *Opres* is positive. Therefore, the more destinations a particular carrier offers service to, the greater the utility of the consumer, all else constant. This is consistent with the idea that consumers have a preference for a particular carrier. Consumers within a market will want to reap the rewards of any frequent-flier programs offered by a particular carrier. Thus, the more destinations the carrier offers services to, the consumer can use that particular carrier to travel and obtain the frequent-flier rewards. This is consistent with the idea that consumers exhibit brand loyalty.

The coefficient estimates for *Nonstop_going* and *Nonstop_coming* are each positive. All else constant, utility is greater using nonstop products versus products that require intermediate stop(s). As expected, the evidence suggests that, on average, passengers view intermediate stops as travel inconveniences. The positive coefficient estimates on *Route_qual_going* and *Route_qual_coming* support this argument and go a step further to suggest that among products with equivalent number of intermediate stops, passengers prefer the product with the most direct routing (higher measures of *Route_qual_going* and *Route_qual_coming*) between the origin and destination, all else constant.

Regarding the coefficient estimates on the codeshare variables, first consider *Trad_1_going* and *Trad_1_coming*. These negative coefficient estimates imply that codeshare products, where the ticketing carrier operates at least one coupon segment, are less preferred to pure online products, all else constant. Additionally, the coefficient estimates on *Trad_2_going* and *Trad_2_coming* are negative as well. All else constant, a codeshare product for which the ticketing carrier is not an operating carrier, and the consumer is required to switch carriers at some point during their travel, lowers the utility of the consumer. Switching carriers is an inconvenience for the consumer. It is worth noting that the magnitude of the coefficient estimates for *Trad_1_going* and *Trad_1_coming* are smaller than that of *Trad_2_going* and *Trad_2_coming,* suggesting that products where the ticketing carrier operates on a portion of the itinerary are preferred to products where the ticketing carrier does not operate on a portion of the itinerary. Since the consumer purchased the ticket from the ticketing carrier, this provides evidence that consumers have a preference for the carrier with which they interact when purchasing the travel ticket.

Table 1.3 Demand Estimation Results

(2005Q1 - 2010Q4)				
	OLS		2SLS	
Variable	Estimates	Std. Error	Estimates	Std. Error
Real_price	-0.00002***	(5.22e-7)	-0.00214***	(0.00003)
$\ln(S_{jmt/g})$	0.40303***	(0.00061)	0.16484***	(0.00262)
Opres	0.00501***	(0.00002)	0.00629***	(0.00008)
Nonstop_going	0.80914***	(0.00434)	0.76043***	(0.00870)
Nonstop_coming	0.80146***	(0.00443)	0.75636***	(0.00895)
Route_qual_going	0.00786***	(0.00008)	0.00895***	(0.00018)
Route_qual_coming	0.00730***	(0.00008)	0.00870***	(0.00018)
Trad_1_going	-0.25311***	(0.00180)	-0.04971***	(0.00696)
Trad_2_going	-0.32409***	(0.01270)	-0.18513***	(0.04399)
Trad_1_coming	-0.23605***	(0.00171)	-0.03632***	(0.00683)
Trad_2_coming	-0.27768***	(0.01021)	-0.08736***	(0.04105)
Virtual_going	-0.48041***	(0.00459)	-0.44063***	(0.01190)
Virtual_coming	-0.47594***	(0.00417)	-0.22349***	(0.01243)
Constant	-8.58837***	(0.19404)	-6.51280***	(0.80244)
Ticketing carrier FE	Yes		Yes	
Origin FE	Yes		Yes	
Destination FE	Yes		Yes	
Year FE	Yes		Yes	
Quarter FE	Yes		Yes	
Obs	1,791,108		1,791,108	
R^2	0.7722		0.6978	
Wu-Hausman (χ^2)			94,076.8***	

*indicates significance at the 10% level, **indicates significance at the 5% level and ***indicates significance at the 1% level.

The coefficient estimates on *Virtual_going* and *Virtual_coming* are negative as well. Thus, all else constant, utility is lower with virtual codeshare products versus pure online products. The evidence therefore suggests that consumers view virtual codeshare products as inferior substitutes to pure online products.

The coefficient estimates of the demand model yield a mean own-price elasticity of -2.30. This estimate of the own-price elasticity is similar to what has been found in U.S. domestic air travel markets. For instance, recent estimates of the own-price elasticity by Peters (2006) are in the -3.20 to -3.60 range, while Berry and Jia (2010) estimate own-price elasticities to be in the range of about -1.89 to -2.10.

1.6 Results from Assessing Cooperative Behavior in Carve-out Markets

Non-nested Likelihood Ratio Test

With the demand parameter estimates in hand, equation (8) can now be used to compute markups and subsequently recover marginal costs. However, depending on the structure of matrix, Ω, various estimates of markups and marginal costs can be obtained. In our analysis we define Ω in two ways to denote two different scenarios that we consider. In one scenario, we construct Ω^{coop} assuming the carriers that have been given ATI cooperate in setting prices in all markets. In other words, we are assuming here that ATI partners jointly set prices of their products in a given market. In another scenario, we construct Ω^{coop_nc} assuming carriers that have been given ATI cooperate in all markets except markets in which a carve-out is present. Thus, ATI partners jointly set prices for their products in markets where they each offer products, but non-cooperatively set prices for their products in markets in which there is a carve-out. As a result, we obtain two sets of markup and marginal cost estimates with the purpose of using non-nested statistical tests to uncover which of the two sets is better statistically supported in carve-out markets.

Upon recovering the two respective sets of marginal cost estimates, we estimate the following reduced-form marginal cost functions using OLS:

$$\widehat{mc}_{jmt}^{coop} = \theta W_{jmt} + \varepsilon_{jmt}^{coop}, \tag{10}$$

$$\widehat{mc}_{jmt}^{coop\_nc} = \gamma W_{jmt} + \varepsilon_{jmt}^{coop\_nc}, \tag{11}$$

where $\widehat{mc}_{jmt}^{coop}$ and $\widehat{mc}_{jmt}^{coop\_nc}$ are obtained by $\widehat{mc}_{jmt}^{coop} = p_{jmt} - \widehat{markup}_{jmt}^{coop}$ and $\widehat{mc}_{jmt}^{coop\_nc} = p_{jmt} - \widehat{markup}_{jmt}^{coop\_nc}$, respectively. W_{jmt} is a vector of marginal cost shifters, which include a constant term, *MC_opres*, *MC_opres*^{2}, *Nonstop_going*, *Nonstop_coming*, *Itinerary_dist_going*, *Itinerary_dist_coming*, *Trad_1_going*, *Trad_1_coming*, *Trad_2_going*, *Trad_2_coming*, *Virtual_going* and *Virtual_coming*, all of which have been previously described. Since the purpose is to examine the behavior of carriers in carve-out markets, we estimate these marginal cost equations on subsamples of data from the respective carriers' carve-out markets. The subsamples consist of all products in carve-out markets in which the respective carriers each offer products. Parameter estimates for equations (10) and (11) are reported in Table A.3, Table A.4, Table A.5 and Table A.6, all located in the appendix.

We use a Vuong (1989) non-nested likelihood ratio test to statistically compare the two non-nested model specifications in equations (10) and (11). The test statistic for the non-nested tests, *t*, is calculated as follows:

$$t = \frac{L^{coop}(\hat{\theta}) - L^{coop\_nc}(\hat{\gamma})}{\left(n^{1/2}\right)\hat{\omega}}, \tag{12}$$

where $\hat{\theta}$ and $\hat{\gamma}$ are the parameter estimates from the two respective models; $L^{coop}(\hat{\theta})$ and $L^{coop\_nc}(\hat{\gamma})$ are the log-likelihood function values for the two respective models; n is the number of observations; and $\hat{\omega}$ is the standard deviation of the differences in the log-likelihood functions. The test statistic is asymptotically normally distributed. Given a critical value, c, the null hypothesis is that the two models are equivalent. We reject the null hypothesis if $t > +c$ or $t < -c$. In the case that $t > +c$, then the data better support the model in which the respective ATI partners cooperate in all markets. In the case that $t < -c$, then the data better support the model in which the ATI partners cooperate in all markets except the carve-out markets.

Table 1.4 summarizes the results from the analysis. The competing models of price-setting behavior are not statistically different from each other when estimated on the separate carve-out markets subsamples for the American/LAN, Delta/Air France and United/Air Canada partner pairings. However, in the combined carve-out markets subsample we reject the null hypothesis that the competing models are statistically equivalent in favor of the model in which the ATI partners jointly set their prices in carve-out markets. Thus, there is some evidence that tacit collusion may be occurring in carve-out markets.

Table 1.4 Non-nested Test Statistics from Carve-out Market Subsamples

	AA/LA Carve-out Market(s)	DL/AF Carve-out Market(s)	UA/AC Carve-out Market(s)	Combined Sample of Carve-out Markets
Test statistic, *t*	-0.9719	0.2303	0.2077	2.2204**
Observations, *n*	191	894	435	1,520

*indicates significance at the 10% level, **indicates significance at the 5% level and ***indicates significance at the 1% level (2 tail test).

Reduced-form Markup Equation Estimation

In order to further examine the effects of a carve-out, or how the carriers are behaving in carve-out markets, we first identify markets in which the ATI partners in question each offer products, i.e. the set of markets in which their air travel services overlap. Typically the designated carve-out markets are a subset of the overlap markets for a given ATI partner pairing. Therefore, identifying these overlap markets allow us to compare the markups, marginal costs and prices for the partner carriers in carve-out markets versus non-carve-out markets. The markup, marginal cost and price regressions are estimated using four subsamples consisting of the aforementioned markets. There is a subsample consisting of markets in which AA and LA each offer products, a subsample consisting of markets in which DL and AF each offer products, a subsample consisting of markets in which UA and AC each offer products, and a subsample consisting of the combination of each of the three subsamples. Given the results found in the previous sub-section, we focus on results using the markup and marginal cost estimates under the assumption that the ATI partners in question are cooperating in all markets in which they each offer products.

The markup regression used in the analysis has the following specification:

$$\widehat{markup}_{jmt} = \beta^{markup} z_{jmt} + \lambda_1 AA/LA\_market\_co_{mt} + \lambda_2 AA/LA\_product_{jmt} + \lambda_3 AA/LA\_product\_co_{jmt} + \varepsilon_{jmt}^{markup}, \qquad (13)$$

where z_{jmt} is a vector consisting of the following: a constant, *Opres*, *Nonstop_going*, *Nonstop_coming*, *Route_qual_going*, *Route_qual_coming*, *Trad_1_going*, *Trad_1_coming*, *Trad_2_going*, *Trad_2_coming*, *Virtual_going* and *Virtual_coming* which have been previously described.

The primary variables of interest are: *AA/LA_market_co*, *AA/LA_product* and *AA/LA_product_co*. *AA/LA_market_co* is a zero-one market-level dummy variable that takes the value of one for all products in a market designated as a carve-out market for ATI partners AA and LA. *AA/LA_product* is a zero-one product-level dummy variable that takes a value of one only for AA and LA products in a market in which AA and LA each offer products. *AA/LA_product_co* is effectively the interaction between *AA/LA_market_co* and *AA/LA_product*, i.e., *AA/LA_product_co* is a zero-one product-level dummy variable that takes a value of one only for AA and LA products offered in their carve-out market (i.e. their products that were subject to a carve-out). Similarly, *DL/AF_product*, *DL/AF_product_co*, *DL/AF_market_co*, *UA/AC_product*, *UA/AC_product_co* and *UA/AC_market_co* dummy variables are created for the DL/AF and UA/AC pairings, respectively, to facilitate estimating equations analogous to equation (13) for each of these other ATI partner pairings. The parameter λ_1 illustrates the systematic differences on markups for products in the ATI partners' carve-out markets relative to their non-carve-out markets. Parameter λ_2 illustrates the systematic differences in markups of the ATI partners' products relative to the markups of competitors' products. Parameter λ_3 provides a way to compare the markups of the ATI partners' products in their carve-out markets versus their non-carve-out markets. Specifically, λ_3 tells us how the markups of the ATI partners' products relative to competitors' products differ between carve-out and non-carve-out markets.

Construction of Instruments for Markup Equation Estimation

A variable of concern in equation (13), as well as its counterpart in the equations analogous to equation (13) is, *AA/LA_market_co*. The concern is that this variable may be endogenous. Consider the following: carve-out markets are chosen to be carve-out markets by the DOT based on the competitive characteristics of the market. So the competitive characteristics of a market jointly determine product markup levels and the policy designation of the market to be a carve-out for the relevant ATI partners. Given the potential endogeneity of this variable, we use a two-stage instrumental variables procedure (Two-stage IV) to estimate the aforementioned specification. Likewise, the variable *AA/LA_product_co* is potentially endogenous as it is a function of *AA/LA_market_co*.

In order to construct the instruments, data from the International Passenger Origin and Destination survey for the two years prior to the respective carriers obtaining ATI are compiled. In the case of AA/LA, data from the third quarter of 1997 through the second quarter of 1999 are used. Similarly, the construction of instruments for DL/AF and UA/AC use data from the fourth quarter of 1999 through the third quarter of 2001 and the third quarter of 1995 through the second quarter of 1997, respectively. Only observations in which the origin is the U.S. and the destination is a foreign country are analyzed.

Using the pre-ATI period data, a logit estimation is conducted on the following equation:

$$AA/LA\_carveout_m = \alpha_0 + \alpha_1 AA/LA\_market_{mt} + \alpha_2 AA/LA\_share_{mt}. \tag{14}$$

AA/LA_carveout is a dummy variable equal to one for origin and destination combination(s) in which AA and LA are subject to a carve-out and zero otherwise. *AA/LA_market* is a dummy variable equal to one if AA and LA each operate non-stop service in the market. *AA/LA_share* is a variable that measures the share of passengers in a given market who fly on AA and LA nonstop products, where AA and LA each operate substitutable nonstop products in these markets. [11] The logit model in (14) is the first-stage regression in the two-stage instrumental variables estimation process. Therefore, *AA/LA_market* and *AA/LA_share* are effectively used as instruments to explain the DOT policymaking designation of carve-out markets, based on data leading up to the carve-out designation. The first-stage regression specification in equation (14) is essentially approximating the policymaking decision process of the DOT. Analogous estimations are done for the DL/AF and UA/AC carve-out designations.

The rationale for the instrument variables *AA/LA_market* and *AA/LA_share* is that carve-out markets are likely designated as carve-out markets by the DOT based on the level of competition the DOT observes in the market leading up to its decision. If the ATI partners face little or no competition from other carriers in the market, then cooperation between the ATI

[11] Note that variable *AA/LA_share* is constructed to take on a value of zero in markets where AA and LA do not provide overlapping nonstop service.

partners is likely to have a greater anticompetitive impact. The ATI partners' markets where they each offer non-stop service and face relatively weak competition from other carriers (i.e. where the ATI partners' nonstop service constitute a large share of the market), are markets that should have a relatively high probability of being designated a carve-out by the DOT.

Upon estimating (14), the fitted values for *AA/LA_carveout* are obtained, which we denote as $AA/\widehat{LA\_carveout}$.[12] These fitted values calculated using pre-ATI period information are then used to instrument for *AA/LA_market_co* in the markup equation estimation, which constitutes the second-stage of the two-stage estimation. Similarly, the interaction term between *AA/LA_product* and $AA/\widehat{LA\_carveout}$ is used to instrument for *AA/LA_product_co*. Analogous methods are used to create instruments in the case of DL/AF and UA/AC.

Table 1.5 reports estimation results of equation (14). The results indicate that markets in which the prospective ATI partners each offer nonstop products are more likely to be designated as carve-out markets. This is evident by the positive coefficient estimates on *AA/LA_market*, *DL/AF_market* and *UA/AC_market*. Furthermore, the coefficient estimates on *DL/AF_share* and *UA/AC_share* are positive. Thus, the greater the proportion of passengers travelling in the market using the prospective ATI partners' nonstop products, the more likely the market is to be designated a carve-out market.

Table 1.5 First-stage Logit Estimation Results

	AA/LA_carveout		DL/AF_carveout		UA/AC_carveout	
Variable	Estimates	Std. Error	Estimates	Std. Error	Estimates	Std. Error
AA/LA_market	10.16***	(1.03)	-	-	-	-
AA/LA_share	-1.05	(0.99)	-	-	-	-
DL/AF_market	-	-	7.54***	(0.99)	-	-
DL/AF_share	-	-	8.16***	(2.03)	-	-
UA/AC_market	-	-	-	-	9.56***	(0.79)
UA/AC_share	-	-	-	-	1.19*	(0.67)
Constant	-10.97***	(0.50)	-11.70***	(0.71)	-11.50***	(0.71)
Observations	231,297		240,790		198,238	
Pseudo-R^2	0.3579		0.7653		0.6336	

*indicates significance at the 10% level, **indicates significance at the 5% level

[12] $AA/\widehat{LA\_carveout}$ is origin/destination specific and is calculated by averaging the fitted values from (14) for a given origin/destination over time. This must be done since an origin/destination may be present among the two years and the origin/destination may take on a different fitted value in each quarter based on the value of the independent variables in the quarter.

and ***indicates significance at the 1% level.

Inferences from Markup Equation Estimation

Table 1.6 and Table 1.7 report the OLS and Two-stage IV markup equation estimation results, respectively. The results of a Wu-Hausman test suggest the suspected endogenous variables are indeed endogenous in each subsample. In most cases, the Two-stage IV results regarding the signs and statistical significance of the coefficient estimates are qualitatively similar to the OLS results. The difference between the OLS and Two-stage IV results can be seen in the magnitude of some coefficient estimates. Thus, for brevity the following discussion focuses on the Two-stage IV results.

First, consider the coefficient estimate on *Opres*. The coefficient estimate is consistently positive and statistically significant across each of the subsamples. Therefore, all else constant, the greater the presence a carrier has at the origin airport of a market, the larger the carrier's markups on its products in this market. This result is consistent with economic intuition since a carrier offering products to many destinations from a given airport is likely to attract a relatively larger following of brand-loyal consumers, perhaps reinforced by the carrier's frequent flyer program, which in turn allows the carrier to charge a larger markup on its products going out of this airport.

The results in each subsample suggest that markups are greater on nonstop products, all else constant. If consumers view intermediate stops as travel-inconveniences, as suggested by our demand model estimates, then carriers will have the ability to sustain larger markups on products without any intermediate stops. The coefficient estimates on our measure of itinerary routing quality, however, are mixed. The coefficient estimate for *Route_qual_going* is positive as expected in the DL/AF subsample. The positive coefficient estimate says that the greater the routing quality of the going portion of the itinerary, the higher the markup charged by the carrier, all else constant. This is consistent with the idea that consumers prefer streamlined travel and are not willing to pay more for travel that uses inconvenient routing. However, the coefficient estimate for *Route_qual_going* in the UA/AC subsample is negative. The coefficient estimates for *Route_qual_coming* are mixed across each of the subsamples. In the DL/AF subsample, the coefficient estimate is not statistically significant, but negative in each of the other subsamples.

In each of the three subsamples there is strong evidence that, all else constant, a product's markup will be lower the greater the number of comparable competing products it faces in the market. This is evident by the negative coefficient estimates on *Close_comp_going* and/or *Close_comp_coming*, respectively.

The coefficient estimates for the virtual codeshare variables are consistently negative across each of the subsamples. Thus, all else constant, markups are lower on virtual codeshare products relative to pure online products. This provides support for the argument that consumers exhibit brand loyalty and would prefer to fly with the carrier from which they purchased the itinerary.

In comparing traditional codeshare products to otherwise equivalent pure online products, there are theoretical arguments that can support the size of markup being larger on any one of these product types compared to the other. For instance, Gayle (2013) has argued and shown, as have the demand results in this paper, that all else equal, consumers prefer to fly on a pure online product compared to a traditional codeshare product. This suggests that in equilibrium airlines should charge a larger markup on pure online products compared to otherwise equivalent codeshare products. However, Gayle (2013) and Ito and Lee (2007) also argue that while traditional codesharing reduces double markup, double markup may not be fully eliminated between partner carriers. Since a pure online product cannot have double markup due to a single carrier being responsible for all aspects of providing the product, then an otherwise equivalent traditional codeshare product should have a larger markup.

Based on the previous discussion, not surprisingly the markup results regarding traditional codeshare products compared to pure online products are mixed. For instance, in the DL/AF subsample, the coefficient estimates for variables *Trad_1_going*, *Trad_1_coming*, and *Trad_2_going* are each positive signifying that markups are higher on traditionally codeshared products, all else constant. The analogous coefficient estimates in the UA/AC subsample are not statistically different from zero with the exception of *Trad_2_coming* in which the coefficient is negative. In the AA/LA subsample the coefficient estimate for *Trad_2_going* is negative. However, the coefficient estimates for *Trad_1_going*, *Trad_1_coming* and *Trad_2_coming* are each positive. In the combined sample the coefficient estimate on *Trad_1_going* and *Trad_2_coming* are negative, while the coefficient estimates for *Trad_1_coming* and *Trad_2_going* are not statistically significant.

Table 1.6 Markup Regression Estimates on Subsamples of Markets with Partner Service Overlap (OLS)

	Combined sample markets with AA/LA, DL/AF or UA/AC service overlap		Subsample markets with AA/LA service overlap		Subsample markets with DL/AF service overlap		Subsample markets with UA/AC service overlap	
Variable	Est.	Std. Error	Est.	Std. Error	Est.	Std. Error	Est.	Std. Error
Opres	0.03***	(6.58e-4)	0.01***	(2.22e-3)	0.02***	(6.70e-4)	0.02***	(2.31e-3)
Nonstop_going	2.38***	(0.17)	2.27***	(0.46)	2.89***	(0.17)	2.13***	(0.52)
Nonstop_coming	2.72***	(0.17)	2.37***	(0.47)	3.55***	(0.17)	1.70***	(0.51)
Route_qual_going	1.01e-3	(0.01)	1.28e-3	(0.02)	0.01***	(0.01)	-0.01	(0.01)
Route_qual_coming	-0.01**	(0.01)	-0.04**	(0.02)	0.01	(0.01)	-0.01	(0.01)
Close_comp_going	-0.05***	(0.01)	-1.48e-3	(0.02)	-0.03***	(0.01)	-0.10***	(0.02)
Close_comp_coming	-0.03***	(0.01)	0.04*	(0.02)	-0.02**	(0.01)	-0.09***	(0.02)
Trad_1_going	-0.02	(0.08)	0.80***	(0.25)	0.57***	(0.07)	0.07	(0.30)
Trad_2_going	0.69	(0.54)	-2.37***	(0.83)	1.52***	(0.43)	13.68	(10.36)
Trad_1_coming	0.01	(0.07)	0.52**	(0.25)	0.49***	(0.07)	-0.21	(0.27)
Trad_2_coming	-0.69**	(0.28)	2.56**	(1.29)	0.25	(0.28)	-3.87***	(1.11)
Virtual_going	-1.23***	(0.13)	-1.19***	(0.29)	-0.55***	(0.12)	-0.26	(0.37)
Virtual_coming	-1.23***	(0.12)	-0.68**	(0.30)	-0.59***	(0.12)	-0.58*	(0.32)
AA/LA_market_co	-16.42***	(1.09)	-17.35***	(1.21)	-	-	-	-
AA/LA_product	3.63***	(0.22)	5.37***	(0.53)	-	-	-	-
AA/LA_product_co	4.75***	(0.41)	6.28***	(0.73)	-	-	-	-
DL/AF_market_co	-2.97***	(0.21)	-	-	-3.39***	(0.22)	-	-
DL/AF_product	-0.86***	(0.18)	-	-	1.26***	(0.06)	-	-
DL/AF_product_co	13.89***	(0.38)	-	-	14.13***	(0.38)	-	-
UA/AC_market_co	-2.92***	(0.28)	-	-	-	-	-0.41	(0.68)
UA/AC_product	3.72***	(0.33)	-	-	-	-	4.51***	(0.31)
UA/AC_product_co	3.86***	(0.37)	-	-	-	-	2.80***	(0.53)
Constant	460.32***	(1.36)	455.40***	(2.22)	456.50	(0.87)	473.17***	(1.47)
Obs	60,971		5,356		43,329		12,331	
R^2	0.4414		0.5389		0.4719		0.4650	

*indicates significance at the 10% level, **indicates significance at the 5% level and ***indicates significance at the 1% level.
Quarter, year, ticketing carrier, origin and destination fixed effects are included.

Table 1.7 Markup Regression Estimates on Subsamples of Markets with Partner Service Overlap (Two-stage IV)

Variable	Combined sample markets with AA/LA, DL/AF or UA/AC service overlap Est.	Std. Error	Subsample markets with AA/LA service overlap Est.	Std. Error	Subsample markets with DL/AF service overlap Est.	Std. Error	Subsample markets with UA/AC service overlap Est.	Std. Error
Opres	0.03***	(6.85e-4)	0.01***	(2.21e-3)	0.02***	(7.15e-4)	0.02***	(2.44e-3)
Nonstop_going	2.16***	(0.18)	2.51***	(0.46)	2.46***	(0.18)	2.23***	(0.53)
Nonstop_coming	2.45***	(0.18)	2.60***	(0.48)	3.06***	(0.18)	1.80***	(0.52)
Route_qual_going	-2.69e-3	(0.01)	3.58e-3	(0.02)	0.01*	(0.01)	-0.02**	(0.01)
Route_qual_coming	-0.02***	(0.01)	-0.04**	(0.02)	3.13e-3	(0.01)	-0.02**	(0.01)
Close_comp_going	-0.04***	(0.01)	0.01	(0.02)	-0.03***	(0.01)	-0.10***	(0.02)
Close_comp_coming	-0.02***	(0.01)	0.04**	(0.02)	-0.01	(0.01)	-0.09***	(0.02)
Trad_1_going	-0.16**	(0.08)	0.77***	(0.25)	0.35***	(0.07)	0.10	(0.30)
Trad_2_going	0.65	(0.54)	-2.45***	(0.83)	1.34***	(0.44)	14.23	(10.07)
Trad_1_coming	-0.12	(0.08)	0.50**	(0.25)	0.31***	(0.07)	-0.23	(0.28)
Trad_2_coming	-0.69**	(0.28)	2.53*	(1.29)	0.14	(0.28)	-3.81***	(1.08)
Virtual_going	-1.34***	(0.13)	-1.14***	(0.29)	-0.69***	(0.13)	-0.53	(0.39)
Virtual_coming	-1.35***	(0.13)	-0.65*	(0.30)	-0.77***	(0.13)	-0.59*	(0.34)
AA/LA_market_co	-12.65***	(1.68)	-14.01***	(1.67)	-	-	-	-
AA/LA_product	3.84***	(0.22)	5.50***	(0.53)	-	-	-	-
AA/LA_product_co	1.19	(1.35)	1.68	(1.53)	-	-	-	-
DL/AF_market_co	-1.65***	(0.38)	-	-	-2.92***	(0.41)	-	-
DL/AF_product	-1.04***	(0.18)	-	-	1.09***	(0.06)	-	-
DL/AF_product_co	27.36***	(1.04)	-	-	28.36***	(1.04)	-	-
UA/AC_market_co	-0.47	(0.66)	-	-	-	-	9.32***	(1.48)
UA/AC_product	3.53***	(0.34)	-	-	-	-	4.20***	(0.33)
UA/AC_product_co	10.13***	(1.24)	-	-	-	-	10.34***	(1.48)
Constant	462.82***	(1.26)	454.86***	(2.23)	458.54***	(0.80)	475.57***	(1.46)
Obs	60,971		5,356		43,329		12,331	
R^2	0.4136		0.5376		0.4294		0.4322	
Wu-Hausman (χ^2)	465.438***		25.461***		343.513***		196.529***	

*indicates significance at the 10% level, **indicates significance at the 5% level and ***indicates significance at the 1% level.
Quarter, year, ticketing carrier, origin and destination fixed effects are included.

Turning attention to the key variables of interest, we find that results for these key variables in the combined sample are consistent with the results in the smaller subsamples. Thus, for brevity, we focus the subsequent discussion on results from the combined sample. Consider the negative coefficient estimates on variables *AA/LA_market_co* and *DL/AF_market_co*. This indicates that, on average, product markups are lower in each of these ATI partner parings' carve-out markets compared to their non-carve-out markets. However, the coefficient estimate on *UA/AC_market_co* is not statistically significant in the combined sample, but positive in the UA/AC subsample. Therefore, there is some evidence that markups on products in UA/AC carve-out markets are higher on average compared to their non-carve-out markets.

The coefficient estimate regarding *AA/LA_product* is positive. Therefore, all else constant, AA and LA products have higher markups on average compared to non-AA and non-LA products in their non-carve-out markets. The same result holds for UA and AC products. In the case of DL and AF, the analogous coefficient estimate suggests in contrast that on average DL and AF products have lower markups than competitors' products in their non-carve-out markets, all else constant. Note however, that in the DL/AF subsample this coefficient estimate is positive.

In order to compare the markups of products offered by the partner carriers in their carve-out versus non-carve-out markets, which is the comparison most relevant for the primary objective of our analysis, we must turn to the coefficient estimates on *AA/LA_product_co*, *DL/AF_product_co* and *UA/AC_product_co*, respectively. The carve-out policy is meant to restrict cooperative pricing between ATI partners in those particular carve-out markets. In the absence of cooperation, the two respective carriers would compete with each other in the market. Thus, if the ATI partners are competing in their carve-out markets as required by antitrust authorities, one would expect the coefficient estimates of *AA/LA_product_co*, *DL/AF_product_co* and *UA/AC_product_co* to be negative, indicating that their products have relatively lower markups in their carve-out markets compared to their non-carve-out markets, all else constant. In other words, one would expect the extent to which ATI partners are marking up products relative to competitors' product markups to be lower in their designated cave-out markets. However, the coefficient estimate on *DL/AF_product_co* is positive, indicating that on average DL and AF products have relatively higher markups in their carve-out markets, all else constant. The same result holds true regarding UA and AC. On the other hand, the coefficient estimate regarding *AA/LA_product_co* is not statistically significant, indicating that AA and LA products have the same relative markups in their carve-out markets and non-carve-out markets, all else constant. In other words, AA and LA are marking up products in their carve-out markets no differently than products in non-carve-out markets. Therefore, contrary to the objective of the carve-out policy, the evidence suggests that tacit collusion between ATI partners is occurring in their carve-out markets.

Inferences from Marginal Cost Function Estimation

To provide further insights into the effects a carve-out policy has on partner carriers in their carve-out markets, we estimate the following specification of the marginal cost function:

$$\widehat{mc_{jmt}} = \beta^{mc} W_{jmt} + \tau_1 AA/LA\_market\_co_{mt} + \tau_2 AA/LA\_product_{jmt} + \tau_3 AA/LA\_product\_co_{jmt} + \varepsilon^{mc}_{jmt} \quad (15)$$

where $\widehat{mc_{jmt}}$ is recovered product-level marginal cost estimates from the Nash first-order conditions in equation (7), and W_{jmt} is a vector of marginal cost shifters as defined in section 1.6. The variables *AA/LA_market_co*, *AA/LA_product* and *AA/LA_product_co* are also as previously defined. Similar models are estimated within each of the other subsamples. As in the markup regression, there are concerns over the potential endogeneity of *AA/LA_market_co*, *DL/AF_market_co* and *UA/AC_market_co*. Therefore the marginal cost equations are also estimated using the Two-stage IV estimator, where the first-stage regression equation is the previously discussed equation (14).

The marginal cost equation estimation results are reported in Table 1.9. The Wu-Hausman test indicates that we can reject the null hypothesis that the variables are exogenous in three of the four subsamples. Given these results, the discussion focuses on the Two-stage IV estimates. For comparison the OLS estimation results are reported in Table 1.8. Much of the following discussion draws from results in the combined sample for brevity, as the qualitative features of the estimates are fairly consistent with the smaller subsamples.

Greater origin presence increases marginal costs, but at a diminishing rate, all else constant. This can be interpreted as evidence consistent with the presence of economies of passenger-traffic density, which implies downward pressure on an airline's marginal cost of transporting a passenger on a route as the volume of passengers the airline transports through the route increases. The idea is that the more distinct locations that an airline has nonstop flights from going into the origin airport of a market (a larger origin presence measure for the airline), the more passengers the airline can channel through the market.

Estimation results from Table 1.9 also reveal that products offering nonstop service have higher marginal costs relative to products with an intermediate stop, all else constant. The coefficient estimates on *Itinerary_dist_going* are not statistically significant; although, the coefficient estimates on *Itinerary_dist_coming* show the expected result that marginal cost increases with distance flown, all else constant. The estimates regarding some of the traditional codeshare variables are not statistically significant; however, in each subsample the coefficient estimate is positive when statistically significant. Thus, there is some evidence that there is a cost to codesharing and coordinating flights among carriers that is absent for pure online products. Evidence is also present that suggests virtual codeshare products have higher marginal costs relative to online products, at least with regard to the coming portion of the itinerary.

The coefficient estimate for *AA/LA_market_co* suggests that marginal costs are lower on average for products in the AA and LA carve-out markets versus their non-carve-out markets by about $573, all else constant. A similar qualitative result holds as well for DL and AF carve-out versus their non-carve-out markets. Marginal costs are on average lower by about $126 in DL and AF carve-out markets relative to their non-carve-out markets. In the case of UA and AC carve-out markets, marginal costs are not statistically different in their designated carve-out markets compared to their non-carve-out markets, all else constant.

The results also shed light on the marginal costs of products offered by these respective partner carriers relative to the marginal costs of products offered by other carriers in non-carve-out markets. The coefficient estimate for *AA/LA_product* is positive and statistically significant. All else constant, this implies that marginal costs for products offered by these partner carriers are higher on average than other products offered by other competitors in non-carve-out markets by approximately $132. In the case of DL and AF, the results suggest that the marginal costs of their products are not statistically different than products offered by other carriers in these partners' non-carve-out markets. This is a surprising result as one may expect that full cooperation between carriers may generate cost efficiencies for the partner carriers such that they achieve lower costs than their competitors. However, the data yield the expected cost effects associated with cooperation in case of the UA and AC partnership. All else constant, the relevant coefficient estimate suggests that UA and AC products have lower marginal costs relative to competitors' products in non-carve-out markets by about $152.

Comparing the results of how partner carriers' products marginal costs differ in their carve-out versus non-carve-out markets sheds some light on the effects of a carve-out. In the case of AA and LA, the coefficient estimates for *AA/LA_product_co* is positive. Therefore, all else constant, the data implies AA and LA products have relatively higher marginal costs on average in their carve-out markets by approximately $536. Consistent with a theoretical possibility argued in Brueckner and Proost (2010), the marginal cost results for the AA/LA ATI partnership suggest that the carve-out policy could be preventing a level of cooperation between the partner carriers that is required to generate cost efficiencies. On the other hand, the coefficient on *UA/AC_product_co* is negative. All else constant, the relevant coefficient estimate suggests that UA and AC products have relatively lower marginal costs on average in their carve-out markets by approximately $205. Thus, a reasonable interpretation of this result is that in spite of the carve-out policy, sufficient tacit cooperation occurred between UA and AC in their carve-out markets that allows them to take advantage of some efficiencies and achieve lower costs. The analogous estimate for DL and AF suggests relative marginal costs for their products in carve-out markets are no different than their products in non-carve-out markets. This result could be interpreted in one of two ways. First, the ATI partnership between DL and AF generated no cost efficiencies, in which case marginal costs would remain unchanged across their overlapping markets, regardless of the carve-out policy. Second, cost efficiencies could be generated through the ATI partnership; but in spite of the carve-out policy, sufficient tacit cooperation is occurring that is allowing the carriers to take advantage of some cost efficiencies.

Table 1.8 Marginal Cost Regression Estimates on Subsamples of Markets with Partner Service Overlap (OLS)

	Combined sample markets with AA/LA, DL/AF or UA/AC service overlap		Subsample markets with AA/LA service overlap		Subsample markets with DL/AF service overlap		Subsample markets with UA/AC service overlap	
Variable	Est.	Std. Error	Est.	Std. Error	Est.	Std. Error	Est.	Std. Error
Mc_opres	4.20***	(0.37)	8.53***	(1.41)	4.01***	(0.48)	3.06***	(0.55)
Mc_opres^2	-0.01***	(2.50e-3)	-0.03***	(0.01)	-0.01***	(3.03e-3)	-0.01**	(4.66e-3)
Nonstop_going	61.57***	(14.73)	124.24*	(66.23)	53.46***	(19.01)	52.79**	(21.65)
Nonstop_coming	100.37***	(14.97)	104.86	(66.65)	105.63***	(19.46)	89.18***	(22.32)
Itinerary_dist_going	0.01	(0.02)	-3.32e-4	(0.04)	-0.01	(0.02)	0.01	(0.04)
Itinerary_dist_coming	0.07***	(0.02)	0.05	(0.04)	0.04**	(0.02)	0.12**	(0.05)
Trad_1_going	31.41**	(13.40)	116.29**	(51.34)	18.98	(16.73)	52.65***	(17.57)
Trad_2_going	-0.52	(57.51)	65.19	(111.00)	-7.74	(63.92)	19.50	(132.91)
Trad_1_coming	49.74***	(12.51)	-7.75	(51.72)	63.59***	(15.34)	4.29	(15.31)
Trad_2_coming	99.82*	(53.87)	40.35	(138.19)	89.97	(62.09)	205.90*	(122.38)
Virtual_going	9.00	(17.02)	-16.82	(61.45)	18.01	(22.12)	7.16	(20.49)
Virtual_coming	91.01***	(17.24)	16.29	(62.38)	115.89***	(22.42)	37.26*	(20.50)
AA/LA_market_co	-348.51**	(140.26)	-291.67**	(140.32)	-	-	-	-
AA/LA_product	132.59***	(31.19)	298.32*	(168.33)	-	-	-	-
AA/LA_product_co	522.45***	(148.96)	442.30***	(164.46)	-	-	-	-
DL/AF_market_co	-141.71***	(43.18)	-	-	-144.76***	(43.73)	-	-
DL/AF_product	22.23	(18.06)	-	-	32.46	(27.04)	-	-
DL/AF_product_co	220.03***	(71.61)	-	-	202.91***	(71.98)	-	-
UA/AC_market_co	52.02*	(28.21)	-	-	-	-	66.18**	(31.51)
UA/AC_product	-155.29***	(21.68)	-	-	-	-	-5.09	(24.88)
UA/AC_product_co	-83.67**	(39.76)	-	-	-	-	-38.60	(38.62)
Constant	833.02***	(294.83)	-136.36	(319.69)	1,132.21	(327.13)	-155.48	(136.41)
Obs	60,971		5,356		43,329		12,331	
R^2	0.1792		0.1721		0.1242		0.2013	

*indicates significance at the 10% level, **indicates significance at the 5% level and ***indicates significance at the 1% level.
Quarter, year, operating carrier, origin and destination fixed effects are included.

Table 1.9 Marginal Cost Regression Estimates on Subsamples of Markets with Partner Service Overlap (Two-stage IV)

	Combined sample markets with AA/LA, DL/AF or UA/AC service overlap		Subsample markets with AA/LA service overlap		Subsample markets with DL/AF service overlap		Subsample markets with UA/AC service overlap	
Variable	Est.	Std. Error	Est.	Std. Error	Est.	Std. Error	Est.	Std. Error
Mc_opres	4.21***	(0.37)	8.49***	(1.40)	3.97***	(0.48)	3.26***	(0.54)
Mc_opres^2	-0.01***	(2.52e-3)	-0.03***	(0.01)	-0.01***	(3.04e-3)	-0.01***	(4.55e-3)
Nonstop_going	65.87***	(14.84)	154.62**	(70.26)	55.48***	(18.94)	55.01**	(21.45)
Nonstop_coming	104.74***	(15.05)	134.15*	(69.78)	107.86***	(19.50)	91.42***	(22.18)
Itinerary_dist_going	0.01	(0.02)	2.87e-3	(0.04)	-0.01	(0.02)	0.01	(0.04)
Itinerary_dist_coming	0.07***	(0.02)	0.05	(0.04)	0.04**	(0.02)	0.12**	(0.05)
Trad_1_going	31.75**	(13.35)	112.58**	(50.60)	19.57	(16.67)	52.26***	(17.47)
Trad_2_going	0.20	(57.31)	62.62	(110.28)	-7.35	(63.66)	20.18	(132.05)
Trad_1_coming	49.72***	(12.49)	-15.66	(52.19)	64.04***	(15.27)	4.61	(15.19)
Trad_2_coming	99.29*	(53.70)	45.67	(137.45)	90.13	(61.85)	205.88*	(121.45)
Virtual_going	9.78	(17.00)	-8.35	(61.72)	18.19	(22.04)	5.98	(20.38)
Virtual_coming	91.51***	(17.20)	21.24	(61.86)	116.11***	(22.34)	37.45*	(20.37)
AA/LA_market_co	-572.83***	(186.88)	-505.16***	(192.25)	-	-	-	-
AA/LA_product	131.88***	(31.40)	304.10*	(167.14)	-	-	-	-
AA/LA_product_co	536.23***	(198.36)	407.29	(250.69)	-	-	-	-
DL/AF_market_co	-126.12**	(60.50)	-	-	-115.85*	(61.50)	-	-
DL/AF_product	22.37	(18.02)	-	-	31.83	(26.94)	-	-
DL/AF_product_co	146.40	(92.27)	-	-	127.46	(93.28)	-	-
UA/AC_market_co	53.50	(46.31)	-	-	-	-	156.28***	(52.44)
UA/AC_product	-151.55***	(21.97)	-	-	-	-	-6.00	(24.93)
UA/AC_product_co	-205.14***	(62.61)	-	-	-	-	-144.90**	(58.71)
Constant	821.54***	(293.61)	-200.92	(322.60)	1,129.10***	(325.85)	-152.94	(135.57)
Obs	60,971		5,356		43,329		12,331	
R^2	0.1791		0.1709		0.1242		0.2009	
Wu-Hausman (χ^2)	14.978**		4.475		1.892		9.633***	

*indicates significance at the 10% level, **indicates significance at the 5% level and ***indicates significance at the 1% level.
Quarter, year, operating carrier, origin and destination fixed effects are included.

Inferences from Reduced-form Price Equation Estimation

One important facet regulators may be concerned with is the ultimate effect of granting ATI on price for consumers. In light of this, we estimate a reduced-form price regression using the following specification:

$$price_{jmt} = \beta^{p} z_{jmt} + \eta_1 AA/LA\_market\_co_{mt} + \eta_2 AA/LA\_product_{jmt} + \eta_3 AA/LA\_product\_co_{jmt} + \varepsilon_{jmt}^{price}, \quad (16)$$

where z_{jmt} is a vector consisting of the subsequent list of variables: a constant, *Mc_opres*, *Mc_opres*^{2}, *Nonstop_going*, *Nonstop_coming*, *Route_qual_going*, *Route_qual_coming*, *Itinerary_dist_going*, *Itinerary_dist_coming*, *Close_comp_going*, *Close_comp_coming*, *Trad_1_going*, *Trad_1_coming*, *Trad_2_going*, *Trad_2_coming*, *Virtual_going* and *Virtual_coming*. As with estimations of the markup and marginal cost equations, similar price equation regression models are estimated within each of the other three subsamples. Concerns over the endogeneity of *AA/LA_market_co*, *DL/AF_market_co* and *UA/AC_market_co* are still present in the reduced-form price equation specification; thus, we again implement the Two-stage IV estimator, where the first-stage regression equation is the previously discussed equation (14). The Two-stage IV results are reported in Table 1.11, but for comparison we report the OLS results in Table 1.10.

The Wu-Hausman test results indicate that we can reject the null hypothesis that the variables are exogenous in two of the four subsamples. Given the evidence that the variables of interest may be endogenous, the discussion focuses on the Two-stage IV. Much of the subsequent discussion focuses on results from the combined subsample as these qualitative results when compared to the smaller subsamples are quite consistent.

First, consider the coefficient estimates on *Mc_opres* and *Mc_opres*^{2}. These estimates indicate that the greater the origin presence of an airline, the higher the price it will charge, but the price impact of an airline's origin presence occurs at a diminishing rate, all else constant. This particular result is suggestive of the presence of economies of passenger-traffic density that we also found in estimations of the marginal cost functions previously discussed.

Estimates of the coefficients for nonstop products are positive, indicating that, all else constant, prices are higher on nonstop products versus products with intermediate stops. This follows from the empirically supported idea that consumers view intermediate stops as travel-inconveniences, which allows carriers to put a higher markup on their nonstop products. In the spirit of consumers preferring streamlined travel, the coefficient estimate on *Route_qual_coming* is positive as expected, suggesting that the greater the routing quality on the coming portion of the itinerary, the higher the price will be, all else constant. However, coefficient estimates for *Route_qual_going* in all the subsamples are not statistically significant.

The coefficient estimates regarding itinerary distance for the coming portion of the itinerary indicate that, the greater the flying distance of the product, the greater the price, all else constant. In the combined sample, the coefficient estimates for *Close_comp_coming* is positive, suggesting that a product's price is positively related to the number of competing products with equivalent number of intermediate stops to the product in question. However, results are mixed across the subsamples regarding the price impact of *Close_comp*_going and *Close_comp_coming*. For instance, in the AA/LA subsample the coefficient estimate on *Close_comp_going* is positive, but negative for *Close_comp_coming*.

Contrary to findings by Ito and Lee (2007) on price effects of virtual codesharing in domestic air travel markets, we find that in international air travel markets virtually codeshared products have higher prices relative to pure online products, at least for the coming portion of the itinerary, all else constant. Our previous estimation results on the markup and marginal cost comparisons of virtual codeshare and pure online products suggest that the higher price we now find for virtual codeshare product features is driven by higher marginal cost of virtual codeshare product features.

The coefficient estimates concerning type 1 traditionally codeshared products are positive and significant. Thus, there is evidence that all else constant, prices for type 1 traditionally codeshared products have higher prices than pure online products. This follows from our previous findings that traditional codeshare products tend to have larger markup and marginal cost compared to pure online products. Similar evidence is also present with respect to type 2 traditionally codeshared products.

Turning attention to the variables of interest, the coefficient estimates for variables *AA/LA_market_co* and *DL/AF_market_co* are each negative. Products in the designated carve-out markets for AA and LA on average have prices about $536 lower than non-carve-out markets, all else constant. In the case of the designated DL and AF carve-out markets, prices are about $123 lower on average relative to non-carve-out markets. The estimated coefficient for *UA/AC_market_co* implies that prices are on average $94 higher in these partners' carve-out markets relative to their non-carve-out markets.

The coefficient estimate on *AA/LA_product* suggests that on average AA and LA product prices are higher than competitors' products in non-carve-out markets by about $136, all else constant. This result follows from the evidence that these ATI partners have higher marginal costs relative to their competitors in their non-carve-out markets. In the case of DL and AF, the analogous coefficient estimate suggests their products' prices are not statistically different than competitors' products in non-carve-out markets. In contrast, UA and AC products have lower prices relative to their competitors in non-carve-out markets by approximately $156 on average, all else constant. This UA/AC price comparison result is consistent with the evidence from our previous estimations that UA and AC products on average have lower marginal costs relative to their competitors.

In order to examine how prices of the ATI partners' products differ in their carve-out versus non-carve-out markets, we must turn to the coefficient estimates for variables *AA/LA_product_co*, *DL/AF_product_co* and *UA/AC _product_co*. First, the relative prices of AA and LA products in their carve-out markets are on average approximately $506 greater than in non-carve-out markets, all else constant. Perhaps resulting from the carve-out policy, coordination efficiencies are not realized in the ATI partners' carve-out market, thus leading to higher marginal costs. Second, the results suggest that on average the relative prices of DL and AF products are about $174 higher in their carve-out markets compared to non-carve-out markets. Based on evidence from our markup regressions that these respective ATI partners may be tacitly colluding, it is not surprising that prices for their products are relatively higher in their carve-out markets.

With regards to UA and AC, relative prices for their products are on average lower in their carve-out markets by about $193 compared to non-carve-out markets, all else constant. Although, there is some evidence that in spite of the carve-out policy, UA and AC may engage in some tacit collusion as a result of their relatively higher markups in their carve-out markets, there is also evidence that the tacit cooperation allows these carriers to achieve efficiencies in their carve-out markets. Since overall their prices are relatively lower, the latter effect appears to dominate.

Table 1.10 Price Regression Estimates on Subsamples of Markets with Partner Service Overlap (OLS)

	Combined sample markets with AA/LA, DL/AF or UA/AC service overlap		Subsample markets with AA/LA service overlap		Subsample markets with DL/AF service overlap		Subsample markets with UA/AC service overlap	
Variable	Est.	Std. Error	Est.	Std. Error	Est.	Std. Error	Est.	Std. Error
Mc_opres	4.28***	(0.37)	8.41***	(1.40)	4.09***	(0.48)	2.20***	(0.55)
Mc_opres^2	-0.01***	(2.50e-3)	-0.03***	(0.01)	-0.01***	(3.03e-3)	-0.01	(4.66e-3)
Nonstop_going	61.06***	(16.81)	195.35**	(77.86)	55.70***	(21.15)	28.64	(26.49)
Nonstop_coming	108.93***	(16.57)	5.86	(75.47)	120.53***	(20.81)	57.43**	(26.44)
Route_qual_going	0.19	(0.85)	-6.47	(8.68)	-1.48	(3.36)	-0.32	(1.70)
Route_qual_coming	2.59***	(0.83)	18.84*	(9.63)	11.76***	(3.52)	1.38	(1.63)
Itinerary_dist_going	-3.02e-3	(0.02)	-0.08	(0.14)	-0.04	(0.06)	-0.01	(0.08)
Itinerary_dist_coming	0.10***	(0.03)	0.30*	(0.16)	0.23***	(0.06)	0.14*	(0.08)
Close_comp_going	-0.20	(0.58)	11.31**	(5.07)	-0.44	(0.69)	-2.04**	(0.96)
Close_comp_coming	1.00*	(0.57)	-12.94***	(4.87)	1.58**	(0.67)	-2.19**	(0.96)
Trad_1_going	30.43**	(13.48)	125.97**	(51.87)	16.17	(16.86)	55.77***	(17.71)
Trad_2_going	-0.79	(57.60)	44.00	(111.15)	-9.75	(64.12)	23.35	(135.56)
Trad_1_coming	52.01***	(12.66)	-12.98	(51.72)	65.36***	(15.54)	8.41	(15.41)
Trad_2_coming	99.57*	(53.92)	53.85	(131.94)	91.42	(62.24)	219.14*	(123.19)
Virtual_going	5.09	(17.02)	-24.08	(61.56)	11.30	(22.14)	13.07	(20.42)
Virtual_coming	88.18***	(17.26)	21.35	(62.20)	113.08***	(22.46)	40.92*	(20.45)
AA/LA_market_co	-343.25**	(140.74)	-315.02**	(141.04)	-	-	-	-
AA/LA_product	136.63***	(31.22)	272.80	(169.04)	-	-	-	-
AA/LA_product_co	495.30***	(149.61)	426.67***	(165.94)	-	-	-	-
DL/AF_market_co	-140.92***	(43.21)	-	-	-147.74***	(43.80)	-	-
DL/AF_product	23.26	(18.09)	-	-	30.08	(27.05)	-	-
DL/AF_product_co	233.72***	(71.61)	-	-	213.21***	(71.93)	-	-
UA/AC_market_co	17.40	(28.74)	-	-	-	-	95.94***	(34.67)
UA/AC_product	-158.67***	(22.08)	-	-	-	-	-8.64	(24.94)
UA/AC_product_co	-63.82	(40.43)	-	-	-	-	-85.16**	(40.05)
Constant	849.62***	(299.63)	-1,818.22*	(1,065.30)	-759.40	(664.40)	231.78	(146.35)
Obs	60,971		5,356		43,329		12,331	
R^2	0.1801		0.1751		0.1253		0.2090	

*indicates significance at the 10% level, **indicates significance at the 5% level and ***indicates significance at the 1% level.
Quarter, year, operating carrier, origin and destination fixed effects are included.

Table 1.11 Price Regression Estimates on Subsamples of Markets with Partner Service Overlap (Two-stage IV)

Variable	Combined sample markets with AA/LA, DL/AF or UA/AC service overlap		Subsample markets with AA/LA service overlap		Subsample markets with DL/AF service overlap		Subsample markets with UA/AC service overlap	
	Est.	Std. Error	Est.	Std. Error	Est.	Std. Error	Est.	Std. Error
Mc_opres	4.28***	(0.37)	8.35***	(1.38)	4.06***	(0.48)	2.30***	(0.55)
Mc_opres^2	-0.01***	(2.52e-3)	-0.03***	(0.01)	-0.01***	(3.04e-3)	-0.01	(4.56e-3)
Nonstop_going	64.11***	(16.92)	221.86***	(81.87)	57.20***	(21.07)	29.29	(26.28)
Nonstop_coming	111.97***	(16.62)	30.06	(77.05)	122.20***	(20.80)	58.30**	(26.23)
Route_qual_going	0.22	(0.85)	-5.27	(8.68)	-1.43	(3.35)	-0.33	(1.69)
Route_qual_coming	2.57***	(0.83)	19.36**	(9.59)	11.80***	(3.51)	1.34	(1.62)
Itinerary_dist_going	-2.13e-3	(0.02)	-0.06	(0.14)	-0.03	(0.06)	-0.01	(0.08)
Itinerary_dist_coming	0.10***	(0.03)	0.31*	(0.16)	0.23***	(0.06)	0.14*	(0.08)
Close_comp_going	-0.24	(0.58)	11.53**	(5.07)	-0.46	(0.68)	-2.14**	(0.95)
Close_comp_coming	0.96*	(0.57)	-13.13***	(4.84)	1.56**	(0.67)	-2.27**	(0.95)
Trad_1_going	30.57**	(13.43)	122.10**	(51.05)	16.65	(16.80)	55.72***	(17.60)
Trad_2_going	-0.30	(57.40)	40.88	(110.41)	-9.41	(63.86)	24.20	(134.62)
Trad_1_coming	51.86***	(12.63)	-20.34	(52.24)	65.73***	(15.47)	8.78	(15.30)
Trad_2_coming	99.48*	(53.75)	55.91	(131.02)	91.57	(62.00)	220.25*	(122.35)
Virtual_going	5.74	(16.99)	-16.99	(61.57)	11.49	(22.06)	12.51	(20.28)
Virtual_coming	88.80***	(17.21)	25.57	(61.64)	113.29***	(22.38)	41.45**	(20.31)
AA/LA_market_co	-535.94***	(185.50)	-525.62***	(197.17)	-	-	-	-
AA/LA_product	135.87***	(31.43)	273.66	(167.64)	-	-	-	-
AA/LA_product_co	506.47**	(198.02)	406.82	(258.76)	-	-	-	-
DL/AF_market_co	-122.58**	(60.57)	-	-	-121.54**	(61.75)	-	-
DL/AF_product	22.91	(18.06)	-	-	29.46	(26.95)	-	-
DL/AF_product_co	173.56*	(92.23)	-	-	147.31	(93.19)	-	-
UA/AC_market_co	94.12**	(45.80)	-	-	-	-	168.26***	(51.28)
UA/AC_product	-156.40***	(22.34)	-	-	-	-	-9.30	(24.91)
UA/AC_product_co	-192.52***	(63.26)	-	-	-	-	-163.17***	(59.13)
Constant	839.91***	(298.05)	-2,178.15**	(1,099.04)	-780.76	(663.98)	242.08*	(145.92)
Obs	60,971		5,356		43,329		12,331	
R^2	0.1799		0.1740		0.1253		0.2088	
Wu-Hausman (χ^2)	12.047*		4.076		1.422		6.031**	

*indicates significance at the 10% level, **indicates significance at the 5% level and ***indicates significance at the 1% level.

[1] Quarter, year, operating carrier, origin and destination fixed effects are included.

1.7 Conclusion

The primary goal of this paper is to empirically determine the effects that a carve-out has on markups, costs and prices for carriers that have been granted ATI. Upon first estimating a differentiated products demand model, then specifying a Nash price-setting game between airlines that offer these differentiated products, we were able to compute product markups and recover marginal costs. Furthermore, the structural model allows us to compute markups and recover marginal costs under two alternative scenarios: (1) where we assume the carriers that are given ATI cooperate in all markets; and (2) where we assume the carriers cooperate in all markets except the carve-out markets, as required by a carve-out policy. We then perform a non-nested likelihood ratio test to identify which assumed price-setting behavior has better statistical support from systematic patterns in the data. In the combined subsamples of the American (AA)/LAN-Chile (LA), Delta (DL)/Air France (AF) and United (UA)/Air Canada (AC) ATI pairings, the non-nested test result suggests that the model in which these partner carriers jointly set their product prices in all markets, including the carve-out markets, has better statistical support from systematic patterns in the data. Thus, suggesting that there may be some tacit cooperation occurring between the ATI partners in the carve-out markets.

To further investigate this result we examine how markups, marginal costs and prices differ for the respective ATI partners in their carve-out versus non-carve-out markets. Results from the markup equation estimations suggest that for DL and AF, as well as UA and AC, these partner carriers' products have relatively higher markups in their respective carve-out markets compared to their non-carve-out markets. Furthermore, in the case of AA and LA, these ATI partners are marking up their products in their carve-out markets in the same manner as their non-carve-out markets. Together, these results provide strong supporting evidence that some tacit collusion is occurring in spite of the carve-out policy.

Results from the marginal cost equation estimations suggest that, in the case of the AA/LA ATI pairings, the efficiencies of cooperation are not being realized in their respective carve-out markets. These carriers are apparently tacitly colluding, but not realizing efficiencies of cooperation, each of which serve to raise prices for consumers. For the AA/LA ATI pairing, their product prices relative to competitors' prices are on average $506 higher in their carve-out market versus their non-carve-out markets. DL and AF product prices relative to competitors' prices are on average $174 higher between their carve-out and non-carve-out markets. However, in the case of the UA/AC ATI pairing, we find evidence suggesting that tacit collusion between these partner carriers is apparently sufficient for them to achieve some cost efficiencies in their carve-out markets. Furthermore, the cost efficiencies are apparently sufficiently large to result in lower relative prices on average for UA and AC products in their carve-out markets by approximately $193 on average.

In summary, the findings in this research, at a minimum, call into question whether consumers benefited from the use of the carve-out policy in the cases studied. As such, this paper highlights the need for further research to better understand the efficacy of applying carve-out policy.

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Chapter 2 - Product Quality Effects of International Airline Alliances and Antitrust Immunity

2.1 Introduction

The international airline industry has undergone dramatic changes since the early 1990s. There has been a tendency toward increased cooperation among airlines that provide international air travel. This increase in cooperation may in part be due to regulations restricting the ability of carriers to operate flights to various locations in a foreign country beyond the primary airport in the foreign country that the carrier uses to facilitate international air travel. Cooperation between carriers that are based in different countries effectively allows each carrier greater access to potential passengers in locations of a foreign country that the carrier is not permitted to operate its own flights. In other words, each carrier in the partnership is able to leverage its foreign partner's local route network in the foreign country to better access passengers there.

Much of the existing literature on airline cooperation focuses on the price effects of cooperation, and often infer welfare effects from these price effects. However, it is well-known in economics that, all else equal, consumer welfare is positively related to product quality. The purpose of this paper is to better understand how international cooperation among carriers affects the quality of the cooperating carriers' air travel products. Understanding the product quality effects is important for a complete welfare evaluation of airline cooperation.

International cooperation among carriers can take various forms. Two common types of cooperation involve international alliances and antitrust immunity (ATI). These two forms of cooperation differ in the extent of cooperation. For instance, international airline alliances allow the carriers in the alliance to codeshare flights. Codesharing allows a carrier to sell tickets for seats on its partner carriers' planes. Consumers can benefit from an alliance since carriers in the alliance may coordinate flight schedules in an attempt to decrease layover times, check baggage through to the final destination, share frequent flier programs and decrease the distance between the carriers' gates at airports. These features of alliances serve to increase the convenience of international travel for consumers. These travel conveniences are especially important to passengers traveling internationally because international air travel, as compared to domestic air travel, is more likely to require that passengers switch operating carriers at some point on their journey. In these cases, the products offered by each of the operating carriers are complementary.

The three international alliances are Star, Skyteam and Oneworld. Subsets of carriers within these alliances do have ATI. ATI permits more extensive cooperation in which carriers can cooperate on setting fares and capacity in addition to the types of cooperation that can occur without ATI.

An extensive amount of research has been conducted regarding cooperation among carriers in international air travel markets. As we remarked above, this literature focuses on the effects of cooperation on prices. For instance, Brueckner (2001) presents a theoretical model that explains what may happen to fares and welfare when cooperation among international carriers occurs. The results suggest that fares will decrease and passenger traffic may increase in interline markets. Interline markets are markets in which the domestic and foreign carriers' products are complements, thus requiring passengers to switch from one carrier to the next during the trip. However, in interhub markets (markets in which the carriers offer substitute service), cooperation can have an anticompetitive effect serving to increase fares and decrease passenger traffic. The literature also points out that cooperation may induce some cost efficiencies that serve to lower fares.[13] Numerous empirical studies support the theory regarding cooperation on prices, suggesting that cooperation in the form codesharing, alliance participation, and ATI, benefit passengers in the form of lower fares.[14]

Although there is extensive literature examining the price effects of international airline cooperation, there is little research regarding the effects on air travel product quality. Research regarding air travel product quality has focused on the relationship between competition and the carriers' on-time performance.[15] Furthermore, the existing studies that explore determinants of air travel product quality focus on domestic air travel markets. Thus, the primary contribution of this study is to examine the relationship between international airline cooperation and a carrier's

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[13] Theoretical papers examining the effects of cooperation include, but are not limited to: Bilotkach (2005), Chen and Gayle (2007), Hassin and Shy (2004) and Park (1997).

[14] Empirical papers examining the effects of cooperation include, but are not limited to: Brueckner and Whalen (2000) Brueckner (2003), Brueckner et al. (2011), Flores-Fillol and Moner-Colonques (2007), Park and Zhang (2000) and Oum et al. (1996).

[15] See Mazzeo (2003), Rupp et al. (2006) and Prince and Simon (2010).

product quality. The definition of quality used is directly related to the travel convenience of the product in terms of the directness of the product's itinerary routing (measured by distance flown) between the passengers' origin and destination. This quality measure is termed routing quality [Chen and Gayle (2014)], and is calculated as the minimum flying distance between an origin/destination, divided by the actual distance flown by passengers using a specific itinerary routing between the origin and destination. As the distance flown by a passenger to reach their destination increases relative to the minimum distance, the lower is the routing quality of the product. The reasonable assumption is that, all else equal, passengers prefer the most direct routing to get to their destination.

Cooperation between carriers may require each to rearrange parts of their route network to facilitate network integration. Rearrangement of networks can result in new product offerings and impact the average routing quality of the set of products offered by each carrier in the alliance. Since a given carrier typically needs to accommodate multiple alliance partners, it is not clear a priori that such multi-dimensional network integration necessarily results in a given carrier offering products of higher routing quality. However, to persuade regulatory authorities to approve formation of the alliance, which is required before the alliance can be implemented, carriers typically make arguments suggesting that the alliance will result in their products having better routing quality. Similar arguments are often made to convince regulatory authorities to grant the carriers ATI.

For instance, in a joint application to the U.S. Department of Transportation (DOT) for ATI in 2007 involving Delta Airlines, Northwest Airlines and four European carriers, the carriers make the claim that 1,466 city-pair combinations will be upgraded to one-stop service and 4,071 city-pair combinations will be upgraded to two-stop service. [16] Additionally, after the approval of this ATI application in 2008, Delta Airlines added nonstop service from Newark, Portland, Minneapolis/St. Paul, Seattle and Memphis among other origins to Amsterdam. Similarly, when an ATI agreement between American Airlines and SN Brussels Airlines ceased in 2009, American Airlines then stopped offering nonstop flights from Los Angeles to Brussels. Although, when SN Brussels was granted ATI with United Airlines in 2009, United Airlines

[16] See U.S. Department of Transportation docket: Joint Application for Approval of and Antitrust Immunity for Alliance Agreements (Public Version), DOT-OST-2007-28644-0001-0001.

added nonstop service between Los Angeles and Brussels. Note that SN Brussels was granted ATI with United Airlines shortly prior to joining the Star alliance with United Airlines. These are just a handful of examples. However, it is clear that cooperation can induce changes in flight offerings.

Using rigorous econometric analysis this study seeks to be the first to formally establish and document systematic evidence of the relationship between routing quality and international airline cooperation. We estimate reduced-form regression equations that use a difference-in-differences strategy to identify the relationship of interest. The data sample focuses on products offered by the three carriers: United Airlines, Delta Airlines and American Airlines. Each of these carriers is a founding member of their respective alliance and their participation in the alliance has not wavered over time. Furthermore, any ATI agreement between a U.S. carrier and foreign carrier involves one of these carriers.

The results provide strong evidence that cooperation among international carriers is associated with an increase in a carrier's routing quality on average. This is a result that is consistent for alliance membership and ATI among each of the three carriers examined. Moreover, the results indicate that an increase in alliance membership is associated with relative routing quality increases for online, traditional codeshare and virtual codeshare products offered by the carriers.[17] In each case, the greatest relative routing quality increase shows up in the virtual codeshare products offered by the carriers. The results regarding the routing quality effects of ATI on codeshare products are mixed. However, a consistent result for each of these carriers suggests that an increase in the number of the carrier's ATI partners increases the relative routing quality of the carrier's online products.

This paper proceeds as follows. Section 2.2 provides a brief background history of each of the three major international alliance and ATI with U.S. carriers, defines key concepts, as well as a discussion of the data used in the analysis. Section 2.3 provides a description of the methodology used, while Section 2.4 discusses the empirical results. Section 2.5 concludes the paper.

[17] In the following section of the paper we define and distinguish between these three types of air travel products.

2.2 Background Information, Key Definitions, and Data

Background Information on Alliance and ATI

The landscape in the international airline industry has undergone rapid changes over the past 20 years. There are currently three major international alliances: Star, Oneworld and SkyTeam. The first of these alliances to be founded was the Star alliance in 1997. There were five original members which included United Airlines. As of the first quarter of 2005, the alliance had grown to include 18 official members and by the third quarter of 2011 the alliance included 26 official members. The star alliance is the largest international alliance in terms of the number of members. Table B.1 in the appendix provides a detailed description of how alliance membership for each alliance has changed since each of their inceptions. Figure 2.1 provides a time plot detailing how the size of the alliances has changed from the first quarter of 2005 through the third quarter of 2011.

The next alliance formed was Oneworld in 1999. There were five founding members including American Airlines. The Oneworld alliance has grown to include 11 members as of the third quarter of 2011. SkyTeam was also created in 1999 by Delta Airlines along with three international members. In 2004, Continental Airlines and Northwest Airlines joined the SkyTeam alliance. Continental Airlines was a member of the SkyTeam alliance for five years, before leaving and joining the Star alliance, eventually merging with United Airlines in the second quarter of 2010. Delta Airlines and Northwest Airlines announced their plan to merge in April 2008, but their ground operations and reservations systems were not combined until January 31, 2010. From 2005 through the third quarter of 2011, the SkyTeam alliance grew from 9 official members to 15 official members.

Figure 2.1 Total Number of Carriers in Three International Alliances by Time

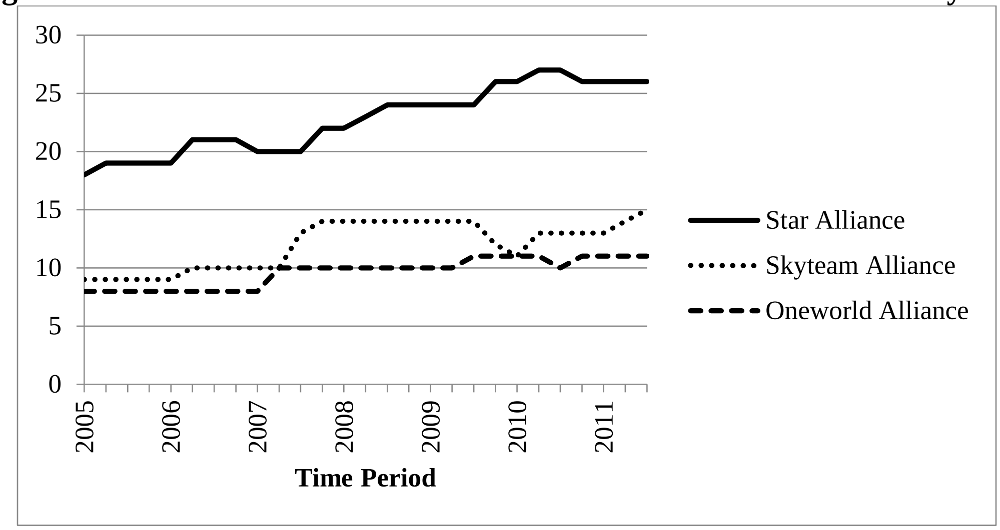
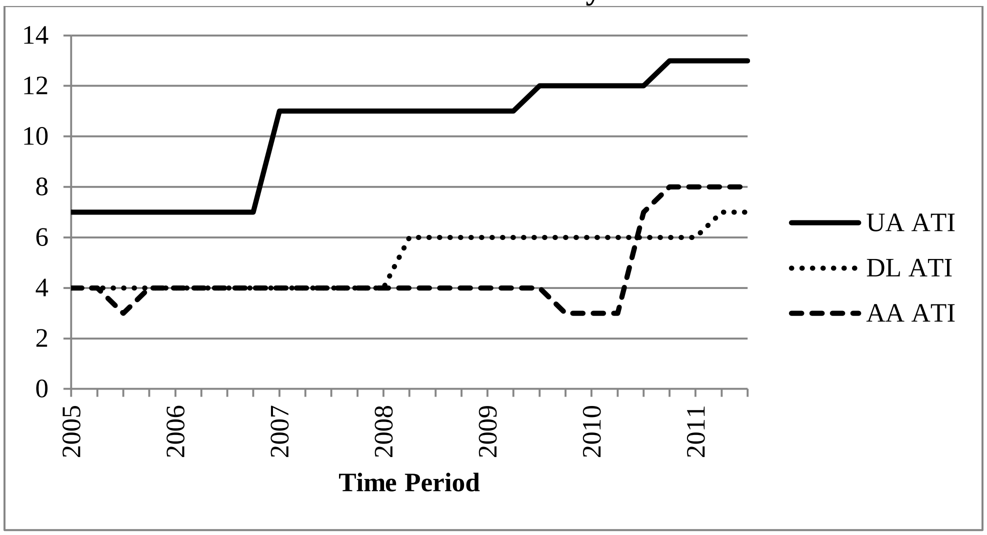


Table B.2 in the appendix gives a chronological history of the DOT's granting of ATI to U.S. carriers. One important aspect to note is the trend in ATI decisions by the DOT. Most ATI rulings in the 1990s consisted of an ATI agreement between only two carriers. However, recently many of these agreements have been extended to include multiple carriers.

The DOT's first ATI approval came in 1993 to Northwest and KLM ATI. In 1996 the DOT granted ATI to Delta and three foreign carriers: Austrian Airlines, Sabena and Swissair. Also in 1996, the DOT granted ATI to United Airlines and Lufthansa. American Airlines was first given ATI with Canadian Airlines in 1996 as well. As of the first quarter of 2005, United Airlines had 7 ATI partners while Delta Airlines and American Airlines each had 4 ATI partners. Through the third quarter of 2011; however, United Airlines had ATI agreements with 13 carriers, Delta Airlines had ATI agreements with 7 carriers and American Airlines had ATI agreements with 8 carriers. Figure 2.2 illustrates how the number of ATI partners has evolved over this time span.

Figure 2.2 Total Number of ATI Partners with United Airlines, Delta Airlines and American Airlines by Time



This study focuses on the three carriers (United Airlines, Delta Airlines and American Airlines) based on their involvement in their respective alliance and their ATI agreements. Each of the three carriers is a founding member of their respective alliance and their participation in the alliance has not changed since their alliances were formed. However, over time other carriers have entered/exited the alliance. Furthermore, each of the aforementioned carriers are the only U.S. carriers to have multiple ATI agreements and the number of ATI partners for each of these carriers has changed over time.

Key Definitions

Before describing the variables used in the analysis, it is worth defining a few key concepts. First, a market is defined as an origin, destination and time period combination. For example, Chicago to Paris in the first quarter of 2005 is a different market than Chicago to Paris in the second quarter of 2005. Furthermore, there is a set of products offered by a carrier or carriers in each market. A product is defined by the unique combination of ticketing carrier, operating carrier(s), origin airport, destination airport, sequence of intermediate stop airport(s) and time period. The ticketing carrier is the carrier from which a passenger bought the travel ticket for the itinerary, while the operating carrier(s) are the carrier(s) that physically transport the passenger between the origin and destination. Our analysis focuses on products with a single ticketing carrier.

Products in which the ticketing carrier is the same as the operating carrier on each trip segment are defined as online products. For example, a product that is ticketed by United Airlines and United Airlines is the sole operating carrier is an online product. However, in some cases the ticketing carrier and operating carrier of a product may differ. Products that have multiple operating carriers are defined as traditional codeshare products. Thus, a consumer travelling on an itinerary that is traditional codeshared is switching carriers at some point along their trip. For instance, a product ticketed by United Airlines with one intermediate stop where United Airlines operates the first segment and Air Canada operates the second segment is a traditional codeshare product. A product that has a single operating carrier that is different from the ticketing carrier is defined as a virtual codeshare product. Thus, a product in which United Airlines is the ticketing carrier, but Air Canada is the sole operating carrier is a virtual codeshare product.

Data and Sample Selection

This study is performed using quarterly data from the International Passenger Origin and Destination Survey obtained from the U.S. Department of Transportation. This data is a 10% sample of all itineraries involving an international flight segment, where at least one segment is operated by a U.S. carrier. The time period examined in this study spans from the first quarter of 2005 through the third quarter of 2011. Each observation in the dataset is an itinerary containing information regarding the prices, origin airport, intermediate stop airports, destination airport, distance between each airport, operating carrier for each coupon segment, ticketing carrier for each coupon segment, and the number of passengers that purchased the itinerary at a particular price. One key characteristic of this dataset is that it contains information for each direction of travel (going and returning/coming) on the itinerary. Thus, there is information regarding the going portion of the itinerary (origin to destination) and the coming portion of the itinerary (destination back to origin) for roundtrip itineraries.

In order to properly study the effects of international airline alliance and ATI participation on product quality, the data are restricted to itineraries that meet specific criteria.

First, only roundtrip itineraries are used in the analysis. Additionally, itineraries in which there are multiple ticketing carriers are excluded. Itineraries in which the origin airport, destination airport or one of the intermediate airport stops occur more than once for the going portion or coming portion of the itinerary are also excluded. Finally, only itineraries with a price within the range of $100 to $10,000 are examined. The number of itineraries within each quarter of the dataset is extremely large and repeated multiple times. Therefore, repeated itineraries are collapsed into uniquely defined products for each quarter. Thus, each observation in the dataset represents a particular product. The final sample consists of 2,057,144 observations/products spread across 541,978 markets.

In this study we focus on each product's quality of routing between the origin and destination, and we measure routing quality using distance travelled on an itinerary. Given that information is available for the going and coming portion of an itinerary, one can separately measure the routing quality for the going and coming portions of the itinerary. *Routing_quality_going* is calculated as minimum flying distance between the origin/destination (*Mindist_going*) divided by the actual itinerary flying distance for the going portion of the itinerary. Actual flying distance may differ across products due to differences in intermediate stop(s) locations across products. *Routing_quality_coming* is similarly calculated for the coming portion of the itinerary. *Mindist_going* (*Mindist_coming*) is calculated as the minimum distance on the going (coming) portion of a product in a given market.[18] Both routing quality variables are measured in terms of percentage. The highest routing quality product in each market has a measure of 100. Therefore, the routing quality of each product is measured relative to the highest quality product in the market. We also construct a variable, *Routing_quality*, that assigns a unique routing quality value to each product. *Routing_quality* is the mean of *Routing_quality_going* and *Routing_quality_coming*.

Other variables used in the study include a measure of an airline's origin airport presence, *Opres*. *Opres* is calculated as the number of destination airports that a ticketing carrier offers nonstop service to leaving from a given origin airport. *N_comp_nonstop_going*

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[18] It is important to note that the minimum flying distance between the origin and destination is not always equal to the nonstop flying distance. This is because there is not always a nonstop flight available between an origin and destination. In cases where there is not a nonstop flight available, the minimum distance is calculated using the lowest itinerary distance between the origin and destination.

(*N_comp_nonstop_coming*) is defined as the total number of products in a market that do not require an intermediate stop on the going (coming) portion of the itinerary, and these enumerated products are offered by ticketing carriers that are competing with the ticketing carrier of the product for which *N_comp_nonstop_going* (*N_comp_nonstop_coming*) is computed. Analogously, *N_comp_interstop_going* (*N_comp_interstop_coming*) is defined as the total number of products in a market that require an intermediate stop on the going (coming) portion of the itinerary, and these enumerated products are offered by ticketing carriers that are competing with the ticketing carrier of the product for which *N_comp_interstop_going* (*N_comp_interstop_coming*) is computed.

Other key variables in the analysis include codeshare variables. In order to create the codeshare variables regional carriers must be accounted for. Specifically, to facilitate accurate construction of codeshare variables, we make the reasonable assumption that regional carriers operate for a major carrier. For instance, consider the US domestic regional carrier SkyWest Airlines (OO). The assumption is made that SkyWest Airlines is operating a coupon segment for the US major ticketing carrier that often transport passengers internationally. Therefore, in the sample the ticketing carrier/operating carrier combination, UA/OO, would be transformed to UA/UA and classified as online. This procedure ensures that when an itinerary is classified as having codeshare features, this codesharing is between major carriers, and therefore consistent with the focus of much of the literature on airline codesharing.

Two types of codeshare variables are defined: traditional and virtual. *Traditional_going* (*Traditional_coming*) is a zero-one dummy variable that takes the value one only if there are multiple carriers that operate respective coupon segments on the going (coming) portion of the itinerary. *Virtual_going* (*Virtual_coming*) is a zero-one dummy variable that takes the value one only if there is one carrier that operates each coupon segment on the going (coming) portion of the itinerary, but the sole operating carrier is different than the ticketing carrier.

Dummy variables are created to indicate whether a product is a United Airlines, Delta Airlines or American Airlines product. *UA* is a dummy variable equal to one if United Airlines is the ticketing carrier and zero otherwise. *DL* and *AA* are analogously defined dummy variables for Delta Airlines and American Airlines, respectively.

Star is a variable indicating the total number of carriers in the Star alliance other than United Airlines for each quarter. In the event that a carrier enters the alliance in a particular quarter, the number of carriers in the alliance increases for that quarter. Similarly, if a carrier exits the alliance in a particular quarter, the number of carriers in the alliance decreases for that quarter. ATI^{UA} is defined as the total number of carriers in each quarter that have ATI agreement with United Airlines. *Skyteam* and ATI^{DL} are analogously defined variables for the Skyteam alliance and ATI agreements that include Delta Airlines. Additionally, *Oneworld* and ATI^{AA} are analogously defined variables for the Oneworld alliance and ATI agreements that include American Airlines.

Table 2.1 reports summary statistics on each of the variables. The summary statistics in Table 1 for the going portion of all itineraries in the sample indicate that approximately 17% of the products in the sample are traditionally codeshared, and about 2% are virtually codeshared. Therefore, approximately 81% are online products. These statistics are similar when examining the coming portion of itineraries.

The summary statistics in Table 2.1 show that approximately 17% of the products in the sample are United Airlines products, 24% are Delta Airlines products and 18% are American Airlines products. Furthermore, Table 2.2 gives a breakdown of the types of products offered by the three carriers. Table 2.2 indicates that about 23% of United Airlines products are traditionally codeshared and 5% are virtually codeshared. A much larger portion of United Airlines products is codeshared when comparing to Delta Airlines and American Airlines. This could be due to the fact that United Airlines is a member of the largest international alliance and has the most ATI partners. Only about 1% of Delta Airlines' products are virtually codeshared and less than 1% of American Airlines' products are virtually codeshared.

Table 2.1 Descriptive Statistics

(2005Q1 - 2011Q3)				
Variable	Mean	Std. Dev.	Min	Max
Routing_quality_going	93.90	9.29	35.71	100
Routing_quality_coming	93.82	9.38	28.28	100
Routing_quality	93.86	8.62	36.72	100
Opres	26.74	41.14	0	265
Mindist_going	3776.98	2433.80	96	14135
Mindist_coming	3776.37	2432.39	96	14421
N_comp_nonstop_going	0.09	0.81	0	46
N_comp_nonstop_coming	0.09	0.81	0	47
N_comp_interstop_going	7.29	10.94	0	137
N_comp_interstop_coming	7.32	10.94	0	138
Traditional_going	0.17	0.37	0	1
Traditional_coming	0.17	0.38	0	1
Virtual_going	0.02	0.15	0	1
Virtual_coming	0.03	0.16	0	1
UA	0.17	0.38	0	1
Star	22.14	3.18	17	27
ATI^{UA}	10.40	2.24	7	13
DL	0.24	0.43	0	1
Skyteam	11.37	2.26	8	15
ATI^{DL}	5.17	1.11	4	7
AA	0.18	0.38	0	1
Oneworld	8.68	1.22	7	10
ATI^{AA}	4.65	1.67	3	8
Observations	2,057,144			
Markets	541,978			

Table 2.2 Rate of Product Types by Carrier

	UA	DL	AA
Traditional_going	0.234	0.126	0.152
Traditional_coming	0.230	0.135	0.155
Virtual_going	0.050	0.013	0.005
Virtual_coming	0.058	0.018	0.006

2.3 Methodology

The purpose of this study is to examine the effects that involvement in international airline alliance and ATI agreements have on a carrier's product quality. Specifically, the goal is to determine how the routing quality of United Airlines', Delta Airlines' and American Airlines' products change when there is a change in alliance participation or ATI partners. The following reduced-form regression is estimated in an attempt to answer this question, where *i* indexes product, *m* indexes the origin/destination combination and *t* indexes the time period:

$$
\begin{aligned}
Routing\_quality_{imt} = \; & \beta_1 + \beta_2 X_{imt} + \beta_3 UA_{imt} + \beta_4 Star_t + \beta_5 UA_{imt} \times Star_t \\
& + \beta_6 ATI_t^{UA} + \beta_7 UA_{imt} \times ATI_t^{UA} \\
& + \beta_8 DL_{imt} + \beta_9 Skyteam_t + \beta_{10} DL_{imt} \times Skyteam_t \\
& + \beta_{11} ATI_t^{DL} + \beta_{12} DL_{imt} \times ATI_t^{DL} \\
& + \beta_{13} AA_{imt} + \beta_{14} Oneworld_t + \beta_{15} AA_{imt} \times Oneworld_t \\
& + \beta_{16} ATI_t^{AA} + \beta_{17} AA_{imt} \times ATI_t^{AA} \\
& + \alpha_i + \gamma_t + origin_m + dest_m + \varepsilon_{imt}. \qquad (1)
\end{aligned}
$$

X_{imt} is a vector of control variables that are hypothesize to influence a product's routing quality. These controls include: (1) a measure of the origin presence of the ticketing carrier, captured by variable, *Opres*; (2) the minimum distance between the origin and destination, captured by variables, *Mindist_going* and *Mindist_coming*; (3) the number of products that competes with the product in question, captured by variables, *N_comp_nonstop_going*, *N_comp_nonstop_coming*, *N_comp_interstop_going*, and *N_comp_interstop_coming* respectively. The set of variables in (3) control for the level of competition a product faces by type of competing products. Additionally, dummy variables are included in X_{imt} that indicate if the product is traditionally codeshared or virtually codeshared. Operating carrier fixed effects (α_i), year and quarter fixed effects (γ_t), origin fixed effects ($origin_m$) and destination fixed effects ($dest_m$) are included to control for their unobserved effects on a product's routing quality.

The specification in equation (1) can identify how alliance participation and ATI membership affect routing quality of a carrier's products. This is achieved through a difference-in-differences approach. *UA*, *DL* and *AA* are dummy variables indicating if the ticketing carrier is United Airlines, Delta Airlines or American Airlines, respectively. Therefore β_3, β_8 and β_{13} will illustrate how the routing quality of products offered by each of these carriers systematically differs from the routing quality of products offered by other carriers on average, all else constant. *Star*, *Skyteam* and *Oneworld* are as previously defined. Likewise, ATI^{UA}, ATI^{DL} and ATI^{AA} are as previously defined.

One of the variables of importance in this analysis that enables a difference-in-differences identification approach is the interaction variable, $UA \times Star$. The coefficient on this interaction variable, β_5, indicates how, on average, an additional member in the Star alliance affects the routing quality of United Airlines' products relative to the routing quality of non-United products, all else constant. A positive value for β_5 indicates that an additional member in the Star alliance increases the routing quality of United Airlines' products relative to non-United products, while a negative value indicates a relative decrease in routing quality of United Airlines' products. Similarly, β_7, indicates how the routing quality of United Airlines' products change on average relative to non-United products when United receives an additional ATI partner. Note that β_4 and β_6 respectively capture how an additional member in the Star alliance and an additional ATI partner for United Airlines affect the routing quality of other carriers' products on average, all else constant. The total effect of an additional Star alliance member can be calculated as $\beta_4 + \beta_5$. This total effect captures the total change in routing quality of United Airlines' products on average with an additional member in the Star alliance. Similarly, the total effect of an additional ATI partner of United can be calculated as $\beta_6 + \beta_7$. β_9, β_{10}, β_{11} and β_{12} can be interpreted similarly for Delta Airlines and the Skyteam alliance, while β_{14}, β_{15}, β_{16} and β_{17} can be interpreted similarly for American Airlines and the Oneworld alliance.

As mentioned previously, one characteristic of the International Passenger Origin and Destination Survey is that it contains information for the going and coming portions of roundtrip itineraries. The method proposed in this study is to separately examine the going and coming portions. In line with this, the reduced-form equation (1) will be estimated under three sets of information. Equation (1) will be estimated using only the information for the going portion of the itinerary, using only information for the coming portion of the itinerary, and using information from the entire itinerary.

2.4 Estimation Results

The Effects of Alliance Membership and ATI on Average Routing Quality

Table 2.3 reports parameter estimates for equation (1). Regressions are estimated using ordinary least squares (OLS). The first column in the table shows estimation results based on information from the going portion of each itinerary, estimates in the second column are based on information from the coming portion of each itinerary, and estimates in the third column are based on information from each complete itinerary. The qualitative results are quite consistent across each column of estimates. For brevity, the following discussion focuses on estimation results based on information from each complete itinerary.

The first point to be made is in regard to the constant term. The constant term of 92.94 indicates that the minimum distance between an origin and destination is on average 92.94% of the itinerary distances actually flown by passengers when all independent variables in the regression have a value of zero. Although, this mean will change as values of the independent variables change. The result regarding origin presence, *Opres*, suggests that each additional airport that a carrier offers nonstop service to leaving from the origin airport of the market increases routing quality of the carriers' products in that market by 0.02 percentage points on average. In other words, the mean distance flown by passengers decreases and becomes closer to the minimum distance between the origin and destination.

The estimates regarding *Mindist_going* and *Mindist_coming* indicate that the greater the distance between an origin and destination, the greater the routing quality for products in the market on average. For instance, the minimum distance between Chicago and Paris is 4,152 miles and the minimum distance between New York and Paris is 3,635 miles. The average routing quality of products from Chicago to Paris is about 0.29 points greater than the routing quality of products between New York and Paris (94.17% versus 93.88%).

The number of competing products a given product faces in a market also impacts the product's routing quality. A given product's routing quality tends to be higher the greater the number of competing products with nonstop service (going or coming) it faces. In contrast, a given product's routing quality tends to be lower the greater the number of competing products with interstop service (going or coming) it faces.

The results indicating the effects of codesharing also provide interesting results. A product can be online, traditionally codeshared or virtually codeshared. The results indicate that products where the going or coming portion are traditionally codeshared have lower routing quality than online products on average. Specifically, the going (coming) portion of itineraries that are traditionally codeshared have routing quality that is on average 0.37 percentage points (0.47 points) lower than routing quality of online itineraries. Perhaps this result is primarily driven by the fact that traditional codeshared products require intermediate stop(s) to facilitate a change of operating carrier, while some online products do not have an intermediate stop.

Table 2.3 Routing Quality Estimation Results

	Dependent Variable					
	Routing_quality_going		Routing_quality_coming		Routing Quality	
	Estimate	St. Error	Estimate	St. Error	Estimate	St. Error
Opres	0.019***	(0.000)	0.019***	(0.000)	0.020***	(0.000)
Mindist_going	0.003***	(0.000)			0.001***	(0.000)
Mindist_coming			0.003***	(0.000)	0.002***	(0.000)
N_comp_nonstop_going	1.017***	(0.009)			0.534***	(0.008)
N_comp_nonstop_coming			1.012***	(0.009)	0.547***	(0.009)
N_comp_interstop_going	-0.101***	(0.001)			-0.048***	(0.001)
N_comp_interstop_coming			-0.097***	(0.001)	-0.040***	(0.001)
Traditional_going	-0.682***	(0.040)			-0.368***	(0.023)
Traditional_coming			-0.724***	(0.037)	-0.473***	(0.023)
Virtual_going	1.916***	(0.045)			1.273***	(0.038)
Virtual_coming			1.760***	(0.041)	1.273***	(0.035)
UA	-2.726***	(0.132)	-2.820***	(0.134)	-2.996****	(0.123)
Star	-0.026**	(0.013)	-0.027**	(0.013)	-0.027**	(0.012)
UA×Star	0.050***	(0.008)	0.049***	(0.009)	0.047***	(0.008)
ATI^{UA}	-0.064*	(0.037)	-0.036	(0.037)	-0.033	(0.034)
$UA \times ATI^{UA}$	0.072***	(0.012)	0.072***	(0.012)	0.077***	(0.011)
DL	-4.401***	(0.094)	-4.379***	(0.094)	-4.217***	(0.089)
Skyteam	-0.052***	(0.009)	-0.049***	(0.009)	-0.047***	(0.009)
DL×Skyteam	0.120***	(0.011)	0.115***	(0.011)	0.102***	(0.010)
ATI^{DL}	-0.028	(0.021)	-0.052**	(0.021)	-0.044**	(0.019)
$DL \times ATI^{DL}$	0.188***	(0.021)	0.197***	(0.022)	0.203***	(0.020)
AA	-2.553***	(0.135)	-2.404***	(0.135)	-2.631***	(0.123)
Oneworld	-0.007	(0.022)	-0.018	(0.022)	-0.020	(0.020)
AA×Oneworld	0.152***	(0.015)	0.141***	(0.015)	0.160***	(0.014)
ATI^{AA}	0.009	(0.010)	0.011	(0.010)	0.010	(0.009)
$AA \times ATI^{AA}$	0.024**	(0.011)	0.017	(0.011)	0.021**	(0.009)
Constant	93.512***	(0.651)	93.263***	(0.655)	92.943***	(0.611)
OP Carrier FE	Yes		Yes		Yes	
Time FE	Yes		Yes		Yes	
Origin/Dest FE	Yes		Yes		Yes	
R^2	0.201		0.200		0.227	
Observations	2,057,144					

Notes: Equations are estimated using ordinary least squares (OLS). *** indicates statistical significance at the 1% level, ** indicates statistical significance at the 5% level and * indicates statistical significance at the 10% level..

On the other hand, products in which the going or coming portion of the itinerary are virtually codeshared have higher routing quality than online products on average. Routing quality for products where the going (coming) itinerary portion is virtually codeshared is on average 1.27 percentage points (1.27 percentage points) higher than if the itinerary portion was online. This result suggests that ticketing carriers of virtual codeshare products tend to practice this type of codesharing with operating carriers that offer online products with higher routing quality than the ticketing carriers' own online products.

The key variables in this analysis are the variables involving the carriers United Airlines, Delta Airlines and American Airlines as well as the variables regarding membership changes in their respective alliance and ATI agreement. The coefficient estimate on *UA* suggests that the mean routing quality for products offered by United Airlines are 3.00 percentage points lower than the mean routing quality of all products in the sample. The coefficient estimate on *Star* indicates that an additional member in the Star alliance is associated with lower routing quality of non-United Airlines products by 0.03 percentage points on average. However, the coefficient estimates on the interaction term, $UA \times Star$, indicates that each additional member in the Star alliance increases the routing quality of United Airline's products relative to other carriers' products by 0.05 percentage points on average. Table 3.1 provides estimates of the total effect of alliance membership and ATI partnerships. The estimates regarding the total effect of an additional Star alliance member provide some evidence that on average the routing quality of United Airlines' products increase with each additional Star alliance member. The coefficient estimate for $UA \times ATI^{UA}$ indicates that each additional ATI partner for United Airlines increases the relative routing quality of United Airlines' products by 0.08 percentage points on average. However, the total effect an additional ATI partner for United Airlines indicates there is no statistically significant effect on the routing quality of United Airlines' products.

The mean routing quality of Delta Airlines' products is about 4.22 percentage points lower than the mean routing quality of all products in the sample. This is evident from the coefficient estimate on *DL*. The coefficient estimate for *Skyteam* indicates that the routing quality of non-Delta Airlines products decreases by 0.05 percentage points on average with each additional member of the Skyteam alliance. On the other hand, the results suggest that each additional member in the Skyteam alliance increases the routing quality of Delta Airlines' products relative other carriers' products on average by 0.10 percentage points. Similarly, each additional ATI partner for Delta Airlines increases the relative routing quality of Delta Airlines' products by 0.20 percentage points on average. The total effect of an additional Skyteam member or ATI partner indicate an average increase in routing quality of Delta Airlines' products of about 0.06 percentage points and 0.15 percentage points, respectively.

In the case of American Airlines, the mean routing quality of products offered by American Airlines is about 2.63 percentage points lower than the mean routing quality of competitors' products. An additional member in the Oneworld alliance has no statistically significant impact on the routing quality of non-American Airlines products. Although, each additional member in the Oneworld alliance and each additional ATI partner increases the routing quality of American Airlines' products relative to other carriers' products by 0.16 percentage points and 0.02 percentage points on average, respectively. The total effect of an additional Oneworld member or ATI partner for American Airlines is associated with an increase in routing quality of about 0.14 percentage points and 0.03 percentage points on average, respectively.

The results concerning Delta Airlines suggest that an additional ATI partner has a bigger impact on routing quality of their products than an additional alliance member. However, the results concerning United Airlines and American Airlines suggest that an additional ATI partner has a smaller impact on the routing quality of their products than an additional alliance member.

Table 2.4 Total Effects of Alliance Membership and ATI Partnerships

	Dependent Variable					
	Routing_quality_going		Routing_quality_coming		Routing Quality	
Total Effect	Estimate	F-Statistic	Estimate	F-Statistic	Estimate	F-Statistic
Star ($\beta_4 + \beta_5$)	0.024*	2.78	0.022	2.29	0.021	2.47
ATI^{UA} ($\beta_6 + \beta_7$)	0.008	0.04	0.036	0.89	0.044	1.61
Skyteam ($\beta_9 + \beta_{10}$)	0.068***	31.07	0.066***	28.60	0.056***	24.23
ATI^{DL} ($\beta_{11} + \beta_{12}$)	0.159***	38.79	0.146***	31.92	0.158***	45.10
Oneworld ($\beta_{14} + \beta_{15}$)	0.145***	31.98	0.122***	22.50	0.141***	36.78
ATI^{AA} ($\beta_{16} + \beta_{17}$)	0.033**	6.33	0.028**	4.66	0.031***	7.05

*** indicates statistical significance at the 1% level, ** indicates statistical significance at the 5% level and * indicates statistical significance at the 10% level..

The Effects on Average Routing Quality by Product Type

The key results shown in Table 2.3 indicate that more extensive cooperation, either in the form of alliance or ATI membership increase, is associated with increases in relative product quality. Equation (1) can be modified to identify the changes in relative routing quality by types of products when there is an additional alliance member or ATI partner. The routing quality effects by product type are identified by the coefficient estimates on three-way interaction variables included in the regressions. For example, the coefficient estimates on three-way interaction variables, *UA×Star×online*, *UA×Star×traditional*, and *UA×Star×virtual*, identify the extent to which increases in membership of the Star alliance influence routing quality of United Airline's online, traditional codeshare, and virtual codeshare products relative to other carriers' products respectively. Analogous three-way interaction variables in the cases of the other two alliances (Skyteam and Oneworld) and carriers (Delta Airlines and American Airlines) are included in the regressions to identify analogous relative routing quality effects by product types.

An increase in the routing quality of a carrier's online products suggests that the carrier's rearrangement of its own network resulted in new routing to more conveniently transport passengers between their origin and destination. An increase in the routing quality of a carrier's codeshare products suggests that an expansion in alliance members/ATI partners resulted in new higher quality routing options that require using its partner carriers' networks.

The estimation results from this modified specification are shown in Table 2.5. Separate regressions are estimated using information from the going portion of itineraries and information from the coming portion of the itineraries, respectively. One reason it makes sense to estimate separate regressions for the going and coming portions of itineraries is that each portion of an itinerary is either online, traditionally codeshared or virtually codeshared, but it is not always the case that the going portion is the same type as the coming portion.

First, consider the results of alliance membership. The results indicate that an increase in membership in the Star alliance increases the routing quality for each type of product offered by United Airlines relative to competitors' products. Specifically, each additional member in the Star alliance increases the relative routing quality of United Airlines' online products by approximately 0.02%, traditional codeshare products by 0.11% and virtual codeshare products by 0.15% on average. Similarly, an increase in membership in the Skyteam and Oneworld alliances increase the relative routing quality for each type of product offered by Delta Airlines and

American Airlines, respectively. In particular, each additional member in the Skyteam increases the routing quality of Delta Airlines' online, traditional codeshare and virtual codeshare products relative to competitors' products by about 0.12%, 0.07% and 0.33% on average, respectively.[19] Likewise, each additional member in the Oneworld Alliance increases American Airlines' routing quality relative to competitors' products for online, traditional codeshare and virtual codeshare products by about 0.13%, 0.20% and 1.15% on average, respectively. These results suggest that an increase in alliance membership is accompanied with higher relative routing quality for each type of product a carrier can offer. Furthermore, in each of these cases, the types of products that experience the largest increase in relative routing quality are virtually codeshared products. This suggests that the greater the number of alliance members, the greater the number of flights in which other alliance members can sell to conveniently transport passengers.

[19] Note that the coefficient indicating effect of Skyteam alliance membership on the routing quality of Delta Airlines' traditional codeshare products is not statistically significant for coming portion of the itineraries.

Table 2.5 Routing Quality Estimation Results for Various Types of Products

	Dependent Variable			
	Routing_quality_going		Routing_quality_coming	
	Estimate	St. Error	Estimate	St. Error
Opres	0.019***	(0.000)	0.019***	(0.000)
Mindist_going	0.003***	(0.000)		
Mindist_coming			0.003***	(0.000)
N_comp_nonstop_going	1.019***	(0.009)		
N_comp_nonstop_coming			1.012***	(0.009)
N_comp_interstop_going	-0.101***	(0.001)		
N_comp_interstop_coming			-0.097***	(0.001)
Traditional_going	-0.750***	(0.045)		
Traditional_coming			-0.762***	(0.042)
Virtual_going	1.381***	(0.067)		
Virtual_coming			1.422***	(0.065)
UA	-2.823***	(0.136)	-2.824***	(0.137)
Star	-0.027**	(0.013)	-0.027**	(0.013)
UA×Star×online	0.021**	(0.009)	0.020**	(0.009)
UA×Star×traditional	0.108***	(0.011)	0.111***	(0.012)
UA×Star×virtual	0.154***	(0.021)	0.124***	(0.020)
ATI^{UA}	-0.066*	(0.037)	-0.035	(0.037)
UA×ATI^{UA}×online	0.107***	(0.014)	0.112***	(0.014)
UA×ATI^{UA}×traditional	-0.016	(0.020)	-0.029	(0.021)
UA×ATI^{UA}×virtual	-0.065	(0.040)	-0.041	(0.039)
DL	-4.534***	(0.095)	-4.468***	(0.096)
Skyteam	-0.052***	(0.009)	-0.049***	(0.009)
DL×Skyteam×online	0.120***	(0.011)	0.122***	(0.012)
DL×Skyteam×traditional	0.070***	(0.022)	0.009	(0.022)
DL×Skyteam×virtual	0.326***	(0.052)	0.408***	(0.047)
ATI^{DL}	-0.028	(0.021)	-0.051**	(0.021)
DL×ATI^{DL}×online	0.181***	(0.023)	0.180***	(0.023)
DL×ATI^{DL}×traditional	0.279***	(0.047)	0.411***	(0.046)
DL×ATI^{DL}×virtual	-0.116	(0.112)	-0.320***	(0.102)

Table 2.4 (Continued) Routing Quality Estimation Results for Various Types of Products

	Routing_quality_going		Routing_quality_coming	
	Estimate	St. Error	Estimate	St. Error
AA	-2.757***	(0.139)	-2.476***	(0.139)
Oneworld	-0.005	(0.022)	-0.018	(0.022)
AA×Oneworld×online	0.132***	(0.016)	0.129***	(0.016)
AA×Oneworld×traditional	0.200***	(0.019)	0.153***	(0.019)
AA×Oneworld×virtual	1.153***	(0.059)	0.967***	(0.050)
ATI^{AA}	0.008	(0.010)	0.010	(0.010)
AA×ATI^{AA}×online	0.044*	(0.012)	0.037***	(0.012)
AA×ATI^{AA}×traditional	-0.044**	(0.018)	-0.044**	(0.018)
AA×ATI^{AA}×virtual	-1.268***	(0.089)	-1.085***	(0.074)
Constant	93.784***	(0.653)	92.413***	(0.626)
OP Carrier FE	Yes		Yes	
Time FE	Yes		Yes	
Origin/Dest FE	Yes		Yes	
R^2	0.201		0.200	
Observations	2,057,144			

Notes: Equations are estimated using ordinary least squares (OLS). *** indicates statistical significance at the 1% level and ** indicates statistical significance at the 5% level.

Next, consider the effects of ATI. The results regarding the effects of ATI on routing quality of the different product types are mixed. With regard to United Airlines, each additional ATI partner increases relative routing quality of United Airlines' online products, but not the relative routing quality of its codeshare products. More precisely, each additional ATI partner increases relative routing quality for United Airlines' online products by about 0.11% on average. With respect to Delta Airlines, each additional ATI partner increases the relative routing quality of Delta Airlines' online products by 0.18% and traditional codeshare products by 0.28% on average. The results concerning Delta Airlines' virtual codeshare products are mixed. Examining the going portion of itineraries reveals an additional ATI partner has no effect on the relative routing quality of Delta Airlines' virtual codeshare products, whereas examining the coming portion of itineraries reveals a decrease in the routing quality of Delta Airlines' virtual codeshare products relative to competitors' products of about 0.32% on average. Finally, the results suggest that an additional ATI partner with American Airlines increases relative routing quality of American Airlines' online products by about 0.04% on average. However, an additional ATI partner decreases relative routing quality for traditional and virtual codeshare products by 0.04% and 1.27% on average, respectively.

Although the results regarding the impact of ATI on routing quality of codeshare products are mixed among the three carriers, a consistent result is that an increase in membership of the three carriers' ATI partners increases relative routing quality of the three carriers' online products. Overall, this result suggests that increases in the membership of a carrier's alliance or ATI partners incentivize the carrier to rearrange its own network to accommodate partner carriers' network, and this network rearrangement tend to result in products with higher routing quality.

2.5 Conclusion

The purpose of this study is to examine how the routing quality of products a carrier offers is affected by expansions in the numbers of the carrier's alliance and ATI partners. Prior research regarding alliance membership and ATI has focused on the price effects. However, it is also important to understand how cooperation affects product quality. The empirical results are obtained by estimating reduced-form product quality regressions, which are specified to use a difference-in-differences approach for identifying relevant quality effects.

The results give strong evidence indicating that cooperation among international carriers is associated with an increase in routing quality of a carrier's products on average. This result holds for expansions in alliance membership for each of the three carriers examined: United Airlines, Delta Airlines and American Airlines and expansions in ATI partnerships involving Delta Airlines and American Airlines. Furthermore, the results suggest that increases in alliance membership are associated with relative routing quality increases for each type of product the carrier offers (online, traditional codeshare and virtual codeshare) with virtual codeshare products experiencing the greatest relative routing quality increase. Although the results regarding the impact of ATI on routing quality of codeshare products are mixed among the three carriers, a consistent result is that an increase in membership of the three carriers' ATI partners increases relative routing quality of the three carriers' online products.

Much of the literature to date has focused on the price effects of airline cooperation, and have used these price effects to infer associated welfare effects. It is well-known in economics that, all else equal, consumer welfare is positively related to product quality. This research formally provides evidence of product quality effects associated with airline cooperation, which implies that a complete welfare evaluation of airline cooperation must account for both price and product quality effects.

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Appendix A - Additional Tables for Chapter 1

Table A.1 Chronological History of ATI by U.S. Carrier

U.S. Carriers	ATI partners	ATI approval	ATI close-out	Associated carve-outs
Northwest	KLM	1/1993		
	KLM and Alitalia*	12/1999	10/2001	
United Airlines	Lufthansa	5/1996		Chicago-Frankfurt and Washington D.C.-Frankfurt
	Lufthansa and SAS*	11/1996		
	Air Canada	9/1997		Chicago-Toronto and San Francisco-Toronto
	Air New Zealand	4/2001		Los Angeles-Auckland and Los Angeles-Sydney
	Austrian Airlines, Lufthansa and SAS*	1/2001		
	Copa Airlines	5/2001		
	Asiana	5/2003		
	Austrian Airlines, Lufthansa, Air Canada, SAS, British Midland, LOT, Swiss International Air Lines and TAP*[1]	2/2007		
	Austrian Airlines, Lufthansa, Air Canada, SAS, British Midland, LOT, Swiss International Air Lines, TAP and SN Brussels*[1]	7/2009		
	ANA	11/2010		

*indicates an expansion of previous ATI decisions.

1. British Midland did not operate in the alliance beyond 4/2012.

Table A.1 (Continued) Chronological History of ATI by U.S. Carrier

U.S. Carriers	ATI partners	ATI approval	ATI close-out	Associated carve-outs
Delta	Austrian Airlines, Sabena and Swissair	6/1996	5/2007[2]	Atlanta-Zurich, Atlanta-Brussels, Cincinnati-Zurich, New York-Brussels, New York-Vienna, New York-Geneva and New York-Zurich
	Air France, Alitalia, Czech Airlines	1/2002		Atlanta-Paris and Cincinnati-Paris
	Korean Air Lines, Air France, Alitalia and Czech Airlines*	6/2002		
	Virgin Blue Group	6/2011		
Delta and Northwest	Air France, KLM, Alitalia, Czech Airlines*	5/2008		Atlanta-Paris and Cincinnati-Paris carve-outs removed
American Airlines	Canadian Airlines	7/1996	5/2007[3]	New York-Toronto
	LAN	9/1999		Miami-Santiago
	Swissair	5/2000	11/2001	Chicago-Brussels
	Sabena	5/2000	3/2002	Chicago-Zurich
	Finnair	7/2002		
	Swiss International Air Lines	11/2002	8/2005	
	SN Brussels	4/2004	10/2009	
	LAN and LAN-Peru*	10/2005		Miami-Lima
	British Airways, Iberia, Finnair and Royal Jordanian*	7/2010		
	Japan Airlines	11/2010		

*indicates an expansion of previous ATI decisions.

2. Although not officially closed until 2007, this alliance was only active until 8/2000.

3. Although not officially closed until 2007, this alliance was only active until 6/2000.

Table A.2 Marginal Cost Regressions using AA/LA Carve-out Markets

Variable	ATI Partners Cooperate in all markets: Estimates	Std. Error	ATI Partners Cooperate only in non-carve-out markets: Estimates	Std. Error
Mc_opres	11.44	(21.50)	10.99	(21.49)
Mc_opres^2	-0.03	(0.41)	-0.03	(0.41)
Nonstop_going	392.13	(376.51)	393.56	(376.44)
Nonstop_coming	1,428.70	(1,008.59)	1,429.33	(1,007.64)
Itinerary_dist_going	0.02	(0.07)	0.02	(0.07)
Itinerary_dist_coming	0.78*	(0.47)	0.78*	(0.47)
Trad_1_going	1,996.52***	(204.76)	1,991.52***	(204.55)
Trad_1_coming	5,267.44***	(1,020.02)	5,267.98***	(1,019.06)
Virtual_going	-145.49	(129.34)	-145.13	(129.30)
Virtual_coming	-136.43	(103.81)	-136.23	(103.84)
Constant	-4,426.27*	(2,440.38)	-4,425.37*	(2,437.94)
Quarter FE	yes		yes	
Year FE	yes		yes	
Operating carrier FE	yes		yes	
Origin/Destination FE	yes		yes	
Observations	191		191	
R^2	0.4597		0.4590	
Non-nested test stat	-0.9719			

*indicates significance at the 10% level, **indicates significance at the 5% level and ***indicates significance at the 1% level.

Table A.3 Marginal Cost Regressions using DL/AF Overlap Carve-out Markets

Variable	ATI Partners Cooperate in all markets: Estimates	Std. Error	ATI Partners Cooperate only in non-carve-out markets: Estimates	Std. Error
Mc_opres	0.29	(4.23)	0.07	(4.23)
Mc_opres^2	-0.02	(0.02)	-0.02	(0.02)
Nonstop_going	364.99**	(168.61)	365.09**	(168.58)
Nonstop_coming	535.46***	(153.04)	535.35***	(153.00)
Itinerary_dist_going	0.49*	(0.27)	0.49*	(0.27)
Itinerary_dist_coming	-0.04	(0.14)	-0.04	(0.14)
Trad_1_going	76.08	(196.79)	75.71	(196.76)
Trad_1_coming	523.84***	(186.10)	523.46***	(186.06)
Virtual_going	-56.16	(156.44)	-56.65	(156.42)
Virtual_coming	146.50	(152.83)	146.21	(152.85)
Constant	-1,977.80	(1,222.11)	-1,955.22	(1,221.65)
Quarter FE	yes		yes	
Year FE	yes		yes	
Operating carrier FE	yes		yes	
Origin/Destination FE	yes		yes	
Observations	894		894	
R^2	0.2175		0.2194	
Non-nested test stat	0.2303			

*indicates significance at the 10% level, **indicates significance at the 5% level and ***indicates significance at the 1% level.

Table A.4 Marginal Cost Regressions using UA/AC Overlap Carve-out Markets

Variable	ATI Partners Cooperate in all markets: Estimates	Std. Error	ATI Partners Cooperate only in non-carve-out markets: Estimates	Std. Error
Mc_opres	5.57**	(2.35)	5.29**	(2.34)
Mc_opres^2	-0.04**	(0.02)	-0.04**	(0.02)
Nonstop_going	99.32**	(44.75)	99.72**	(44.76)
Nonstop_coming	-66.65	(41.93)	-66.29	(41.96)
Itinerary_dist_going	0.12	(0.10)	0.12	(0.10)
Itinerary_dist_coming	-0.05	(0.10)	-0.05	(0.10)
Trad_1_going	86.00	(106.22)	86.33	(106.22)
Trad_1_coming	69.00	(98.99)	69.82	(99.03)
Virtual_going	141.25	(115.63)	141.31	(115.66)
Virtual_coming	190.98*	(114.85)	191.36*	(114.82)
Constant	3.94	(182.34)	10.41	(182.09)
Quarter FE	yes		yes	
Year FE	yes		yes	
Operating carrier FE	yes		yes	
Origin/Destination FE	yes		yes	
Observations	435		435	
R^2	0.1708		0.1704	
Non-nested test stat	0.2077			

*indicates significance at the 10% level, **indicates significance at the 5% level and ***indicates significance at the 1% level.

Table A.5 Marginal Cost Regressions using AA/LA, DL/AF and UA/AC Overlap Carve-out Markets

Variable	ATI Partners Cooperate in all markets: Estimates	Std. Error	ATI Partners Cooperate only in non-carve-out markets: Estimates	Std. Error
Mc_opres	7.79***	(2.51)	7.64***	(2.51)
Mc_opres^2	-0.05***	(0.02)	-0.05***	(0.02)
Nonstop_going	457.89***	(102.54)	461.88***	(102.55)
Nonstop_coming	403.86***	(84.67)	407.54***	(84.72)
Itinerary_dist_going	0.18	(0.15)	0.18	(0.15)
Itinerary_dist_coming	0.15	(0.15)	0.15	(0.15)
Trad_1_going	200.89	(131.89)	203.64	(131.90)
Trad_1_coming	362.86***	(112.88)	365.63***	(112.90)
Virtual_going	36.68	(99.47)	37.92	(99.51)
Virtual_coming	117.29	(98.06)	118.23	(98.11)
Constant	-1,684.19**	(806.71)	-1,676.32**	(806.79)
Quarter FE	yes		yes	
Year FE	yes		yes	
Operating carrier FE	yes		yes	
Origin/Destination FE	yes		yes	
Observations	1,520		1,520	
R^2	0.2372		0.2389	
Non-nested test stat	2.2204			

*indicates significance at the 10% level, **indicates significance at the 5% level and ***indicates significance at the 1% level.

Appendix B - Additional Tables for Chapter 2

Table B.1 Chronological History of Alliance Participation by Alliance

Alliance	Carriers	Dates beginning	Dates ended
Star	**United Airlines**, Air Canada, Lufthansa, SAS and Thai Airways	5/1997	
	VARIG Brazilian Airlines	10/1997	
	Ansett Australia, Air New Zealand and ANA	3/1999	
	Austrian Airlines Group[1]	3/2000	
	Singapore Airlines	4/2000	
	British Midland and Mexicana Airlines	7/2000	
	Ansett Australia		3/2002
	Asiana Airlines	3/2003	
	Spanair	4/2003	
	LOT Polish Airlines	10/2003	
	Mexicana Airlines		3/2004
	US Airways	5/2004	
	Blue 1[2], Adria Airways and Croatia Airlines	11/2004	
	TAP Portugal	5/2005	
	South African Airways and Swiss Int. Air Lines	4/2006	
	VARIG Brazilian Airlines		1/2007
	Air China and Shanghai Airlines	12/2007	
	Turkish Airlines	4/2008	
	EGYPTAIR	7/2008	
	Continental	10/2009	
	SN Brussels Airlines	12/2009	
	Continental[3]		5/2010
	TAM	5/2010	
	Aegean Airlines	6/2010	
	Shanghai Airlines		10/2010

1. Austrian Airlines, Tyrolean and Lauda Air compose the Austrian Airlines Group
2. Blue 1 is a regional carrier
3. United Airlines and Continental merge

Table B.1 (Continued) Chronological History of Alliance Participation by Alliance

Alliance	Carriers	Dates beginning	Dates ended
Oneworld	**American Airlines**, British Airways, Cathay Pacific, Canadian Airlines and Qantas	2/1999	
	Finnair and Iberia	9/1999	
	Canadian Airlines		6/2000
	Air Lingus and LAN-Chile	6/2000	
	Air Lingus		4/2007
	Japan Airlines, Malev and Royal Jordanian	4/2007	
	Mexicana Airlines	11/2009	8/2010
	S7 Airlines	11/2010	
SkyTeam	**Delta Airlines**, Air France, Aeromexico and Korean Air	6/1999	
	Czech Airlines	3/2001	
	Alitalia	7/2001	
	Continental, **Northwest** and KLM[4]	9/2004	
	Aeroflot	4/2006	
	Air Europa, Copa Airlines and Kenya Airlines	9/2007	
	China Southern Airlines	11/2007	
	Continental and Copa Airlines		10/2009
	Northwest[5]		1/2010
	Vietnam Airlines and TAROM Romanian Air	6/2010	
	China Eastern	6/2011	
	China Airlines	9/2011	

4. Northwest and KLM alliance partners since 1/1993

5. Delta and Northwest announced their plan to merge in April 2008, but their ground operations and reservations systems were not combined until January 31, 2010.

Table B.2 Chronological History of ATI by U.S. Carrier

U.S. Carriers	ATI partners	ATI approval	ATI close-out	Associated carve-outs
Northwest	KLM	1/1993		
	KLM and Alitalia*	12/1999	10/2001	
United Airlines	Lufthansa	5/1996		Chicago-Frankfurt and Washington D.C.-Frankfurt
	Lufthansa and SAS*	11/1996		
	Air Canada	9/1997		Chicago-Toronto and San Francisco-Toronto
	Austrian Airlines, Lufthansa and SAS*	1/2001		
	Air New Zealand	4/2001		Los Angeles-Auckland and Los Angeles-Sydney
	Copa Airlines	5/2001		
	Asiana	5/2003		
	Austrian Airlines, Lufthansa, Air Canada, SAS, British Midland, LOT, Swiss International Air Lines and TAP*[1]	2/2007		
	Austrian Airlines, Lufthansa, Air Canada, SAS, British Midland, LOT, Swiss International Air Lines and TAP, SN Brussels Airlines*[1]	7/2009		
	ANA	11/2010		

*indicates an expansion of previous ATI decisions.

1. British Midland did not operate in the alliance beyond 4/2012.

Table B.2 (Continued) Chronological History of ATI by U.S. Carrier

Table A2 Cont. Chronological history of ATI by U.S. Carrier				
U.S. Carriers	**ATI partners**	**ATI approval**	**ATI close-out**	**Associated carve-outs**
Delta Airlines	Austrian Airlines, Sabena and Swissair	6/1996	5/2007[2]	Atlanta-Zurich, Atlanta-Brussels, Cincinnati-Zurich, New York-Brussels, New York-Vienna, New York-Geneva and New York-Zurich
	Air France, Alitalia, Czech Airlines	1/2002		Atlanta-Paris and Cincinnati-Paris
	Korean Air, Air France, Alitalia and Czech Airlines*	6/2002		
	Virgin Australia	6/2011		
Delta Airlines and Northwest	Korean Air, Air France, KLM, Alitalia, Czech Airlines*	5/2008		Atlanta-Paris and Cincinnati-Paris carve-outs removed
American Airlines	Canadian Airlines	7/1996	5/2007[3]	New York-Toronto
	LAN	9/1999		Miami-Santiago
	Swissair	5/2000	11/2001	Chicago-Brussels
	Sabena	5/2000	3/2002	Chicago-Zurich
	Finnair	7/2002		
	Swiss International Air Lines	11/2002	8/2005	
	SN Brussels	4/2004	10/2009	
	LAN and LAN-Peru*	10/2005		Miami-Lima
	British Airways, Iberia, Finnair and Royal Jordanian*	7/2010		
	Japan Airlines	11/2010		

*indicates an expansion of previous ATI decisions.

2. Although not officially closed until 2007, this alliance was only active until 8/2000

3. Although not officially closed until 2007, this alliance was only active until 6/2000