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

Gayle, Philip and Thomas, Tyson

Kansas State University

27 April 2016

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

Philip G. Gayle* and Tyson Thomas**

This draft: April 27, 2016
First draft: September 29, 2014

Forthcoming in *Journal of Economic Behavior & Organization*

Abstract

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 more consistent with cooperative pricing in carve-out markets in spite of the policy, calling into question the effectiveness of the policy in achieving intended market outcomes.

Keywords: Airline competition; Antitrust immunity; Carve-out Policy

JEL classification codes: L13; L40; L93

Acknowledgements: For very helpful comments and suggestions we thank co-editor, Thomas Gresik, two anonymous referees, Peri da Silva, Yang-Ming Chang, and Tian Xia. Any remaining errors are our own.

*Kansas State University, Department of Economics, 322 Waters Hall, Manhattan, KS 66506; Voice: (785) 532-4581; Fax: (785) 532-6919; email: gaylep@ksu.edu; **Corresponding author**.

**Kansas State University, Department of Economics, 327 Waters Hall, Manhattan, KS 66506; email: tysnthms@ksu.edu.

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.

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

---

[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).

market effects of policymakers imposing carve-outs, which is the primary contribution of this study.

A discussion of carve-outs requires a discussion of ATI. There have been numerous theoretical and empirical studies examining the implications of ATI. The results of these studies suggest the consequences of ATI vary by 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) theoretical analysis suggests that ATI will lead to lower prices in interline markets, a prediction that is also consistent with theoretical analysis in Choi (2008). This is the result of elimination of double marginalization in the interline markets. However, in interhub markets 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. 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 [see Brueckner and Spiller (1994) and Gresik and Mansley (2001)]. These cost efficiencies have a countervailing effect to the anticompetitive effect in interhub markets. Thus, if cost efficiencies in interhub markets are sufficiently large, prices may fall in these markets. Numerous empirical studies including Brueckner and Whalen (2000), Brueckner et. al (2011) and Whalen (2007) conclude codesharing and ATI each serve to lower fares in interline markets; although, ATI has the greater effect on prices. This supports the hypothesis that ATI eliminates double marginalization.[2]

Although there are numerous studies examining the effects of ATI, the literature regarding carve-outs is limited. Brueckner and Proost (2010) use a formal theoretical model to better understand when a carve-out can be beneficial or harmful to consumers. The theory suggests that ATI has an anticompetitive effect in interhub markets serving to put an upward

---

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

pressure on prices for passengers. However, in the presence of economies of passenger-traffic density, ATI may bring cost efficiencies to the carriers. These cost efficiencies can be passed on to 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) explore the question of whether cooperation in interline markets increases the incentive to collude in interhub markets if a carve-out is present. 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 pose a problem for regulators since the carve-out may not influence the outcome resulting from cooperative behavior of the ATI partners. However, Brueckner and Picard's (2012) theoretical analysis finds that there exists no incentive for tacit collusion.

The main purpose of this paper is to empirically investigate whether market outcomes are consistent with cooperative price-setting behavior among ATI partners in their carve-out markets. In other words, do ATI partner carriers refrain from cooperatively setting prices in their carve-out markets as required by policymakers, or is there evidence of collusion in the carve-out markets? Answering this question is tantamount to assessing the extent to which application of carve-out policy elicits the market behavior of carriers that policymakers intend. 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 cooperatively set their product prices in markets designated as carve-outs; and (2) where we assume the ATI partner carriers non-cooperatively set their product prices in their 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.[3] 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 cooperatively set their product prices in their carve-out markets has better statistical support from systematic patterns in the data.

The paper proceeds as follows. In section 2 we provide discussion of examples in which the DOT granted carriers ATI with carve-outs. In section 3 we discuss the data and define variables used in the analysis. Section 4 discusses the econometric model used in the analysis. Section 5 discusses estimates from the model, Section 6 discusses empirical results regarding the outcomes of partner carriers' behavior in their carve-out markets, and Section 7 summarizes findings and offer concluding remarks.

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.[4] 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 interhub markets), an effective 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.

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

---

[3] 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).

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

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.[5]

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.[6]

3. Data, Definitions and Descriptive Statistics

3.1 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

---

[5] For a complete history of ATI decisions and associated carve-outs, see Table A1 in the appendix.

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

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 airport appears multiple times on the going (outbound) or coming (inbound) 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.

Consistent with the objective of our analysis, our sample data focus on markets in which ATI partner carriers each sell differentiated substitute products to consumers, i.e., consumers have the option to purchase substitutable products from each ATI partner carrier in a given market.[7] In addition, a subset of these markets are designated as carve-out for the partner carriers. In the dataset, there are 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

---

[7] A key point to note is that the data sample we use pertains to markets where the ATI partners are selling (ticketing carriers) products, not always necessarily where the ATI partners operate flights.

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 illustrates the defined carve-out markets in our sample that we analyze.

Table 1. Carve-Out Markets in the Data Sample that we Analyze*

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	2/2008
	Cincinnati-Paris	1/2005	2/2008
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.

3.2 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 only considers codesharing between major carriers.

There are two main types of codesharing: (1) Traditional; and (2) Virtual. We distinguish between these two types of codesharing based on whether or not passengers are required to transfer from one operating carrier to another on the relevant portion of the itinerary being labeled as codeshare. Specifically, on virtual codeshare portions of the itinerary passengers are not required to transfer from one operating carrier to another, while transfer across operating carriers is required on traditional codeshare portions of the itinerary. Effectively, traditional codesharing requires complementary operating services between partner carriers, while virtual codesharing does not. We further distinguish between two types of traditional codesharing: (*i*) Traditional 1; and (*ii*) Traditional 2. Traditional 1 requires that the ticketing carrier also provides operating services on at least one segment of the traditional codeshare portion of the itinerary, while for Traditional 2 the ticketing carrier does not provide any operating services on the traditional codeshare portion of the itinerary. Note that Traditional 2 necessarily involves at least three partner carriers, where one carrier is solely the ticketing carrier and the others are operating carriers.

We construct variables that correspond to the three types of codesharing described above. 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 on the going portion of the product is operated by the ticketing carrier, and the remaining coupon segment(s) on the going portion of the product is(are) operated by a partner 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 partner operating carriers on this going(coming) portion of the product. With each of these 2 types of traditional codeshare products, passengers are switching operating carriers at some point along their journey between the origin and destination. *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 each airline's presence at the origin airport of each market in the data. Variable *Opres* takes a value equal to the number of distinct destination airports to which a carrier offers non-stop service leaving from the relevant origin airport for which variable *Opres* is being used to measure the size of the airline's presence. In contrast, variable *MC_opres* takes on a value equal to the number of distinct airports from which a carrier offers non-stop service going to the relevant origin airport for which *MC_opres* is being used to measure the size of the airline's presence. Effectively, *Opres* is measured from the perspective of an airline's distinct "outbound" activities from an origin airport of a market, while *MC_opres* is measured from the perspective of an airline's "inbound" activities to the origin airport of a market.[8] 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.[9]

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

---

[8] An airline’s inbound and outbound nonstop service activities at an airport need not be symmetrical in terms of the number and/or identity of endpoint cities from which its inbound flights come compared to the number and/or identity of endpoint cities to which it provides nonstop outbound service. A reason for the potential asymmetry is that the plane used to provide inbound nonstop service to the relevant airport for a subset of passengers on the plane, may not contain nonstop passengers for the outbound service from the relevant airport to possibly a different city. As such, while variables *Opres* and *MC_opres* are likely positively correlated, they need not be perfectly correlated.

[9] As described previously, 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.

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.[10]

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).[11] Table 2 shows summary statistics for the aforementioned variables.

Table 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. Fare for entire round-trip itinerary measured in constant year 2005 dollars

---

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

[11] 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.

4. Model

4.1 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:

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

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:

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

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 ϕ^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 $D_g = \Sigma_{k \in G_g} \exp\left[\frac{\mu_k}{1-\delta}\right]$, 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:

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

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:

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

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:

$$s + (\Omega .\!* \Delta) \times (p - mc) \; = \; 0, \qquad (7)$$

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. 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. Specifically, element Ω_{jk} equals to 1 only when products *j* and *k* are jointly priced, otherwise element Ω_{jk} equals to 0. The following is a simple example of what the Ω matrix looks like for a market with five products being offered for sale to consumers by three distinct ticketing carriers that do not cooperate in setting prices. In this example, suppose product 1 is offered for sale to consumers by airline A, while airline B offers products 2 and 3, and airline C offers products 4 and 5, i.e., based on notation above products are grouped across airlines A, B and C respectively as follows: F_A ={1}, F_B ={2, 3} and F_C ={4, 5}. In this case, product 1 is priced separately from the other four products, products 2 and 3 are jointly priced, while products 4 and 5 are jointly priced, which yields the following Ω matrix:

$$\Omega = \Omega^{non-coop} = \begin{bmatrix} 1 & 0 & 0 & 0 & 0 \\ 0 & 1 & 1 & 0 & 0 \\ 0 & 1 & 1 & 0 & 0 \\ 0 & 0 & 0 & 1 & 1 \\ 0 & 0 & 0 & 1 & 1 \end{bmatrix}. \qquad (8)$$

Note that off-diagonal elements in Ω take the value 1 only when the two distinct products that correspond to the matrix row and column respectively are jointly priced. For example, since products 2 and 3 are jointly priced, then off-diagonal elements in the second row and third column, and third row and second column are equal to 1. Analogously, since products 4 and 5 are jointly priced, then off-diagonal elements in the fourth row and fifth column, and fifth row and fourth column are equal to 1.

As can be seen from our simple example above, 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 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. For instance, in the example above if airline A and airline B became ATI partners, then products 1, 2 and 3 will be jointly priced, and the new Ω, denoted Ω^{coop}, is as follows:

$$\Omega = \Omega^{coop} = \begin{bmatrix} 1 & 1 & 1 & 0 & 0 \\ 1 & 1 & 1 & 0 & 0 \\ 1 & 1 & 1 & 0 & 0 \\ 0 & 0 & 0 & 1 & 1 \\ 0 & 0 & 0 & 1 & 1 \end{bmatrix}. \qquad (9)$$

In other words, Ω_{jk} is set equal to one for all products in the market offered by each of the respective ATI partners. 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:

$$mkup(p, x, \xi;\ \phi^x, \phi^p, \delta) =\ p - mc = -(\Omega .\!* \Delta)^{-1}\ \times s. \tag{10}$$

Furthermore, equation (7) can be re-arranged to yield the following supply equation:

$$p = mc + mkup(\cdot). \tag{11}$$

4.2.1 Alternate Supply Equations

In our analysis we define Ω in two ways to denote two different scenarios that we consider. In one scenario we construct Ω, denoted by $\Omega^{ATI\text{-}cvout}$, assuming carriers that have been given ATI cooperate in all markets except markets in which the ATI is subject to a carve-out. Thus, in this scenario the structure of the supply-side of our model is built on the assumption that ATI partners non-cooperatively set prices for their products in their carve-out markets, but jointly/cooperatively set prices for their products in non-carve-out markets where they each offer products. Drawing on the explicit market example previously described with 5-products and 3-airlines, if the market is designated as a carve-out, then $\Omega^{ATI\_cvout} = \Omega^{non\text{-}coop}$ from equation (8) for that market, but if the market is not designated as a carve-out, then $\Omega^{ATI\_cvout} = \Omega^{coop}$ from equation (9) for that market. Effectively, $\Omega^{ATI\text{-}cvout}$ is constructed under the assumption that carve-outs work as policymakers intend.

In an alternate scenario we construct Ω, denoted by Ω^{ATI}, assuming the carriers that have been given ATI cooperate in setting prices in all markets that they each sell products. In other words, irrespective of whether or not a given market is designated as a carve-out, under this alternate scenario the structure of the supply-side of our model is built on the assumption that ATI partners cooperatively set prices of their products in each market. Again drawing on the explicit market example previously described with 5-products and 3-airlines, $\Omega^{ATI} = \Omega^{coop}$ from equation (9).

The two alternate price-setting behavioral assumptions described above yield the following two alternate structural expressions for computing product markups:

$$mkup^{ATI}(p, x, \xi;\ \phi^x, \phi^p, \delta) = -(\Omega^{ATI} .\!* \Delta)^{-1}\ \times s, \tag{12}$$

$$mkup^{ATI\_cvout}(p, x, \xi;\ \phi^x, \phi^p, \delta) = -(\Omega^{ATI\_cvout} .\!* \Delta)^{-1}\ \times s. \tag{13}$$

Note that these expressions illustrate that product markups can be computed once we have in hand the demand parameter estimates, $\widehat{\phi^x}$, $\widehat{\phi^p}$ and $\hat{\delta}$. Equation (7), along with the two markup expressions in (12) and (13) imply the following two alternate structural supply equations:

$$p_{jmt} = mc_{jmt}^{ATI} + mkup_{jmt}^{ATI}, \tag{14}$$

$$p_{jmt} = mc_{jmt}^{ATI\_cvout} + mkup_{jmt}^{ATI\_cvout}, \tag{15}$$

where mc_{jmt}^{ATI} and $mc_{jmt}^{ATI\_cvout}$ are marginal cost functions only known up to parameters by us the researchers. In particular, let the marginal cost functions be parametrically specified as:

$$mc_{jmt}^{ATI} = \theta W_{jmt} + \varepsilon_{jmt}^{ATI}, \tag{16}$$

$$mc_{jmt}^{ATI\_cvout} = \gamma W_{jmt} + \varepsilon_{jmt}^{ATI\_cvout}, \tag{17}$$

where W_{jmt} is a vector of marginal cost shifting variables, while θ and γ are the associated vectors of parameters. ε_{jmt}^{ATI} and $\varepsilon_{jmt}^{ATI\_cvout}$ are components of marginal cost that are unobserved to us the researchers, which we assume to be random and each have a mean of zero.

Last, substituting equations (16) and (17) into (14) and (15) yields the following empirical specifications of the supply equations:

$$Model\ h\text{:}\ \ p_{jmt} = \theta W_{jmt} + \varepsilon_{jmt}^{ATI} + mkup_{jmt}^{ATI}, \tag{18}$$

$$Model\ g\text{:}\ \ p_{jmt} = \gamma W_{jmt} + \varepsilon_{jmt}^{ATI\_cvout} + mkup_{jmt}^{ATI\_cvout}, \tag{19}$$

where ε_{jmt}^{ATI} and $\varepsilon_{jmt}^{ATI\_cvout}$ are the structural error terms. The key objective of the empirical analysis is to estimate these two alternate structural supply equations (*Model h* versus *Model g*), and evaluate which of the two has better statistical support from the data.

Our methodology is to first estimate the demand parameters, use these demand parameter estimates to compute product markups under each alternate pricing behavior ($mkup_{jmt}^{ATI}$ versus $mkup_{jmt}^{ATI\_cvout}$), then use these product markups as variables when estimating the alternate supply equations, *Model h* and *Model g*. Finally, in the spirit of Villas-Boas (2007), Gayle

(2013), and Gayle and Brown (2014), we use non-nested statistical tests based on Vuong (1989) to see which supply specification best fits the data. Note that the estimated markups ($mkup_{jmt}^{ATI}$ versus $mkup_{jmt}^{ATI\_cvout}$) are different under each alternate pricing behavior, as such, the competing estimated supply equations are not nested, which is why a non-nested statistical test is needed to evaluate which supply model best fits the data.

5. Estimation and Results

5.1 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:

$$\ln(S_{jmt}) - \ln(S_{0mt}) = x_{jmt}\phi^{x} - \phi^{p}p_{jmt} + \delta\ln(S_{jmt/g}) + \xi_{jmt}, \qquad (20)$$

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 (20) needs to take into account the potential endogeneity of p_{jmt} and $S_{jmt/g}$.

5.1.2 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.[12] (1) and (2) instrument for price, while (3) instruments for the within group share.

---

[12] 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.

The instruments for price stem from the fact that price, as shown in equation (11), 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 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.

5.2 Results from Demand Estimation

Table 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 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, all else constant, the more destinations a particular carrier offers service to leaving from the consumer's origin airport, the more likely it is that the consumer will choose to fly with that carrier. 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, consumer 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 partner operating 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.

The coefficient estimates on *Virtual_going* and *Virtual_coming* are negative as well. Thus, all else constant, consumer 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. It is worth noting that the magnitudes of coefficient estimates on the codeshare variables suggest that consumers least prefer virtual codeshare products. This provides additional evidence that consumers have a preference for using products in which the carrier with which they interact when purchasing the travel ticket also provides operating service on at least one segment of the trip. This may be particularly true for international air travel compared to domestic air travel since for international air travel the gap in consumers' familiarity between the ticketing carrier and partner operating carrier(s) may be wider due to the fact that the partner operating carrier(s) is (are) likely to be foreign carrier(s) that is (are) less frequently used by the consumer.

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

To the best of our knowledge this paper is the first to formally investigate and provide evidence of consumers' preference over various types of international codeshare products. However, since this is not the main focus of this research, we leave more detailed investigations of such consumer preferences for future research.

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.

5.3 Prices, Product Markups and Recovered Product Marginal Costs

With the demand parameter estimates in hand, we use these estimates along with the product markup expressions in equations (12) and (13) to compute product markup variables $mkup_{jmt}^{ATI}$ and $mkup_{jmt}^{ATI\_cvout}$, respectively. Table 4 reports summary statistics on these product markups and prices in carve-out markets.

The data in Table 4 reveal that in carve-out markets, on average, ATI partner carriers charge higher prices and have larger markups than other carriers. As expected, ATI partner carriers' product markups generated by the model under the assumption of cooperative behavior between these carriers ($mkup_{jmt}^{ATI}$) are higher than markups generated by the model under the assumption of non-cooperative behavior between these partner carriers ($mkup_{jmt}^{ATI\_cvout}$). Given that our demand model generates elasticity estimates similar to what other researchers have found, and given that standard static oligopoly theory suggests that markups are determined by demand elasticities, then the product markups generated by our model should also be consistent with markups that would be generated from other empirical studies on air travel demand.

Product level marginal costs can be recovered from the alternate supply models by simply subtracting product markups from price, i.e., $p_{jmt} - mkup_{jmt}^{ATI}$ and $p_{jmt} - mkup_{jmt}^{ATI\_cvout}$ yield product level marginal costs under the alternate supply models respectively. The summary statistics in Table 4 suggest that marginal costs of ATI partner carriers' products in their carve-out markets are, on average, higher than the marginal costs of products offered by other carriers in these markets.

Table 4
Summary Statistics on Prices, Product Markups and Recovered Product Marginal Costs

		AA/LA Carve-out Markets		**DL/AF Carve-out Markets**		**UA/AC Carve-out Markets**	
		AA/LA Products	Other Carriers Products	DL/AF Products	Other Carriers Products	UA/AC Products	Other Carriers Products
		Mean (Std. error)	Mean (Std. error)	Mean (Std. error)	Mean (Std. error)	Mean (Std. error)	Mean (Std. error)
Price ($)		1,569.71*** (68.55)	758.30*** (124.40)	1,486.66*** (56.76)	845.98*** (36.35)	723.19*** (28.04)	586.16*** (21.83)
Product Markups ($)	Assuming ATI Partners Non-cooperatively Set Prices $\left(mkup_{jmt}^{ATI\_cvout}\right)$	473.92*** (0.40)	466.94*** (0.05)	486.19*** (0.44)	467.54*** (0.05)	480.40*** (0.24)	467.65*** (0.06)
	Assuming ATI Partners Cooperatively Set Prices $\left(mkup_{jmt}^{ATI}\right)$	479.34*** (0.25)	466.94*** (0.05)	490.69*** (0.36)	467.54*** (0.05)	480.96*** (0.17)	467.65*** (0.06)
Recovered Marginal Cost ($)	Assuming ATI Partners Non-cooperatively Set Prices $\left(p_{jmt} - mkup_{jmt}^{ATI\_cvout}\right)$	1,095.80*** (68.43)	291.36** (124.39)	1,000.48*** (56.86)	378.44*** (36.35)	242.78*** (28.03)	118.51*** (21.82)
	Assuming ATI Partners Cooperatively Set Prices $\left(p_{jmt} - mkup_{jmt}^{ATI}\right)$	1090.37*** (68.54)	291.36** (124.39)	995.97*** (56.80)	378.44*** (36.35)	242.22*** (28.04)	118.51*** (21.82)

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

5.4 Results from Estimation of Alternate Supply Equations

As shown in the specification of the structural supply equations (18) and (19), coefficients on product markup variables $mkup_{jmt}^{ATI}$ and $mkup_{jmt}^{ATI\_cvout}$ are restricted to be equal to 1. This coefficient restriction effectively implies that $p_{jmt} - mkup_{jmt}^{ATI}$ and $p_{jmt} - mkup_{jmt}^{ATI\_cvout}$ are the dependent variables in supply *Model h* and *Model g* respectively. In fact, $p_{jmt} - mkup_{jmt}^{ATI}$ and $p_{jmt} - mkup_{jmt}^{ATI\_cvout}$ are recovered marginal costs. Therefore, the coefficients that are actually estimated in the supply equations are marginal cost function parameters associated with the marginal cost shifting variables in W_{jmt} . Since it is assumed that marginal cost shifting variables are exogenous, then we simply estimate supply *Model h* and *Model g* using ordinary least squares.

Recall that the key objective of estimating the alternate supply equations is to examine price-setting behavior of carriers in carve-out markets. Given this objective, it is most appropriate to estimate the supply equations on data from the respective carriers' carve-out markets. The data sample used for estimating the supply equations consist of all products in carve-out markets, not just products offered by ATI partner carriers. Furthermore, in our data sample ATI partners each sell products in each of their carve-out markets. Parameter estimates for supply *Model h* and *Model g* are reported in Table 5.

Table 5. Supply Equation Regressions Estimated using Data from AA/LA, DL/AF and UA/AC Carve-out Markets

	ATI Partners Cooperate in all markets: *Model h*	ATI Partners do not Cooperate in carve-out markets: *Model g*
	Dependent Variable: $p_{jmt} - mkup_{jmt}^{ATI}$	Dependent Variable: $p_{jmt} - mkup_{jmt}^{ATI\_cvout}$
	Coefficient Estimate (Standard error)	Coefficient Estimate (Standard error)
Mc_opres	**7.99*****	**7.84*****
	(2.42)	(2.42)
Mc_opres^2	**-0.05*****	**-0.05*****
	(0.02)	(0.02)
Nonstop_going	**457.82*****	**461.73*****
	(102.50)	(102.52)
Nonstop_coming	**453.46*****	**457.04*****
	(83.98)	(84.03)
Itinerary_dist_going	**0.22**	**0.22**
	(0.17)	(0.17)
Itinerary_dist_coming	**0.19**	**0.19**
	(0.15)	(0.15)
Trad_1_going	**253.99***	**256.84***
	(136.15)	(136.18)
Trad_1_coming	**387.56*****	**390.30*****
	(115.18)	(115.21)
Virtual_going	**120.04**	**121.43**
	(100.87)	(100.93)
Virtual_coming	**145.98**	**147.09**
	(102.81)	(102.86)
Constant	**-2,176.26*****	**-2,167.95*****
	(833.04)	(833.17)
Observations	1,408	1,408
R^2	0.2591	0.2607

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

First, the sign pattern of the coefficient estimates on the size of an airline's airport presence variables (*Mc_opres* and *Mc_opres*^{2}) suggests that the size of an airline's airport presence has a positive marginal impact on the airline's marginal cost at relatively low levels of its airport presence, but eventually has a negative marginal impact on the airline's marginal cost at relatively high levels of its airport presence. These coefficient estimates can be interpreted as capturing the effect of an airline's "hub-size" on its marginal cost. In other words, the sign pattern of these coefficient estimates suggests that an airline is not likely to achieve marginal cost efficiencies in a market until the airline reaches a certain scale of operation at an endpoint airport of the market. Therefore, we believe the size of an airline's airport presence variables in the marginal cost function indirectly capture economies of passenger-traffic densities that airlines can achieve by channeling a relatively large volume of passengers through endpoint airports of the market. [13]

The coefficient estimates for *Nonstop_going* and *Nonstop_coming* are each positive, suggesting that, all else constant, an airline's marginal cost is higher for providing nonstop itineraries versus itineraries that require intermediate stop(s). A rationale for intermediate stop(s) itineraries being associated with lower marginal cost compared to nonstop itineraries is that airlines often channel passengers from different origins, who have common destinations, through common intermediate stop hub airport(s). This practice allows airlines to better fill individual flights, which can result in the airline incurring a lower cost per passenger to transport passengers, i.e., an airline can exploit economies of passenger-traffic density by using intermediate stop(s).

Even though the coefficient estimates on the itinerary flying distance variables (*Itinerary_dist_going* and *Itinerary_dist_coming*) are not statistically significant at conventional levels of statistical significance, these coefficient estimates have the expected positive sign in the marginal cost function. The coefficient estimates on these variables suggest that itinerary flying distance positively affect marginal cost, likely driven by the link between fuel usage and flying distance.

---

[13] We also consider specifications of marginal cost that allow for a more explicit capture of economies of passenger-traffic densities. Specifically, such marginal cost equation specifications include as right-hand-side variables (linear and quadratic) the total number of passengers using an airline's products at the origin airport for these products. The idea is that as the volume of passengers that an airline serves at an origin airport increases, economies of passenger-traffic density effect should lower the marginal cost to the airline of providing products that have the airport as an origin. In these marginal cost regression specifications, consistent with the eventual impacts of economies of passenger-traffic density, we obtain a positive coefficient estimate on the linear part of this right-hand-side variable, but a negative coefficient estimate on the quadratic part of this variable. We are happy to provide these regression results upon request.

The positive coefficient estimates on the traditional codeshare variables (*Trad_1_going* and *Trad_1_coming*) suggest that airlines' marginal cost of providing these codeshare itineraries is higher compared to providing pure online itineraries.[14] The relatively higher marginal cost associated with these codeshare itineraries may be related to inefficiencies associated with transferring passengers across the networks of partner carriers. Interestingly, the coefficient estimates on the virtual codeshare variables (*Virtual_going* and *Virtual_coming*) are statistically insignificant at conventional levels of statistical significance, suggesting that the marginal cost of providing virtual codeshare itineraries is statistically equal to the marginal cost of providing pure online itineraries. As is the case for pure online itineraries, passengers are not required to travel across different carriers networks on virtual codeshare itineraries, which rules out inefficiencies associated with transferring passengers across the networks. As such, the statistical equality of marginal costs associated with providing pure online and virtual codeshare itineraries is consistent with the rationale we posit for traditional codeshare itineraries having higher marginal cost compared to pure online itineraries.

6. Results from Assessing Cooperative Behavior in Carve-out Markets

Up until this point we have not determine which of the two alternate structural supply equations best approximates strategic interaction between ATI partner carriers in their carve-out markets. For this investigation we rely on a likelihood-based non-nested statistical test in Vuong (1989). The Vuong (1989) non-nested statistical test is used to compare which of the two alternate non-nested supply model regressions shown in Table 5 has better statistical support from the data. The test statistic, t, for the non-nested test is calculated as follows:

$$t = \frac{\sum_{i=1}^{n}(LL_i^{ATI}(\hat{\theta}) - LL_i^{ATI\_cvout}(\hat{\gamma}))}{\left(n^{1/2}\right)\hat{\omega}}, \tag{21}$$

where $\hat{\theta}$ and $\hat{\gamma}$ are the parameter estimates from the two respective models; $LL_i^{ATI}(\hat{\theta})$ and $LL_i^{ATI\_cvout}(\hat{\gamma})$ are the log-likelihood function values for observation i from the two respective

---

[14] Unlike in the full data sample used for estimating the demand model, the data subsample (carve-out markets) used for estimating the supply equations do not have products with traditional codeshare itineraries that are of the *Trad_2_going* and *Trad_2_coming* type. The products with traditional codeshare itineraries in the data subsample used for estimating the supply equations are only of the *Trad_1_going* and *Trad_1_coming* type.

models; n is the number of observations; and $\hat{\omega}$ is the standard error of the differences in the log-likelihood function values. The test statistic is asymptotically normally distributed. The null hypothesis is that the two models are statistically equivalent. Given critical values, $-c$ and c, we cannot reject the null hypothesis when $-c < t < c$, but 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 (*Model h*). In the case that $t < -c$, then the data better support the model in which the ATI partners do not cooperate in carve-out markets (*Model g*).

For the two supply models in Table 5 the value of the non-nested test statistic, t, is 2.8883. Since this test statistic value is positive and greater than the 5% critical value of 1.64 for a one-tail test, then we conclude that at conventional levels of statistical significance, the data better statistically support the supply model that is estimated under the assumption that ATI partners cooperate in all markets (*Model h*). In other words, in spite of policymakers forbidding cooperative behavior among ATI partners in carve-out markets, the evidence suggests that ATI partners, perhaps tacitly, manage to achieve cooperative outcomes in carve-out markets.

7. Conclusion

The primary goal of this paper is to empirically determine the extent of ATI partners' cooperative behavior in their carve-out markets. Upon first estimating a differentiated products demand model, then specifying a Nash price-setting game between airlines that offer these differentiated products, we are 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 cooperatively set their product prices in markets designated as carve-outs; and (2) where we assume the ATI partner carriers non-cooperatively set their product prices in their 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. For the three ATI partner pairings we study - American (AA)/LAN-Chile (LA), Delta (DL)/Air France (AF) and United (UA)/Air Canada (AC) - the non-nested test result suggests that the model in which these partner carriers jointly/cooperatively set their product prices in markets designated as their carve-out markets has better statistical support from systematic patterns in the data.

To the best of our knowledge this paper is the first to formally investigate and provide evidence of consumers' preference over various types of international codeshare products. Specifically, estimates from our demand model suggest that consumers least prefer virtual codeshare products. This provides evidence that consumers have a preference for using products in which the carrier with which they interact when purchasing the travel ticket also provides operating service on at least one segment of the trip.

A well established literature that may have implications for the issues examined in this paper is the literature that posits the idea of mutual forbearance [Bernheim and Whinston (1990); Evans and Kessides (1994); Baum and Korn (1996); Gimeno (1999); Gimeno and Woo (1999); Bilotkach (2011); Zou, Yu and Dresner (2012); Ciliberto and Williams (2014)]. In the field of industrial organization the concept of mutual forbearance posits that a firm will be inclined not to compete aggressively in a given market for fear of retaliation in other markets where it competes with the same firms. In other words, a firm may choose to be more cooperative with other firms in a market when it has substantial multimarket contact (MMC) with these firms. Our empirical analysis shows evidence that, on average, ATI partner carriers jointly/cooperatively set their product prices in markets designated as their carve-out markets. However, it is possible that the strength of this result depends on the extent of MMC between the ATI partner carriers that are servicing the given carve-out market. We leave examining such possibilities for future research.

In summary, the key finding in this research, at a minimum, calls into question the effectiveness of carve-out policy in achieving intended market outcomes. As such, this paper highlights the need for further research to better understand the efficacy of applying carve-out policy.

Appendix

Table A1. 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 A1 Cont. 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.

References

Baum, Joel A. C and Helaine J. Korn (1996), "Competitive Dynamics of Inter-firm Rivalry," *Academy of Management Journal*, 39 (2): 255-291.

Bernheim, B. Douglas and Michael D. Whinston (1990), "Multimarket Contact and Collusive Behavior," *RAND Journal of Economics*, 21 (1): 1-26.

Berry, Steven T. (1994), "Estimating Discrete Choice Models of Product Differentiation." *RAND Journal of Economics*, 25: 242-262.

Berry, Steven T and Panle Jia (2010), "Tracing the Woes: An Empirical Analysis of the Airline Industry," *American Economic Journal: Microeconomics*, 2 (3): 1-43.

Bilotkach, Volodymyr (2011), "Multimarket Contact and Intensity of Competition: Evidence from an Airline Merger," *Review of Industrial Organization*, 38: 95-115.

Bilotkach, Volodymyr (2005), "Price Competition between International Airline Alliances," *Journal of Transport Economics and Policy*, 39 (2): 167-189.

Bilotkach, Volodymyr and Kai Huschelrath (2011), "Antitrust Immunity for Airline Alliances," *Journal of Competition Law and Economics*, 7 (2): 335-380.

Bilotkach, Volodymyr and Kai Huschelrath (2012), "Airline Alliances and Antitrust Policy: The Role of Efficiencies," *Journal of Air Transport Management*, 21 (12): 76-84.

Brueckner, Jan K. (2001), "The Economics of International Codesharing: An Analysis of Airline Alliances," *International Journal of Industrial Organization*, 19: 1475-1498.

Brueckner, Jan K. (2003a), "The Benefits of Codesharing and Antitrust Immunity for International Passengers, with an Application to the Star Alliance," *Journal of Air Transport Management*, 9: 83-89.

Brueckner, Jan K. (2003b), "International Airfares in the Age of Alliances: The Effects of Codesharing and Antitrust Immunity," *The Review of Economics and Statistics*, 85 (1): 105-118.

Brueckner, Jan K., Darin N. Lee and Ethan S. Singer (2011), "Alliances, Codesharing, Antitrust Immunity, and International Airfares: Do Previous Patterns Persist," *Journal of Competition Law and Economics*, 7(3): 573-602.

Brueckner, Jan K. and Pablo T. Spiller (1994), "Economies of Traffic Density in the Deregulated Airline Industry," *Journal of Law and Economics*, Vol. XXXVII, pp. 379 – 415.

Brueckner, Jan K. and Pierre M. Picard (2013), "Airline Alliances, Carve-outs and Collusion," *Review of Network Economics*, 12: 211-227.

Brueckner, Jan K. and Stef Proost (2010), "Carve-outs Under Airline Antitrust Immunity," *International Journal of Industrial Organization*, 28: 657-668.

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

Choi, Jay Pil (2008), "Mergers with Bundling in Complementary Markets," *The Journal of Industrial Economics*, Vol. LVI, No. 3, September 2008, pp. 553 - 577.

Chen, Yongmin and Philip G. Gayle (2007), "Vertical Contracting Between Airlines: An Equilibrium Analysis of Codeshare Alliances," *International Journal of Industrial Organization*, 25: 1046-1060.

Chen, Yongmin and Philip G. Gayle (2014), "Mergers and Product Quality: Evidence from the Airline Industry," Manuscript, *Kansas State University*, 2014.

Ciliberto, Federico and Jonathan Williams (2014), "Does Multimarket Contact Facilitate Tacit Collusion? Inference on Conduct Parameters in the Airline Industry," *RAND Journal of Economics*, Winter 2014, 45 (4): 764-791.

Evans, William N. and Ioannis N. Kessides (1994), "Living by the 'Golden Rule': Multimarket Contact in the U.S. Airline Industry," *Quarterly Journal of Economics*, 109 (2): 341-366.

Flores-Fillol, Ricardo and Rafael Moner-Colonques (2007), "Strategic Formation of Airline Alliances," *Journal of Transport Economics and Policy*, 41: 427-449.

Gasmi, F., J. J. Laffont and Q. Vuong (1992), "Econometric Analysis of Collusive Behavior in a Soft-Drink Market," *Journal of Economics & Management Strategy*, 1: 277-311.

Gayle, Philip G. (2013), "On the Efficiency of Codeshare Contracts Between Airlines: Is Double Marginalization Eliminated?," *American Economic Journal: Microeconomics*, 5 (4): 244-273.

Gayle, Philip G. and Dave Brown, (2014) "Airline Strategic Alliances in Overlapping Markets: Should Policymakers be Concerned?" *Economics of Transportation*, Volume 3, Issue 4, December 2014, Pages 243–256.

Gayle, Philip G. and Xin Xie, (2014), "Firms' Markup, Cost, and Price Changes when Policymakers Permit Collusion: Does Antitrust Immunity Matter?" Manuscript, *Kansas State University*, 2014.

Gimeno, Javier (1999), “Reciprocal Threats in Multimarket Rivalry: Staking out 'spheres of influence' in the U.S. Airline Industry,” *Strategic Management Journal*, 20: 101-128.

Gimeno, Javier and Carolyn Y. Woo (1999), “Multimarket Contact, Economies of Scope, and Firm Performance,” *Academy of Management Journal*, 43(3): 239-259.

Gresik, Thomas A. and Edward C. Mansley, (2001), “The Strategic Effects of Batch Processing,” *International Economic Review*, Vol. 42, No. 3, August 2001, Pages 697-728.

Hassin, Orit and Oz Shy (2004), “Code-sharing Agreements and Interconnections in Markets for International Flights,” *Review of International Economics*, 12: 337-352.

Ito, Harumi and Darin Lee (2007), “Domestic Codesharing, Alliances and Airfares in the U.S. Airline Industry,” *Journal of Law and Economics*, 50: 355-380.

Kadiyali, Vrinda, K. Sudhir and Vithala R. Rao (2001), “Structural Analysis of Competitive Behavior: New Empirical Industrial Organizations Methods in Marketing,” *International Journal of Research in Marketing*, 18: 161-186.

Park, Jong-Hun and Anming Zhang (2000), “An Empirical Analysis of Global Airline Alliances: Cases in North Atlantic Markets,” *Review of Industrial Organization*, 16: 367-383.

Peters, Craig (2006), “Evaluating the Performance of merger Simulation: Evidence from the U.S. Airline Industry,” *Journal of Law and Economics*, 49: 627-649.

U.S. Department of Transportation Office of the Secretary, Final Order 2008-5-32, May 22, 2008. < http://www.regulations.gov/#!documentDetail;D=DOT-OST-2007-28644-0185;oldLink=false>.

Villas-Boas, Sofia Berto (2007), “Vertical Relationships between Manufacturers and Retailers: Inference with Limited Data, ” *Review of Economic Studies*, Vol. 74, No. 2, pp. 625 - 652.

Vuong, Quang H. (1989), “Likelihood Ratio Tests for Model Selection and Non-Nested Hypotheses,” *Econometrica*, 57: 307-333.

Whalen, W. Tom (2007), “A Panel Data Analysis of Code-sharing, Antitrust Immunity, and Open Skies Treaties in International Aviation Markets,” *Review of Industrial Organization*, 30: 39-61.

Zou, Li, Chunyan Yu and Martin Dresner (2012), "Multimarket Contact, Alliance Membership, and Prices in International Airline Markets," *Transportation Research Part E*, 48: 555-565.