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CHAPTER _____

**Joint Ventures in the
Transatlantic Airline Market¹**

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Abstract

This study investigates, both theoretically and empirically, the effects of joint ventures on traffic. Although alliances are a pre-condition for joint ventures, both cooperation agreements differ in their nature. The reason is that alliances are revenue-sharing agreements whereas joint ventures also involve a cost-sharing commitment. Our empirical analysis focuses on the transatlantic market including non-stop routings (interhub markets) and one-stopover routings (interline markets). Our theoretical and empirical findings emphasize the relevance of economies of traffic density and reveal a positive effect of joint ventures on traffic, both in interhub and interline markets.

Keywords: alliances; joint ventures; interhub markets; interline markets; economies of traffic density.

JEL Classification Numbers: L13; L22; L93.

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1. Introduction

The air transport sector has witnessed a number of innovations since its deregulation. Although these innovations affect many dimensions (such as the adoption of new aircraft technologies and business models or the implementation of novel yield management practices), the proliferation of sophisticated and complex cooperation agreements among airlines has been particularly notable in recent years.

Given their global relevance, the air-transportation literature has mostly focused on the study of airline alliances. In fact, most network carriers in the world belong to one of the “three big alliances”: Oneworld, Star Alliance, and SkyTeam. However, airlines are increasingly adopting alternative forms of cooperation, which can either be *softer* than standard alliances such as cross-equity partnerships, or *deeper* such as joint ventures.

In comparison with an alliance, a joint venture constitutes a step further in terms of cooperation and, therefore, alliances are a pre-condition for joint ventures. However, both cooperation agreements differ in their nature. The reason is that alliances are revenue-sharing agreements whereas joint ventures also involve a cost-sharing commitment.

More precisely, a joint venture usually implies *partial* cost sharing on a certain route where the two carriers work together while they remain separate entities. This involves the cooperation on certain cost components implying, e.g., joint purchase of fuel, ground handling, catering and other supplies or joint use of marketing and Global Distribution Systems (GDS). In the case of a full joint venture, partner airlines behave as a merged entity at the route level. These agreements are also called metal-neutral joint ventures since both revenues and costs are shared proportionally no matter which airline actually operates the flights on a route. An example of this kind of joint venture would be the agreement among Air France/KLM, Delta/Northwest, and Alitalia on the route between Atlanta and Paris.

The studies on the impact of alliances reveal a positive effect yielding lower fares and higher traffic volumes in interline markets due to the elimination of a negative externality stemming from double-marginalization. By contrast, the effect of alliances on interhub markets where airline networks overlap could be anticompetitive due to airlines’ tacit collusion (see Brueckner, 2001). This would justify the need of carve-outs to compensate for this negative effect in interhub markets while preserving the positive effect in interline markets (see Brueckner and Proost, 2010; and Gayle and Thomas, 2016).

Our study aims at extending this analysis to the realm of cost-sharing agreements. We analyze both

theoretically and empirically the effect of joint ventures on traffic in interline and interhub markets. Our theoretical analysis is based on the model in Fageda *et al.* (2019) and derives the predictions that are tested in the empirical part of this chapter. Our empirical analysis focuses on the transatlantic market including non-stop routings (interhub markets) and one-stopover routings (interline markets). We use quarterly data at the airline-routing level for the period 2010-2017 with approximately 14,400 observations for interhub and 178,000 for interline markets.

The main novelty of our analysis is its focus on joint venture agreements and the use of a unique dataset with information on non-stop and connecting passengers on transatlantic routings, characterized by a rich variation in the degree of airline cooperation. Only the studies of Calzaretta *et al.* (2017), Bilotkach and Hüscherlath (2019), and Fageda *et al.* (2019) provide some specific insights about the effects of joint ventures. As a particular merit, our analysis is based on: *i*) the differentiation between revenue-sharing and cost-sharing agreements, *ii*) the distinction between interhub and interline markets, and *iii*) the consideration of both economies of traffic density and decreasing returns.

Our main findings can be summarized as follows. Theoretically, in the presence of economies of traffic density (i.e., increasing returns) the effect of deeper joint ventures on traffic is positive in both interhub and interline markets. With decreasing returns (i.e., severely congested airports), the ultimate effect on the equilibrium traffic could be negative. Our empirical analysis finds an increase of traffic associated with joint ventures both for interhub and interline markets. This is true for all the considered subsamples and could be related to the presence of economies of traffic density in the transatlantic airline market. Therefore, our theoretical and empirical findings coincide in indicating a positive effect of joint ventures on traffic and emphasize the relevance of economies of traffic density in deriving this result.

The rest of this paper is organized as follows. In the next section, we present a literature review. The theoretical framework is presented in Section 3. Section 4 explains the data, specifies the empirical model, and reports the regression results. The last section contains our concluding remarks along with some policy implications.

2. Literature review

The theoretical literature is rather scarce and has mainly focused on the study of airline alliances.⁵ While Brueckner (2001) analyzes the effect of alliances on fares, Flores-Fillol and Moner-Colonques (2007)

⁵See Bilotkach (2019) for a recent exhaustive review on the effects of airline alliances.

focus on their profitability using a game-theoretic approach. Finally, Brueckner and Proost (2010) study the effect of carve-outs, which aim at correcting the potential anticompetitive effects of alliances with antitrust immunity (ATI) on interhub markets.⁶

The empirical literature has mainly focused on the impact of alliances on fares and traffic and their distinguished effects on interhub and interline markets. In interhub markets, no clear evidence has been found about the potential anticompetitive effects of alliances. Oum *et al.* (1996) find that codesharing agreements between non-leader airlines increase output and reduce fares of the market leader airline. Park and Zhang (1998) show that traffic of partner airlines increases on alliance routes more than on non-alliance routes. Brueckner and Whalen (2000) do not find statistically significant increases in fares caused by an alliance between two previously competitive carriers. By contrast, Gillespie and Richard (2012) obtain that granting ATI to two competing non-stop carriers has a fare effect that is equivalent to the loss of an independent competitor, and fares are significantly higher in markets with fewer independent competitors. Alderighi *et al.* (2015) also find that codesharing agreements may lead to higher fares in non-stop city-pair markets. Bilotkach and Hüscherlath (2013) show that ATI agreements produce a traffic increase on interhub routes operated by the alliance members, whereas a traffic reduction is observed on routes operated by non-partner airlines that connect other endpoints with the partner's hubs. Finally, Bilotkach and Hüscherlath (2019) evaluate the incremental effects of joint ventures on alliance partners in the transatlantic market. They find that joint ventures yield an increase of flight frequency on interhub routes at the expense of other routes.

In interline markets, the evidence is clearly in favor of the hypothesis that incremental levels of cooperation between airlines (mainly, codesharing and ATI) lead to fare reductions. This conclusion can be inferred from the results obtained in the studies made by Brueckner and Whalen (2000), Brueckner (2003), Whalen (2007), Brueckner *et al.* (2011), and Calzaretta *et al.* (2017). Whalen (2007) also finds that alliances are associated with large increases in passenger volumes. The reason underlying the fare reduction is the elimination of the double marginalization externality that arises when airlines are unallied. Only the study of Zou *et al.* (2011) find evidence of higher fares with alliances in interline markets. They show that this result may be explained by the fact that complementary alliances provide connecting passengers with improved transfer services and greater convenience, as for instance, shorter layover time, one-stop check-in, more flexible scheduling, and shared frequent flyer programs. These enhanced services lead to an increased willingness of passengers to pay higher fares.

⁶Other theoretical studies on alliances include Park (1997), Park and Zhang (1998), Park *et al.* (2001), Hassin and Shy (2004), Bilotkach (2005), Heimer and Shy (2006), Zhang and Zhang (2006), Flores-Fillol and Moner-Colonques (2007), Brueckner and Proost (2010), and Fageda *et al.* (2019).

3. Theoretical model

Next, we present a reduced version of the model in Fageda *et al.* (2019) which allows us to derive the predictions that are subject to empirical testing later on.

3.1. Network

We assume a simple 2-airline-2-hub network that includes one interhub and one interline market, as observed in Fig. 1. The interhub market (hereafter market H) comprises all trips between hub airports H_1 and H_2 and the interline market (hereafter market S) encompasses trips between spoke airports S_{1k} and $S_{2\ell}$. For simplicity, we assume no market demand in the remaining potential markets (i.e., markets $S_{1k}-H_1$, $S_{1k}-H_2$, $S_{2\ell}-H_1$, $S_{2\ell}-H_2$) since the inclusion of these markets does not provide any relevant insight and distracts attention from the main economic intuitions that affect markets H and S.⁷

- Insert Fig. 1 here -

All trips initiated in spoke S_{1k} are carried out by airline 1, whereas all trips initiated in spoke $S_{2\ell}$ are carried out by airline 2. Thus, there is a demand for a composite good (or system) in market S, where each complementary input is provided by a different monopoly firm (e.g., a trip initiated at spoke S_{1k} is composed by a service between S_{1k} and H_2 provided by airline 1 and another complementary service between H_2 and $S_{2\ell}$ provided by airline 2). By contrast, carriers compete in market H where there is network overlap. Finally, we also assume that all outbound trips come along with the corresponding return service, i.e., they are round trips. This allows us to treat equally all passengers in market S independently of whether they are located in spoke S_{1k} or $S_{2\ell}$.⁸

3.2. Revenues

Let us denote fares and quantities in markets H and S by p_H , p_S , q_H , and q_S . Direct and inverse demand

⁷Brueckner (2001) proposes a model to study the effects of airline alliances under constant returns by considering a positive demand in every potential city-pair market. He concludes that the relevant effects occur in the interhub and interline markets. Consequently, Brueckner and Proost (2010) focus on these two markets by assuming no market demand in the remaining potential markets. We follow this approach because it yields a more tractable setting that allows studying more sophisticated cooperation agreements and cost technologies.

⁸Relaxing this simplifying assumption would introduce asymmetries into the analysis since airlines would need to set two different partial prices for passengers located in S_{1k} and $S_{2\ell}$. While this would make the analysis substantially more cumbersome, it would not offer any additional insight.

functions in both markets are assumed to be identical and given by $d(\cdot)$ and $D(\cdot)$, respectively.⁹ Airlines are assumed to be symmetric. Competition in market H is à la Cournot, i.e., carrier i chooses its quantity q_H^i to maximize profits. By contrast, as in market S there is an demand for a composite good, carrier i chooses monopolistically a subfare p_S^i for its complementary input, so that the total fare in this market is $p_S^i + p_S^j$, with $i, j = 1, 2$ and $i \neq j$.¹⁰ Therefore, the total revenue for airline i can be written as

$$R^i = p_S^i d(p_S^i + p_S^j) + D(q_H^i + q_H^j) q_H^i. \quad (1)$$

3.3. Costs

In network analysis, while revenues are associated with markets, costs are related to links or routes. A carrier's operating cost on a route can be decomposed into several components related to the purchase of fuel, ground handling, catering and other supplies or marketing and GDS. Carrier i 's cost function is assumed to be additively separable in these cost components, which are given by $C_m = a_m C[Q]$, with $m = 1, \dots, M$ and Q being the total traffic carried by the airline on this route. Normalizing $\sum_{m=1}^M a_m = 1$, the cost borne by each airline on a route becomes $\sum_{m=1}^M C_m = C[Q]$.¹¹

Each airline bears the cost $C[Q]$ of operating the spoke-to-hub routes and the hub-to-hub route, where $C' > 0$ and $C'' \leq 0$. Therefore, the analysis encompasses the following cases: economies of traffic density ($C'' < 0$), constant returns ($C'' = 0$), and decreasing returns ($C'' > 0$). The latter case typically arises in the presence of airport congestion.

The cost of operating a route stems from the *total* traffic that passes through it. In particular, total traffic on the hub-to-hub route is the sum of traffic in markets S and H, while traffic on spoke-to-hub routes comes exclusively from market S. Furthermore, the existing duopoly competition in market H can be

⁹Notice that $d(\cdot)$ denotes the aggregate demand in all interline markets. Thus, in the case that spokes have the same number of consumers, demand in each interline market is $d(\cdot)/2KL$, where the 2 factor reflects that trips can be initiated at either S_{1k} or S_{2k} .

¹⁰While choosing either prices or quantities is equivalent in market S (since there are two local monopolies), the existence of a composite good implies having partial prices (i.e., subfares) as firms' choice variables.

¹¹This functional form can be rationalized assuming cost minimization under commonly used production technologies, such as general CES technologies of the form $Q = A[\sum_{m=1}^M \beta_m x_m^\rho]^{1/\epsilon}$, where Q is total output, x_m is input m , $\epsilon > 0$ denotes the returns-to-scale parameter, $A > 0$, $0 < \beta_m < 1$, and $\rho \leq 1$. The case $\epsilon < 1$ indicates decreasing returns, $\epsilon = 1$ constant returns, and $\epsilon > 1$ increasing returns. With these technologies, minimization of production costs $\sum_{m=1}^M C_m = \sum_{m=1}^M r_m x_m$, where r_m denotes the price of cost component m , gives rise to conditional input demand functions given by $x_m = f_m(r_1, \dots, r_M) Q^{1/\epsilon}$. Therefore, the resulting cost function is $\sum_{m=1}^M C_m = \sum_{m=1}^M a_m Q^{1/\epsilon} = Q^{1/\epsilon}$, with $a_m = r_m f_m(r_1, \dots, r_M)$ (and normalizing $\sum_{m=1}^M a_m = 1$). As it can be observed, $\sum_{m=1}^M C_m = C[Q] = Q^{1/\epsilon}$, implying that all cost components are evaluated at the same output level and inherit symmetrically the returns to scale exhibited by the production function.

affected by cost-sharing agreements, such as joint ventures and mergers.

A joint venture implies partial cost sharing on a certain route where the two carriers work together while they remain separate entities. Such agreements are halfway between the polar cases of independent firms (no cost sharing) and a merger (full cost sharing).

At this point, denoting C_{HH}^i airline i 's cost related to operating the hub-to-hub route, we can distinguish three cases depending on the presence and intensity of cost sharing on this route:

i) Absence of joint ventures (i.e., no cost sharing), where $C_{HH}^i = C[q_S^i + q_H^i]$.

ii) Merger (i.e., full cost sharing), where $C_{HH}^i = C[q_S + q_H]/2$.¹² This is the case of a *merger of equals* where there is a joint cost that is shared 50/50 between the two airline partners.¹³

iii) Joint venture (i.e., partial cost sharing), where there is cooperation on some cost components $m=1, \dots, \omega$ while the rest of components $m=\omega+1, \dots, M$ remain independently borne by each airline, so that $C_{HH}^i = \sum_{m=1}^{\omega} a_m C[q_S + q_H]/2 + \sum_{m=\omega+1}^M a_m C[q_S^i + q_H^i]$. Denoting $\mu \in [0, 1]$ the scope of joint ventures, understood as the share of cost components on which there is airline cooperation (i.e., $\mu \equiv \sum_{m=1}^{\omega} a_m$), the above cost function becomes $C_{HH}^i = \mu C[q_S + q_H]/2 + (1 - \mu)C[q_S^i + q_H^i]$.¹⁴

The presence of economies of traffic density ($C'' < 0$) creates cost synergies from pooling resources and $C[q_S + q_H]/2 < C[(q_S + q_H)/2]$ can be observed. In such a case, deeper cost-sharing agreements become more advantageous. Regarding decreasing returns, it is assumed that they are bounded from above in the following way: $C' \left[\frac{q_S + q_H}{2} \right] > \frac{C'[q_S + q_H]}{2}$.¹⁵ In general terms, carrier i 's overall cost is given by

$$C^i = \underbrace{C[q_S]}_{C_{SH}^i} + \underbrace{\mu C[q_S + q_H]/2 + (1 - \mu)C[q_S^i + q_H^i]}_{C_{HH}^i}, \quad (2)$$

where C_{SH}^i denotes airline i 's cost related to operating the *spoke-to-hub* route and the aforementioned three cost-sharing agreements on the hub-to-hub route can be derived.¹⁶ Using $q_S^i = \frac{d(p_S^i + p_S^j)}{2}$, $q_S =$

¹²In a symmetric equilibrium, we have $q_S^i = q_S/2$ and $q_H^i = q_H/2$.

¹³The distinction between $C_{HH}^i = C[q_S^i + q_H^i]$ and $C_{HH}^i = C[q_S + q_H]/2$ is the key element to model cost synergies in Brueckner and Proost (2010).

¹⁴An alternative way of modeling joint ventures would be to assume that they involve a certain share μ of total traffic on the hub-to-hub route. In such a case, airline i 's cost would become $C_{HH}^i = C[(1 - \mu)(q_S^i + q_H^i)] + C[\mu(q_S + q_H)]/2$. Notice that both approaches are equivalent in the case of constant returns.

¹⁵The main results of our analysis do not depend on this assumption. However, assuming a limit in the convexity of the cost function under decreasing returns allows ruling out an empirically irrelevant case and renders the analysis more tractable.

¹⁶Notice that, when carriers' technology exhibits constant returns, the effect of μ vanishes because $C[q_S + q_H]/2 = C[(q_S + q_H)/2]$ and (2) becomes $C^i = C[q_S] + C[q_S^i + q_H^i]$.

$d(p_S^i + p_S^j)$, and $q_H = q_H^i + q_H^j$, the overall cost in (2) can be rewritten as

$$C^i = C[d(p_S^i + p_S^j)] + (1 - \mu)C \left[\frac{d(p_S^i + p_S^j)}{2} + q_H^i \right] + \mu \frac{C[d(p_S^i + p_S^j) + q_H^i + q_H^j]}{2}. \quad (3)$$

3.4. A unified model of cooperation agreements

Airline cooperation agreements may involve revenue sharing and/or cost sharing. Revenue-sharing partnerships are modeled as cross-equity (or cross-ownership) agreements.¹⁷ We denote δ the scope of alliances with $\delta \in [0, 1]$, so that airline i 's profit is

$$\Pi^i = \pi^i + \delta \pi^j, \quad (4)$$

where $\pi^i = R^i + C^i = p_S^i d(p_S^i + p_S^j) + D(q_H^i + q_H^j) q_H^i - C[q_S] - \frac{\mu C[q_S + q_H]}{2} - (1 - \mu)C[q_H^i + q_H^j]$.

Alternatively, alliances can also be interpreted as revenue-sharing agreements in a proportion δ of traffic in markets S and H.

Cross-equity agreements are labeled as revenue-sharing agreements (and not profit-sharing agreements) to emphasize the fact that they do not imply any kind of cost-sharing. More precisely, even in the case of a full alliance (i.e., $\mu=0$, $\delta=1$), where airline i maximizes $\Pi^i = \pi^i + \pi^j = R^i + R^j - C^i - C^j$, no cost synergies from pooling resources would be exploited (the two cost terms are independent). Differently, in the case of a merger (i.e., $\mu=1$, $\delta=1$), we would have revenue sharing and a single cost term, meaning that cost synergies are exploited.

Recognizing that $q_S = d(p_S)$, $p_S = D(q_S)$, $D'(q_S) = 1/d'(p_S)$ and focusing on the symmetric equilibrium where $q_H^1 = q_H^2 = q_H/2$ and $p_S^1 = p_S^2 = p_S/2$, the maximization of Π^i choosing p_S^i and q_H^i yields two first-order conditions that can be rewritten as

$$\Lambda_S = \frac{2}{1 + \delta} q_S D'(q_S) + D(q_S) - 2C'[q_S] - (1 - \mu)C' \left[\frac{q_S + q_H}{2} \right] - \mu C'[q_S + q_H] = 0, \quad (5)$$

¹⁷A similar approach is followed in Zhang and Zhang (2006).

$$\Lambda_H = D(q_H) + \frac{1 + \delta}{2} q_H D'(q_H) - (1 - \mu) C' \left[\frac{q_S + q_H}{2} \right] - (1 + \delta) \mu \frac{C'[q_S + q_H]}{2} = 0. \quad (6)$$

The analysis of the second-order conditions is discussed in the next section. Depending on the values of μ and δ , the following types of cooperation agreements can be derived.

1. *Independent firms*: $\mu=0$ and $\delta=0$. In this case, there is no revenue or cost sharing. The only cooperation that exists in this scenario consists in the needed coordination to provide the composite good in market S, where each firm provides monopolistically a complementary input.
2. *Soft alliance*: $\mu=0$ and $\delta \in (0,1)$. Soft alliances are partial revenue-sharing agreements where there is some degree of cross-ownership (or cross-equity).
3. *Full alliance*: $\mu=0$ and $\delta=1$. In this scenario, there is full revenue sharing, i.e., airlines maximize joint profits. However, costs on the hub-to-hub link remain firm specific, i.e., firms cannot pool traffic and eliminate one of the links between hubs.
3. *Joint venture*: $\mu \in (0,1)$ and $\delta \in (0,1)$ with $\mu \leq \delta$. Revenue sharing constitutes a necessary condition to implement cost sharing. At this point, we assume $\mu \leq \delta$ since a joint venture constitutes a step further in terms of cooperation (involving both revenue and cost sharing) as compared to an alliance (which just involves revenue sharing).¹⁸
5. *Joint venture with full revenue sharing*: $\mu \in (0,1)$ and $\delta=1$. Under this cooperation agreement, a part from full revenue sharing, cooperation also involves some partial cost sharing.
6. *Merger*: $\mu=1$ and $\delta=1$. A merger is a full joint venture where both firms constitute a new monopoly entity that operates alone in markets S and H.

This unified model allows studying the welfare effects associated with hybrid cooperation agreements, which are increasingly observed in the airline industry. Interestingly, the model could also be adapted to accommodate the potential presence of carve-outs. Carve-outs are intended to correct for the possible anticompetitive effects of alliances in the interhub market (where there is network overlap) by preventing revenue sharing between alliance partners when they are endowed with ATI. In terms of our model, for airline i , this would require to introduce a new parameter $\gamma \in [0,1]$ in the interhub revenues coming from its partner airline (i.e., in π^j).¹⁹ This would have no effect on (5), while (6) would become

¹⁸It could be argued that cost-sharing agreements under decreasing returns may be unnatural. However, it makes sense to include this possibility because they are commonly observed in reality since joint ventures (and especially mergers) between airlines involve many routes characterized by different types of returns. In addition, joint ventures also imply revenue sharing (i.e., $\mu \leq \delta$). Therefore, even if there are negative effects stemming from cost sharing agreements under decreasing returns, such effects could be overcome by the positive ones implied by revenue sharing. Finally, it should be noticed that we are not studying the equilibrium in the formation of airline cooperation agreements but the effect of such potential agreements on consumer welfare.

¹⁹In this case, airline i 's profit in (4) would become

$\Lambda_H = D(q_H) + \frac{1+\delta\gamma}{2}q_H D'(q_H) - (1-\mu)C' \left[\frac{q_S+q_H}{2} \right] - (1+\delta)\mu \frac{C'[q_S+q_H]}{2} = 0$. A *full alliance with a carve-out* would be obtained for $\delta=1$, $\mu=0$, and $\gamma=0$, recovering the result in Brueckner and Proost (2010).²⁰ As the effect of carve-outs is already analyzed in detail in the aforementioned study and would divert attention from the main focus of our analysis (which is to study joint ventures), we have refrained from incorporating this additional parameter that would complicate the exposition of our main results.²¹

3.5. The effect of joint ventures

As suggested above, the scope of alliances (δ) and the scope of joint ventures (μ) allow distinguishing the different kinds of cooperation agreements. In this section, we analyze the effect of μ on traffic in markets S and H.²²

The following conditions are assumed to hold

$$\frac{\partial \Lambda_S}{\partial q_S} < 0, \quad \frac{\partial \Lambda_H}{\partial q_H} < 0. \quad (7)$$

$$\Gamma \equiv \frac{\partial \Lambda_S}{\partial q_S} \frac{\partial \Lambda_H}{\partial q_H} - \frac{\partial \Lambda_S}{\partial q_H} \frac{\partial \Lambda_H}{\partial q_S} > 0. \quad (8)$$

These inequalities coincide with the second-order conditions in the full alliance and merger cases (i.e., when $\delta=1$) and do not exactly match them in the rest of the cases (a similar approach is followed in Brueckner and Proost, 2010).²³

$$\begin{aligned} \Pi^i = & \underbrace{\left\{ p_S^i d(p_S^i + p_S^j) + D(q_H^i + q_H^j) q_H^i - C[q_S] - \frac{\mu C[q_S + q_H]}{2} - (1-\mu)C[q_H^i + q_H^j] \right\}}_{\pi^i} \\ & + \delta \underbrace{\left[p_S^j d(p_S^i + p_S^j) + \gamma D(q_H^i + q_H^j) q_H^j - C[q_S] - \frac{\mu C[q_S + q_H]}{2} - (1-\mu)C[q_H^i + q_H^j] \right]}_{\pi^j}. \end{aligned}$$

¹⁹More recently, Gayle and Thomas (2016) analyze the effect of carve-outs using data from international air travel where at least one segment on the itinerary is operated by a US carrier. They conclude that carve-outs may not be effective in preventing airline cooperation in practice.

²¹More information is available from the authors on request.

²²The analysis of the effect of δ on traffic can be found in Fageda *et al.* (2019).

²³The sufficient conditions that ensure $\frac{\partial \Lambda_S}{\partial q_S} < 0$, $\frac{\partial \Lambda_H}{\partial q_H} < 0$, and $\Gamma > 0$ are available from the authors on request. The general second-order conditions, which can be computed from $\frac{\partial^2 \Pi^i}{\partial (p_S^i)^2}$, $\frac{\partial^2 \Pi^i}{\partial (q_H^i)^2}$, and $\frac{\partial^2 \Pi^i}{\partial p_S^i \partial q_H^i}$, are also available from the authors on request. As explained in Fageda *et al.* (2019), with linear expressions for demand and marginal cost, an upper bound on the intensity of economies of traffic density is required to ensure compliance with second-order conditions and positivity of marginal costs.

We can now consider the effect of a change in the scope of alliances on the traffic in the interline and the interhub markets. Totally differentiating (5) and (6) with respect to q_S , q_H , and μ yields

$$\frac{\partial q_S}{\partial \mu} = \frac{-\frac{\overset{?}{\partial \Lambda_S}}{\partial \mu} \frac{\overset{<0}{\partial \Lambda_H}}{\partial q_H} + \frac{\overset{?}{\partial \Lambda_S}}{\partial q_H} \frac{\overset{?}{\partial \Lambda_H}}{\partial \mu}}{\underset{\substack{\Gamma \\ >0}}{\Gamma}}. \quad (9)$$

$$\frac{\partial q_H}{\partial \mu} = \frac{-\frac{\overset{<0}{\partial \Lambda_S}}{\partial q_S} \frac{\overset{?}{\partial \Lambda_H}}{\partial \mu} + \frac{\overset{?}{\partial \Lambda_S}}{\partial \mu} \frac{\overset{?}{\partial \Lambda_H}}{\partial q_S}}{\underset{\substack{\Gamma \\ >0}}{\Gamma}}. \quad (10)$$

From the analysis of these expressions, we obtain the following proposition.

Proposition 1 *The presence of increasing returns (economies of traffic density) constitutes a sufficient condition ensuring that the effect of deeper joint ventures on traffic is positive in both markets.*

The detailed proof is provided in the appendix. A rise in the scope of joint ventures can produce efficiency gains that yield higher traffic levels, i.e., $\frac{\partial q_S}{\partial \mu} > 0$ and $\frac{\partial q_H}{\partial \mu} > 0$. This is always observed in the presence of economies of traffic density ($C'' < 0$), where $\frac{\partial \Lambda_S}{\partial q_H} > 0$, $\frac{\partial \Lambda_H}{\partial q_S} > 0$, $\frac{\partial \Lambda_S}{\partial \mu} > 0$, and $\frac{\partial \Lambda_H}{\partial \mu} > 0$. The reason is that pooling resources by means of cost-sharing agreements leads to a marginal cost reduction, which affects both markets.

When carriers' technology exhibits constant returns ($C'' = 0$), cost sharing does not convey any synergy and the effect of μ vanishes. Therefore, the scope of joint ventures produces no effect on the equilibrium traffic, i.e., $\frac{\partial q_S}{\partial \mu} = \frac{\partial q_H}{\partial \mu} = 0$.

Finally, the pooling of resources implied by deeper joint ventures in the presence of decreasing returns ($C'' > 0$) leads to a marginal cost increase, as it is observed in severely congested airports. In this case, the ultimate effect on the equilibrium traffic could be negative.²⁴

The effect of joint ventures on traffic in interhub and interline markets is tested empirically in the following section.

²⁴Generally, in this case, the sign of $\frac{\partial q_S}{\partial \mu}$ and $\frac{\partial q_H}{\partial \mu}$ is ambiguous since $\frac{\partial \Lambda_S}{\partial q_H} < 0$, $\frac{\partial \Lambda_H}{\partial q_S} < 0$, $\frac{\partial \Lambda_S}{\partial \mu} < 0$, and $\frac{\partial \Lambda_H}{\partial \mu} < 0$.

4. Empirical application

In this section, we propose a novel empirical application to test the effects of joint ventures on traffic in transatlantic routings. Note that on these routings the proportion of the traffic that is channeled by airlines within joint ventures is much higher than in any other geographical market.

4.1. Data and sample

The sample considers one-way routings connecting a North American (US/Canadian) and a European airport.²⁵ It includes non-stop routings (interhub markets) and one-stopover routings (interline markets). An example of an interhub market is the route Detroit-Amsterdam, while an example of an interline market is the routing Houston-Frankfurt-Prague, being Frankfurt the gateway connecting the origin and destination airports. In the case of interline markets, we exclude the routings with competing non-stop connections.

We use quarterly data for the period 2010 (first quarter)-2017 (third quarter) with about 14,400 observations for interhub markets and 178,000 for interline markets. We have complete information for all of our variables. Data is at the airline-routing level. We restrict our attention to: *i*) routings with more than 100 passengers per quarter to have a feasible dataset, and *ii*) urban areas with a population exceeding 300,000 inhabitants to have consistent information for North America and Europe.

Passenger data come from the Official Airlines Guide (OAG). This database includes bookings made through GDS, so that tickets directly sold by airlines are excluded. As control variables, we have the distance of the routing, the population of the urban areas at the origin and destination of the routings, and Gross Domestic Product (GDP) per capita at both endpoints of the routing at the country level. Information on distances comes from RDC Aviation (Innovata data), data on urban population have been obtained from United Nations (World Urbanization Prospects), and GDP per capita is obtained from the World Bank (World Development Indicators).

As a control variable, we also include a dummy for routings where the origin and destination countries have an open skies agreement. This information has been obtained from the US Department of State and Transport Canada, respectively. Regarding the US, European open-skies partners include all

²⁵The European airports include non-EU countries like Russia, Turkey, Ukraine, and other smaller countries.

countries from the EU, Norway, Switzerland, Turkey, Albania, Bosnia and Herzegovina, Georgia, Macedonia (since the last quarter of 2012), Serbia (since the third quarter of 2015), and Ukraine (since the last quarter of 2015). As for Canada, they comprise all countries from the EU and Switzerland since the last quarter of 2010. We also add an additional control variable in interline markets identifying routings having a North American gateway.

Our main variable of interest is a dummy that takes the value one if the routing is affected by a joint-venture agreement between a North American and a European carrier. Table 1 shows the current joint-venture agreements in the transatlantic market. Our empirical analysis identifies any routing affected by joint ventures although we may find differences in the degree of cooperation implied by these agreements (Thomas and Catling, 2014). While the degree of cooperation is strong in all current joint ventures, those led by Delta (Delta-Air France/KLM-Alitalia and Delta-Virgin Atlantic) imply a virtual merger on specific routes.

- Insert Table 1 here -

For interhub markets, the joint venture variable takes the value one when the routing involves two hubs of partner airlines. An example is the routing Atlanta-Amsterdam where both Delta and Air France/KLM operate and are joint-venture partners. Another interhub market affected by a joint venture is Washington-Zurich. However, in this case only United provides air services. Therefore, to distinguish between these two situations, we incorporate a variable that takes value 1 when there is network overlap (i.e., both airlines involved in the joint venture agreement operate). In the aforementioned examples, this overlap variable would take value 1 in the Atlanta-Amsterdam case and 0 in the Washington-Zurich case. Finally, we interact the joint venture variable with the overlap variable so that the joint venture variable can capture the impact of this cooperation agreement on traffic (discounting the effect of overlap), whereas the interaction between the joint venture and the overlap variables captures the differential impact related to network overlap.

For interline markets, the analysis is more complex because we have to distinguish between the routings that are operated by just one airline (*online service*) and the routings where there is cooperation between a North American and a European carrier. In this regard, there is a limitation coming from our dataset because it only provides information of operating carriers on the transatlantic segment. For example, on the routing Indianapolis-Charlotte-Paris, we only know that the Charlotte-Paris connection is operated by American Airlines. Taking this fact into account, we assume that the two segments are operated by the same airline (*online case*) in these two scenarios: *i*) When a North American carrier operates the

transatlantic segment and the gateway is one of their hubs located in North America (e.g., Jacksonville-Miami-Paris where the transatlantic segment is operated by American Airlines), and *ii*) When a European carrier operates the transatlantic segment and the gateway is one of their hubs located in Europe (e.g., Orlando-London-Dublin where the transatlantic segment is operated by British Airways). In all other cases, we assume that there is cooperation between a North American and a European carrier. Therefore, for interline markets, we add two additional control variables: a dummy for routings operated by just one airline (*online case*) and a dummy for routings that have a North American gateway.

We consider airlines to be joint-venture partners when the routing includes two hubs of the airlines involved in the agreement. An example of a routing affected by a joint venture would be Atlanta-Amsterdam-Glasgow, where the transatlantic segment is operated by Delta. In the same way as we do for interhub markets, we interact the joint-venture with the overlap variable. Therefore, since the transatlantic segment is operated by both Delta and Air France/KLM, the overlap variable takes the value 1. Differently, although the routing Washington-Zurich-Athens is affected by a joint venture, the overlap variable takes the value 0 because the transatlantic segment is only operated by United.

Looking at the two types of markets, it is important to highlight that: *i*) for interhub markets, the relevant comparison is simply between routings affected and not affected by joint ventures, whereas *ii*) for interline markets, the relevant comparison has to do with routings affected by joint ventures as compared to other routings unaffected by joint ventures where there is cooperation between two airlines.

4.2. Estimation and results

We estimate the following equations where the dependent variable is the total number of passengers channeled by airline a on routing k in period t .

Interhub markets:

$$\begin{aligned}
 PAX_{akt} = & \beta_0 + \beta_1 \text{Overlap}_{akt} + \beta_2 \text{JV}_{akt} + \beta_3 \text{JVxOverlap}_{akt} + \beta_4 \text{Dist}_{kt} + \beta_5 \text{Pop_origin}_{kt} \\
 & + \beta_6 \text{Pop_destin}_{kt} + \beta_7 \text{GDPpc_origin}_{kt} + \beta_8 \text{GDPpc_destin}_{kt} \\
 & + \beta_9 \text{Open_skies} + \gamma' \text{airline} + \lambda' \text{year} + \mu' \text{quarter} + \nu' \text{airport_origin} \\
 & + \rho' \text{airport_destin} + \varepsilon_{akt}
 \end{aligned} \tag{11}$$

Interline markets:

$$\begin{aligned}
PAX_{akt} = & \beta_0 + \beta_1 \text{Overlap}_{akt} + \beta_2 \text{JV}_{akt} + \beta_3 \text{JVxOverlap}_{akt} + \beta_4 \text{Online}_{akt} + \beta_5 \text{Dist}_{kt} \\
& + \beta_6 \text{Pop_origin}_{kt} + \beta_7 \text{Pop_destin}_{kt} + \beta_8 \text{GDPpc_origin}_{kt} \\
& + \beta_9 \text{GDPpc_destin}_{kt} + \beta_{10} \text{Open_skies} + \beta_{10} \text{NA_gateway}_{kt} + \gamma' \text{airline} \\
& + \lambda' \text{year} + \mu' \text{quarter} + \nu' \text{airport_origin} + \rho' \text{airport_destin} + \varepsilon_{akt}
\end{aligned} \tag{12}$$

All continuous variables are expressed in logs and the main variable of analysis is the dummy for routes affected by joint ventures. Unreported year, quarter, airline, and airport fixed effects are also added in the regressions. Standard errors are robust to heteroscedasticity and clustered by route.

A limitation of our data lies in the difficulty of disentangling routings characterized by increasing and decreasing returns. Therefore, we run regressions for the entire sample and for subsamples that may exhibit differences in terms of returns. In such a way, the impact of deeper degrees of airline cooperation on traffic can be explained by the predominance of a certain type of returns. More precisely, we consider a subsample comprising routings with traffic volume within the lowest 25% percentile and another subsample consisting of routings with traffic volume within the highest 25% percentile. In principle, decreasing returns should be expected on dense routes, whereas thin routes should have a higher potential to exploit economies of traffic density. However, note that traffic density could also indicate a higher potential to increase traffic. In such a case, dense routes would exhibit increasing returns. Consequently, we need to be cautious in the interpretation of our results in this respect.

Table 2 shows the results for the interhub and interline markets for the full sample. Regarding the controls, the coefficient of the distance variable is positive for both markets although it is only statistically significant for interline markets. A priori, we should expect a negative relationship between demand and distance but the particularity of our sample, based on long-haul flights, may explain the observed result. The effect of the population and income variables are, in general, also contrary to our expectations because we would expect demand being positively related with population and income. In this case, the explanation comes from the presence of airport and time fixed effects that may be capturing the effect of these variables. Interestingly, the more liberalized environment implied by open-skies agreements leads to more traffic both in interhub and interline markets. For interline markets, we also find that the dummy for North American gateways is negative and statistically significant. Finally, we find that routings operated by just one airline channel more traffic.

- Insert Table 2 here -

Table 3 shows the results just for the overlap and joint-venture variables for the entire sample and the subsamples for the thinnest and densest routings. The overlap variable may indicate some anticompetitive effects via higher airfares. This seems to be the case for interhub markets, except when we focus on the densest routings. For interline markets, this potential anticompetitive effect only seems to be present for the thinnest routings.

- Insert Table 3 here -

If we look at the full sample, the joint-venture variable is positive and statistically significant both for interhub and interline markets. Hence, we find clear evidence of a positive effect of joint ventures in the absence of network overlap. For interhub markets, the positive effect without network overlap seems to be compensated by the negative effect induced by network overlap. However, the positive effect of joint ventures on traffic is clearer when we consider the subsamples of thinnest and densest routings because the negative effect with overlap is smaller than the positive without overlap. For interline markets, the positive effect without overlap is always higher than the negative effect with overlap. In fact, we do not even find a negative effect of joint ventures with overlap when we focus on the thinnest routings.

Overall, the results of our empirical analysis show an increase of traffic associated with joint ventures both for interhub and interline markets. This is true for all the considered subsamples and could be related to the presence of economies of traffic density in the transatlantic airline market.

We can relate our empirical results with our theoretical predictions by stressing the relevance of economies of traffic density in the considered subsamples. Proposition 1 states that the presence of increasing returns constitutes a sufficient condition ensuring the positive effect of deeper joint ventures on traffic in both markets. Our empirical results confirm this positive effect.

5. Concluding remarks and policy implications

In this paper we have analyzed the effect of joint venture agreements on traffic in the transatlantic market. We obtain a positive effect of joint ventures on traffic, both in interhub and interline markets, especially in the presence of economies of traffic density.

The results of this paper have relevant policy implications. Thus, given that joint ventures typically translate into efficiency gains, in principle, they should be clearly favored. However, given that alliances are a pre-condition for joint ventures, a potential conflict could arise when alliances are used as a

subterfuge to sustain other anticompetitive practices in interhub markets. In such a case, two conflicting effects would arise simultaneously: a negative one coming from revenue-sharing (alliances) and a positive one coming from cost-sharing (joint venture). In this situation, applying a carve-out would not be an optimal solution because it would avoid collusion but, at the same time, prevent partner airlines to exploit the efficiency gains associated with joint ventures. The current debate on the unclear potential anticompetitive effect of alliances in interhub markets along with the questioned efficacy of carve-outs would suggest a favorable consideration of joint ventures.

Our results suggest some avenues for future research. First, the effect of joint venture agreements could be tested in other network industries, such as telecommunications, industrial distribution, or postal services. Second, the strategic formation of joint ventures seems still an open question and it would be interesting to investigate when and why allied carriers decide to go further in their cooperation agreements and move from alliances to joint ventures.

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Appendix: Proofs

Proof of Proposition 1. Notice that

$$\frac{\partial \Lambda_S}{\partial q_H} = -\frac{1-\mu}{2} C'' \left[\frac{q_S + q_H}{2} \right] - \mu C''' [q_S + q_H], \quad (\text{A.1})$$

$$\frac{\partial \Lambda_H}{\partial q_S} = -\frac{1-\mu}{2} C'' \left[\frac{q_S + q_H}{2} \right] - \frac{(1+\delta)\mu}{2} C''' [q_S + q_H], \quad (\text{A.2})$$

$$\frac{\partial \Lambda_S}{\partial \mu} = C' \left[\frac{q_S + q_H}{2} \right] - C' [q_S + q_H], \quad (\text{A.3})$$

$$\frac{\partial \Lambda_H}{\partial \mu} = C' \left[\frac{q_S + q_H}{2} \right] - (1+\delta) \frac{C' [q_S + q_H]}{2}. \quad (\text{A.4})$$

Thus, from inspection of (A.1)-(A.4), $C'' < 0$ implies that $\frac{\partial \Lambda_S}{\partial q_H} > 0$, $\frac{\partial \Lambda_H}{\partial q_S} > 0$, $\frac{\partial \Lambda_S}{\partial \mu} > 0$, and $\frac{\partial \Lambda_H}{\partial \mu} > 0$. Therefore, $\frac{\partial q_S}{\partial \mu} > 0$ and $\frac{\partial q_H}{\partial \mu} > 0$ follow immediately as both terms in the numerators of (9) and (10) are positive. ■

Figures and Tables

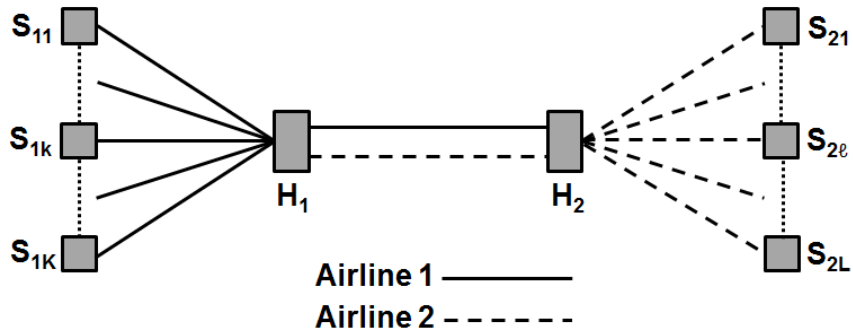


Fig. 1: The network

Table 1. Joint ventures in the transatlantic market

Alliance	Airlines and period	Hubs
SkyTeam	Delta/Northwest and Air France/KLM (June 2009), Alitalia (July 2010)	Atlanta, Detroit, Minneapolis, New York, Cincinnati, Memphis, Salt Lake City, Amsterdam, Paris, Rome
Star Alliance	Air Canada, United/Continental, and Lufthansa (October 2009), BMI (April 2010), Austrian and Swiss (July 2011), Brussels Airlines (March 2012)	Chicago, Denver, Houston, New York, San Francisco, Washington D.C., Toronto, Vienna, Zurich, Brussels, Frankfurt, Munich
Oneworld	American Airlines, British Airways, and Iberia (October 2010), Finnair (July 2013), US Airways (April 2014)	Charlotte, Chicago, Dallas, Los Angeles, Miami, New York, Philadelphia, Phoenix, London, Helsinki, Madrid
SkyTeam	Delta and Virgin Atlantic (January 2014)	Atlanta, Detroit, Minneapolis, New York, Cincinnati, Memphis, Salt Lake City, London

Table 2. Estimation results for all sample

	Dependent variable: PAX	
	Interhub markets	Interline markets
<i>JV</i>	0.22 (0.02)***	0.22 (0.009)***
<i>JVxOverlap</i>	-0.25 (0.04)***	-0.11 (0.007)***
<i>Overlap</i>	-0.10 (0.02)***	0.004 (0.003)
<i>Online</i>	-	0.22 (0.007)***
<i>Dist</i>	0.12 (0.12)	0.14 (0.01)***
<i>Pop_origin</i>	0.26 (0.34)	-0.14 (0.04)***
<i>Pop_destin</i>	-1.73 (0.83)**	-0.79 (0.10)***
<i>GDPpc_origin</i>	-0.41 (1.67)***	0.19 (0.03)***
<i>GDPpc_destination</i>	-0.32 (0.20)	-0.79 (0.10)***
<i>Open_skies</i>	0.39 (0.09)***	0.02 (0.01)**
<i>NA_gateway</i>	-	-0.02 (0.005)***
<i>Intercept</i>	107.22 (0.19)***	9.64 (4.02)***
<i>Year fixed effects</i>	YES	YES
<i>Quarter fixed effects</i>	YES	YES
<i>Airline fixed effects</i>	YES	YES
<i>Airport fixed effects</i>	YES	YES
<i>R²</i>	0.55	0.21
<i>Observations</i>	14,436	178,163

Note 1: Standard errors in parentheses (robust to heteroscedasticity and clustered by routing).

Note 2: Statistical significance at 1% (***), 5% (**), and 10% (*).

Note 3: The reference case for cooperation variables is: *i*) in interhub markets, routes not affected by joint ventures, and *ii*) in interline markets, routes operated by at least two airlines not involved in a joint venture.

Table 3. Estimation results for all sample and subsamples

	Dependent variable: <i>PAX</i>					
	Interhub markets			Interline markets		
	All sample	Thinnest routings	Densest routings	All sample	Thinnest routings	Densest routings
<i>JV</i>	0.22 (0.02)***	0.45 (0.06)***	0.39 (0.04)***	0.22 (0.009)***	0.11 (0.01)***	0.22 (0.02)***
<i>JVxOverlap</i>	-0.25 (0.04)***	-0.35 (0.10)***	-0.21 (0.07)***	-0.11 (0.007)***	0.01 (0.01)	-0.14 (0.02)***
<i>Overlap</i>	-0.10 (0.02)***	-0.11 (0.05)**	-0.004 (0.04)	0.004 (0.003)	-0.03 (0.004)***	0.01 (0.008)**
<i>Controls</i>	ALL	ALL	ALL	ALL	ALL	ALL
<i>R²</i>	0.55	0.44	0.56	0.21	0.13	0.17
<i>Observations</i>	14,436	3,237	3,740	178,163	44,431	44,479