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# Airport's Profit Sharing: Effects on Investment Incentives, Competition and Social Welfare

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The aim of this paper is to investigate the effects of airport's profit sharing on the incentives to invest, market competition and social welfare. The analysis is developed under two frameworks, one with a single airport and one with two competing airports, and both with airline competition. We conclude that airport's profit sharing may display the highest incentive to invest when compared to alternative vertical relations. Also, we found that airport's profit sharing excludes the independent airline, as long as the profit airport participation is not below 60%. Moreover, airport's profit sharing does not allow the elimination of double marginalization and thus the effects on social welfare are ambiguous.

*Keywords:* vertical relations, air transport, investment incentives

## 1. Introduction

The liberalization of the European air transport market, started in the end of 1980s/beginning of 1990s, introduced radical changes in the sector. Geographic freedom of operations allowed by open skies agreements, entry of new airline companies, new business models (in particular the low cost carrier model inspired by the Southwest strategy), proliferation of airline alliances, consolidation of hub carriers and development of sophisticated prices strategies are some of the most significant. Another fundamental transformation, central to the theme of this paper, is the relationship between airports and airlines. Traditionally airports had substantial market power due to the natural monopoly features and this justified ex-ante regulation. However, market dynamics induced by liberalization led to the development of an oligopolistic market structure centered on hub and spoke networks.[3] Consequently, air services' supply become more concentrated and the airline's market power was reinforced (Starkie, 2012).

Under this context airports have to compete more intensely for airlines offering attractive prices and better services (Gillen, 2011; Copenhagen Economics, 2012). Moreover, most European airports are being run as modern business (Gillen, 2011; Bottasso and Conti, 2012). Long-term commercial contracts between airports and airlines,[4] quite common in USA, are being intensively

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[3] For a characterization of hub and spoke networks see, for example, Spiller (1989), Oum et al. (1996), Zhang (1996) and Alderighi et al. (2005).
[4] See Starkie (2012) for a detailed description of the main features of the agreements between airports and airlines in several countries and Starkie (2008) for a typology of the more frequent agreements.

used also by European airports, introducing new vertical relations and changing the relative market power of firms. According to Fu et al. (2011), "vertical cooperation is likely to strengthen a carrier's dominance at an airport". The cooperation between airport and airlines is also related with the recent evolution on airports ownership.[5] In the past, most airports had public ownership (central or regional). This continues to be a frequent situation in USA and Europe, although some important airports have been privatized. The London airports owned by BAA (British Airports Authority) were the first European case of privatization in 2006, followed by several other cases as Athens, Rome and Hamburg airports. The airlines' participation in airports' ownership introduces new dimensions in the airport-airlines relation. Fu et al. (2011), based on the work of Kuchinke and Sickman (2005), describe as follows a quite illustrative example of an airport-airline agreement in the European market:

"*Terminal 2 of the Munich Airport was jointly funded by the airport operating company FMG (60%) and the Lufthansa (40%), the dominant airline at the airport. (…). Profits generated from the terminal, including those from leasing areas used for catering and retailing (…) are shared by FMG and Lufthansa.*"

Some other examples, not only from Europe but also from USA and Asia markets, reinforce the importance of investigating the effects of vertical cooperation. For instance, JetBlue invested in Terminal 5 of the New York JFK Airport obtaining in exchange the right to use the terminal under a 30-year lease agreement (Fu et al., 2011). Also, Lufthansa invested in Frankfurt Airport and holds a 29% share of Shanghai Airport cargo terminal (D'Alfonso and Nastasi, 2012). Latvia's Riga Airport has offered a contract to the national airline Air Baltic to build and operate a 92 euro million per annum terminal (D'Alfonso and Nastasi, 2012).[6]

Another crucial aspect in the vertical relation is the incentive to undertake investments. Airport' investments in the improvement of infrastructure and services generate positive externalities to airlines when not all the benefits are included in the airport fares. This can happen because investment creates new value for passengers which increase final demand. With infrastructure investment airports can offer better services not only through the commercial retails concessions (attracting restaurants and others shops) but also by the provision of more efficient services (as car parking, connection to other public transports), more friendly infrastructures for passengers (with cultural entertainments, children playfields, rooms for religious services, etc.). In this way, airlines benefit from demand expansion without having to directly support all the costs of promoting the demand increase.[7]

The main purpose of our work is to investigate the effects of airport's profits sharing. Therefore, we build a model in which airports and airlines seek profit maximization[8] and firms' payoffs functions depend on the type of vertical relation between airports and airlines. We compare three types of vertical configuration: vertical separation, vertical collusion between the airport and the dominant airline (this case corresponds to the vertical integration structure that was the prevailing situation in Europe before liberalization) and partial airport's profit sharing with the

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[5] For an updated survey on airports and airlines economics, covering airport privatization, see Zhang and Czerny (2012) and for a synthesis on the recent evolution on airport's ownership and governance see Gillen (2011).

[6] In some other cases, airports offer special financial facility revenue bonds to finance specific investment programs, and these contracts allow airlines the right to exclusively use facilities. For instance, terminal E at Houston Airport was built for Continental Airlines. A similar agreement was signed between Dallas Love Field Airport and Southwest Airline, and Sidney Airport and Quantas Airlines (Fu et al., 2011). For additional examples of vertical agreements between low cost carriers and secondary airports see, for instance, Barbot (2009) and Fu et al. (2011).

[7] In fact, airports offer a bundle of services both to airlines and passengers. Some authors (Gillen (2011); Ivaldi et al. (2011) for instance) describe airports as platforms that bring together two different markets, the airlines' market and the passengers' market, applying the two-sided markets theory to understand airports' activities and results.

[8] Our analysis does not apply to public owned airports that might pursue other objectives besides profit maximization.

dominant airline.[9] The three types of vertical relation are compared considering separately airport investment and airport competition. When analyzing airport competition we consider that passengers evaluate differently the airports' services not only because they have a different location from airports, and therefore they must bear transportation costs, but also because they evaluate differently other features of the airports as commercial and other complementary services. Therefore we use a model of horizontal differentiation

From the analysis we conclude that airport's profit sharing displays the highest incentive to invest when compared to alternative vertical relations, as long as the airline share is significant. Also, we found that airport's profit sharing excludes the independent airline from the market (or from the airport involved in the agreement in the case of airport competition), when the airline share is not below 60%. Moreover, we conclude that airport's profit sharing does not allow the elimination of double marginalization and thus the global effects on social welfare are ambiguous. Our main contribution is the identification of some crucial features of the vertical relations that should be considered by competition authorities or sectorial regulators when evaluating agreements between airports and airlines.

The paper is organized as follows. After the introduction, section 2 presents a brief literature review on vertical relations in air transport market. Section 3 describes the model with one airport and two airlines. This model is developed in two versions: the first without airport investment (section 3.1) and the second with airport investment (section 3.2) Then, section 4 discusses airport competition through the analysis of a model with two competing airports. Finally section 5 summarizes the main conclusions of the paper and enumerates directions for future research.

## 2. Related literature

Our investigation is closely related with the recent literature on the effects of different types of vertical restraints between airports and airlines in a context of airport competition, namely Starkie (2008), Fu et al. (2011), Barbot (2011), and D'Alfonso and Nastasi (2012).

In the past few papers have examined airport competition analytically. This was understandable since airports were considered as natural local monopolies (Basso and Zhang, 2007). However, this situation changed rapidly, in particular due to market liberalization, commercialization innovations, low cost carriers' strategies and the development of new transport networks, which motivated the development of research on airport competition. Furthermore, vertical relations in air transport sector have received growing attention from researchers in the last years. One of the first works on these topics was Gillen and Morrison (2003) who analyze the effects of vertical integration considering two pairs of firms in a context of product differentiation. Using a Hotelling model to incorporate airlines' differentiation they conclude that vertical integration is both profit enhancing and social desirable due to the elimination of double mark-up. Also, Basso and Zhang (2007) analyze facilities competition focusing on congestion delays and compare the effects of monopoly and duopoly cases. In the same line of research, Basso (2008) investigates the impact of regulation on pricing and capacity decisions of congestible airports concluding that cooperation between airports and airlines allows some improvements regarding congestions but leads to downstream cartel. Barbot (2009) studied vertical agreements between one airport and one dominant airline when both firms face competition in their markets. Building both simultaneous and sequential games, Barbot (2009) concludes that airports and airlines prefer not to collude when they face symmetric conditions regarding services quality and costs. On the contrary, when airports and airlines have different market sizes or when they offer different service quality, vertical agreements may be attractive strategies. Furthermore, Zhang et al. (2010) analyze concession revenue sharing between one airport and its airlines. They conclude that the

[9] We only consider aeronautical revenues. For a discussion of this topic see section 2.

effects on profits and on social welfare crucially depend on how airlines' services are related to each other (complements, independent or substitutes) and also on the existence of airport competition. With a different approach to vertical contracts based on a transaction cost analysis, Fuhr and Beckers (2009) argue that vertical contracts increase social welfare due to lower coordination costs.

As we mention above our work is closer to Starkie (2008), Fu et al. (2011), Barbot (2011) and D'Alfonso and Nastasi (2012). Starkie (2008) presents an overview of the airport-airline relationship, identifying the main features of different types of contracts. Fu et al. (2011) review several alternative forms of vertical relations, offering a detailed description of the relation between airports and signatory airlines, the contracts over airports facilities, the long term use contracts, the airport revenue bonds and the revenue sharing between airports and airlines. Fu et al. (2011) conclude that competition and welfare effects of vertical agreements depend on many factors and therefore a case by case analysis is necessary. Barbot (2011) analyze the effects of three types of vertical contracts previously characterized by Starkie (2008): the European case (which corresponds to vertical integration as the airport and the leader airline maximize their joint profits), the Australian case (where agreements lie in long term leases on terminals), and the USA case (where the signatory airline pays the airport the variable costs of its facility plus a part of its fixed costs). Barbot (2011) concludes that consumers may be better off with all the agreements but the European and the Australian cases have anti-competitive effects. Extending the analysis of Barbot (2011), D´Alfonso and Nastasi (2012) study the same three types of vertical contracts but in a context of airport competition. The authors develop a multistage game where each airport and its dominant airline choose the type of agreement and conclude that there are incentives to collusion, even under symmetric conditions, but this strategy has negative effects on social welfare due to the "misalignment between private and social incentives".

From the above mentioned literature emerges the conclusion that vertical relations have numerous effects on social welfare and competitiveness. Besides the well identified positive effects on consumer and social welfare resulting from the elimination of double marginalization, airport-airline agreements have many other advantages. Vertical agreements might allow airports to obtain financial support to undertake new investments as the long-term nature of the contracts provide security avoiding the hold-up problems (Starkie, 2008). Also, vertical agreements can secure business volume for airports thus reducing their risks (Starkie, 2012, D'Alfonso and Nastasi, 2012). Conversely, for airlines, vertical agreements can ensure the access to key airport facilities on favorable terms, which might reinforce their capacity to influence airport planning and operations including slot allocation (Fu et al, 2011). Additionally, vertical agreements allow both parts to benefit from the growing revenues from airport concessions and from positive demand externalities (D'Alfonso and Nastasi, 2012). Moreover, Fu et al. (2011) argue that vertical relation strengthen the hub status of major airports leading to increased employment and service quality.

Nevertheless, vertical agreements may also have negative impacts. Airports may become more dependent on a small number of airlines which imposes restrictions on their strategies. Furthermore, vertical cooperation raises anticompetitive concerns for, at least, three motives. First, vertical agreements may harm competition in the downstream airline market, excluding independent airlines from the market (Starkie, 2012). Second, if dominant airlines obtain preferential treatment over key airport facilities their market power might increase and this imposes significant entry barriers, especially in congested airports (Fu et al., 2011, D'Alfonso and Nastasi, 2012). Third, when vertical agreements involve price discrimination between airlines, there are negative consequences for some market segments. Overall, as Fu et al. (2011) conclude there is no consensus on the optimal policy toward cooperation between airports and airlines and the advantages and drawbacks of vertical agreements must be evaluated with a case by case analysis.

An indispensable final note on vertical agreements concerns airports concession revenues. In several airports, commercial revenues have been growing faster than aeronautical revenues and in some major airports they already represent more than 50% of total airport revenues (Zhang et al., 2010). Additionally, airport's profit sharing often happens with respect to revenues from concessions and not only to aeronautical revenues. The contract between FMG and Lufthansa mentioned on section 1 is an illustrative example of this situation. Therefore, a complete analysis on profit sharing should take into account concession revenues. In this paper we did not account for this feature in order to focus on other characteristics of the vertical relations but for future research this is an essential point. There is already research on the type of vertical relations considering concession revenues as, for instance, D'Alfonso and Nastasi (2012). Also, recently Fu and Zhang (2010) and Zhang et al. (2010) find that concession revenue sharing can be, under some restraints, welfare improving.

## 3. The single airport model

In this section we present the basic model to study the effects of airport profit sharing. We assume that airport A sells airport services to one leader airline L and to one follower airline F. The airlines offer a homogenous product to the passengers, the flight, and compete à la Stackelberg.[10] According to Barbot (2011) and D'Alfonso and Nastasi (2012) the Stackelberg behavior is realistic to describe the oligopoly interaction in the air transport market as the dominant airline (typically the national flag company) chooses first the quantity and leave the remaining slots for the other carriers.

In order to identify the main features of profit sharing agreement between airport and airlines we first characterize two extreme cases regarding vertical relations, vertical separation and vertical integration. Therefore, we build three versions of the model: first, we assume that there are no vertical relation and hence each firm behaves independently (vertical separation (VS) case); second, we assume that the airport and the leader airline collude (vertical integration (VI) case); third, we analyze a vertical agreement between the leader airline and the airport under which part of the airport's profit belong to the leader airline (profit sharing (PS) case). Hence, under the third case, the leader airline maximizes an objective function that is the sum of its profits at the downstream market with a share of the airport's profits. Conversely, the airport maximizes the remaining share of the upstream profits.

The profit functions of each firm are represented as follows:

Airline L: $\pi^L = (p - w)q^L$

Airline F: $\pi^F = (p - w)q^F$

Airport:[11] $\pi^A = (w - c)(q^L + q^F) - C(I)$

The traffic of the leader and the follower airlines are represented by $q^L$ and $q^F$, respectively. $p$ represents the final price that passengers pay to airlines and it is obtained from the inverse demand function that characterizes the passengers decisions, given by $p = a + \beta I - q^L - q^F$. $I$ stands for the investment undertaken by the airport. The effect of the investment on final demand depends on the parameter $\beta$ ($\beta>0$) which represents the positive spillover from the investment. This representation of investment spillovers was inspired in Foros' (2004) model on vertical

[10] In a duopoly with Stackelberg competition the leader airline firstly decides the quantity that maximizes its payoff function and then, after observing the leader decision, the follower airline sets the quantity that to maximize its payoff function.

[11] Although concession service is an important source of airports' revenue we do not consider it here in order to build a simple model that allows us to concentrate the attention on the investment spillover effects.

spillovers in the broadband market. The investment causes a demand expansion that benefits both airlines. The price $w$ represents the aeronautical fare paid by the airlines to the airport, and we assume an equal value for both airlines. The parameters $a$ and $c$ stand for the demand size prior to the investment and the marginal cost of the airport activity, respectively. We assume $a>c$ and also that any other costs of downstream activities are normalized to zero. Finally, $C(I)$ is the investment cost function.

The objective functions (or payoff functions) of each firm depend on the vertical relation. For the basic model developed in this section we have the following objective functions:

Vertical separation: the payoff functions coincide with the profit functions, then $\prod^{VSA,L} = \pi^L$; $\prod^{VSA,F} = \pi^F$; $\prod^{VSA,A} = \pi^A$.

Vertical collusion: the airport and the leader airline maximize the sum of their profits, hence their payoff function is $\prod^{VIA,L+A} = (p-w)q^L + (w-c)(q^L + q^F) - C(I)$. The payoff function of the follower airline is equal to its profit function, $\prod^{VIA,F} = \pi^F$.

Airport's profit sharing: the leader airline payoff function is given by $\prod^{PSA,L} = (p-w)q^L + \delta\left[(w-c)(q^L + q^F) - C(I)\right]$ where δ represents the share of airport's profit that belong to the leader airline, with $\delta \in (0,1)$; the payoff function of the follower airline is equal to its profit function, $\prod^{PSA,F} = \pi^F$, and the airport payoff function is $\prod^{PSA,A} = (1-\delta)\left[(w-c)(q^L + q^F) - C(I)\right]$.[12]

Moreover, we consider the following standard assumptions: i) the production of one unit of the final service by each airline requires one unit of airport services (fixed coefficients technology)[13]; ii) the quality of the service sold by the airport is the same whether it is sold to the leader airline or to the follower airline (thus, we are not studying sabotage[14]); iii) the final service of the airlines is homogenous; iv) there are no capacity constrains (thus, we do not study congestion issues).

We describe the firms' decisions as a sequential game with the following timing: at stage 1 the airport decides the investment. Then, at stage 2, the airport decides the aeronautical fare, $w$. At stage 3, the leader airline decides its quantity and at stage 4 the follower airline chooses its quantity.

Furthermore, we assume that there is perfect information and we solve the game by backward induction to find subgame perfect Nash equilibria. We consider separately the three alternative vertical restraints. In order to have a benchmark we first solve the three models without considering the investment (section 3.1), and then we introduce the investment (section 3.2).

[12] The superscripts of the payoff functions (that will also be used to represent the final results), indicate: i) the type of vertical relation (VS, VI or PS for vertical separation, vertical integration or profit sharing, respectively) and ii) the model (A, B or C for upstream monopoly without investment, upstream monopoly with investment and upstream duopoly, respectively). In model C we will add the subscripts 1 and 2 to indicate airport 1 and airport 2, respectively.

[13] Fixed coefficient technology is a standard assumption in this framework (see, for instance, Basso and Zhang (2007) and the references therein). Further, in footnote 8, Basso and Zhang (2007) present a simple explanation of this assumption when applied to the air transport sector.

[14] Sabotage refers to the upstream firm' strategy of degrading the input quality sold to independent downstream firms in relation to the quality of the input sold to its subsidiaries. This strategy raises the downstream rival's cost and benefits the vertically integrated firm. For a deep development of this topic applied to the telecommunications sector see, for instance, Weisman (1998), Sibley and Weisman (1998), Weisman and Kang (2001), and Chikhladze and Mandy (2009).

*3.1 The single airport model without investment*

*3.1.1. Vertical separation*
At the downstream market airlines decide the quantities à la Stackelberg. Then, the best reply function of the follower airline is given by $q_F(q_L,w)=\frac{a-w}{2}-\frac{q_L}{2}$. The leader airline maximizes its profit when it produces $q_L(w)=\frac{a-w}{2}$. Considering these quantities, the relevant demand function for the airport is given by $Q(w)=q_L(w)+q_F(w)=\frac{3(a-w)}{4}$ and the aeronautical fare that maximizes the airport profit is $w^{VSA}=\frac{a+c}{2}$. From here the standard equilibrium results under vertical separation are obtained: $q^{VSA,L}=\frac{a-c}{4}$, $q^{VSA,F}=\frac{a-c}{8}$, $p^{VSA}=\frac{5a+3c}{8}$, $\pi^{VSA,L}=\frac{(a-c)^2}{32}$, $\pi^{VSA,F}=\frac{(a-c)^2}{64}$, $\pi^{VSA,A}=\frac{3(a-c)^2}{16}$, $CS^{VSA}=\frac{9(a-c)^2}{128}$ and $W^{VSA}=\frac{39(a-c)^2}{128}$ where CS is the consumer surplus and W is the social welfare defined as the sum of consumer surplus and firms profits.

*3.1.2 Vertical collusion*
Here we have the standard results of vertical integration: to maximize its payoff, the vertically integrated firm produces the monopoly quantity and foreclosures the independent firm: $q^{VIA,L}=\frac{a-c}{2}$ and $q^{VIA,F}=0$. The aeronautical fare and the final price for passengers coincide, $w^{VIA}=p^{VIA}=\frac{a+c}{2}$, due to the elimination of double marginalization. This has positive effects on consumer surplus, as $CS^{VIA}=\frac{(a-c)^2}{8}>CS^{VSA}$, and on total profits as $\prod^{VIA,L+A}=\frac{(a-c)^2}{32}>\prod^{VSA,L}+\prod^{VSA,F}+\prod^{VSA,A}$, and consequently, on social welfare. The main negative feature of vertical integration, deeply studied in industrial organization literature, is the effect on downstream competition, as the independent downstream is out of the market.[15]

*3.1.3 Partial airport's profit sharing*
Considering the follower airline's best reply function, the leader airline maximizes its payoff when it produces $q_L(w)=\frac{a-w}{2}+\frac{w-c}{2}\delta$. Then, the airport sets the aeronautical fare that maximizes its payoff function which yields $w^{PSA}=\frac{3(a+c)-2c\delta}{2(3-\delta)}$. By substitution backwards we obtain the equilibrium results:[16] $q^{PSA,L}=\frac{(a-c)(3+\delta)}{4(3-\delta)}$, $q^{PSA,F}=\frac{(a-c)(3-5\delta)}{8(3-\delta)}$, $p^{PSA}=\frac{5a+3c}{8}$,

15 For a detailed survey on foreclosure in vertical markets see Rey and Tirole (2007). In an application to air transport market Gillen and Morrison (2003) obtained the standard results of vertical integration.
16 These results are obtained assuming that both airlines are active in the market, ie that $\delta < 0.6$. Otherwise, the downstream market would be a monopoly.

$\Pi^{PSA,L} = \frac{(a-c)^2(9-23\delta^2+42\delta)}{32(3-\delta)^2}$, $\Pi^{PSA,F} = \frac{(a-c)^2(5\delta-3)^2}{64(3-\delta)^2}$, $\Pi^{PSA,A} = \frac{9(a-c)^2(1-\delta)}{16(3-\delta)}$,

$CS^{PSA} = \frac{9(a-c)^2}{128}$, $W^{PSA} = \frac{39(a-c)^2}{128}$.

It is important to note that vertical separation is the particular case of airport's profit sharing when δ=0. On the contrary, when δ=1, we do not obtain the vertical integration results in spite of the payoff functions being equal under both cases. This happens because the airport's profits sharing case changes the relationship between airlines. If it was the upstream firm that stayed with part of the profit of one downstream firm then, at the downstream level, the interaction between the firms would not be modified. Under this case δ=1 would represent the vertical integration case. However, here it is one of the downstream firms that capture a share of the upstream profits.

Comparing the results from the three types of vertical relation several conclusions emerge.

First, it is important to notice that airport's profit sharing foreclosures the follower airline from the market when δ ≥ 0.6. Hence, the anti-competitive effects of vertical integration can be achieved with a partial profit sharing.

Second, airport's profit sharing does not eliminate, nor even partially, double marginalization (Proposition 1).

**Proposition 1:** *With one airport and without infrastructure investment the final price under airport's profit sharing does not depend on δ and it is equal to the final price under vertical separation for any positive share participation.*[17]

Hence, airport's profit sharing does not improve consumer welfare comparing with the vertical separation case. We find this result quite surprising as we were expecting that airport's profit sharing would produce intermediate results between vertical separation and vertical integration. What we verify, however, is that even for a very low share, the final price does not change. This happens because under airport's profit sharing the leader airline and the airport decide independently in spite of the proximity of their payoffs functions (that is, both firms desire to increase the upstream profits as it positively contributes to their payoffs). Only when firms decide in a perfect coordinated way, as it happens under vertical collusion, the double marginalization is eliminated.

Third, as a consequence of the result synthesized in Proposition 1, we conclude that profit sharing does not change the total payoffs or social welfare in relation to the vertical separation case. The individual payoffs change (the leader's payoff increases while the follower and airport's payoff decrease), but the aggregate payoffs are the same as under vertical separation.

Fourth, airport's profit sharing changes the firm's relative payoffs in relation to the vertical separation case. Under airport's profit sharing the relative payoffs for each firm ($\Omega_i = \frac{\Pi_i}{\Pi_L + \Pi_F + \Pi_A}$ with i = L, F, A) are the following:

Leader airline: $\Omega^L = \frac{2(9-23\delta^2+42\delta)}{15(3-\delta)^2}$ Follower airline: $\Omega^F = \frac{5\delta-3}{15(3-\delta)^2}$

Airport: $\Omega^A = \frac{12(1-\delta)}{15(3-\delta)^2}$.

[17] The proofs of all propositions are presented in Appendix A.

It is straightforward to verify that the relative payoff of the leader airline increases with δ while both relative payoffs of the other firms decrease with δ. What is happening is that airport's profit sharing increases the aeronautical fare in relation to the vertical separation case, which increases the profits from the upstream activity and decreases the profits from the downstream activity. Then, the payoff of the follower airline decreases with δ. On the contrary, as the leader airline's payoff not only includes profits from downstream activity but also from upstream activity, in spite of the lower downstream profits, the leader airlines' payoff increases with δ due to the higher upstream profits. In this way, the leader airline can use the airport's profit sharing as a strategy to reduce the follower airline payoff (or even to eliminate the rival from the market when the participation share is equal or above 60%) and to reduce the airport's payoff.

*3.2 The single airport model with investment*

Now we consider that the airport undertakes investments to improve the quality of airport services. These investments increase the final demand and, consequently, have positive effects for the airlines (positive externalities).[18] The cost of the investments is bear by the airport and is represented by the following cost function $C(I)=\frac{\varphi I^2}{2}$ with φ > 0. For this function *C′(I)>0* and *C′′(I)>0* which ensures that it is not optimal for the airport to choose an infinite high level of investment in order to enhance passengers demand. Notice that the parameter $\varphi$ represents the slope of the investment marginal cost, therefore an increase in investment leads to a strong increase in the investment cost.

*3.2.1 Vertical separation*

As the airlines decide the quantities à la Stackelberg the best reply function of the follower airline is given by $q^F(q^L,w,I)=\frac{a-w+\beta I}{2}-\frac{q^L}{2}$. Taking into account this function, the leader airline maximizes its profit with $q^L(w,I)=\frac{a-w+\beta I}{2}$. Then, the airport decides the aeronautical fare in order to maximize its profit which yields $w(I)=\frac{a+c+\beta I}{2}$ and after the airport selects the optimal investment $I^{VSB}=\frac{3\beta(a-c)}{8\varphi-3\beta^2}$. In order to ensure that the optimal investment is always positive we consider assumption 1.

**Assumption 1**: *Let us assume that* $\varphi>\frac{3}{8}\beta^2$.

Assumption 1 ensures that the slope of the marginal cost of the investment (φ) is high in relation to the unitary effect of the investment on demand growth (β). Otherwise it would be possible for the airport to choose a considerably high investment, in order to enhance demand, as the increase in the investment cost was relatively small comparing with the demand effect.

With backward substitution, we obtain the following optimal values for the vertical separation case:

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[18] The expansionary investments made by the airport might also have negative effects for airlines, in particular, for incumbent airlines as higher airport capacity might allow the entry of new airlines. This is an important perspective, in particular for the evaluation of entry and competition in air transport markets. Nevertheless, here we do not address the negative effects of the airport infrastructure investments, as we intend to focus on the improvement on airports service quality and we do not discuss entry issues.

$q^{VSB,L}=\frac{2\varphi(a-c)}{8\varphi-3\beta^2}$ $q^{VSB,F}=\frac{\varphi(a-c)}{8\varphi-3\beta^2}$ $w^{VSB}=\frac{4\varphi(a+c)-3c\beta^2}{8\varphi-3\beta^2}$

$p^{VSB}=\frac{5a+3c}{8}+\frac{15\beta^2(a-c)}{8(8\varphi-3\beta^2)}$ $\pi^{VSB,L}=\frac{2\varphi^2(a-c)^2}{(8\varphi-3\beta^2)^2}$ $\pi^{VSB,F}=\frac{\varphi^2(a-c)^2}{(8\varphi-3\beta^2)^2}$

$\pi^{VSB,A}=\frac{3\varphi(a-c)^2}{2(8\varphi-3\beta^2)}$ $CS^{VSB}=\frac{9\varphi^2(a-c)^2}{2(8\varphi-3\beta^2)^2}$ $W^{VSB}=\frac{3\varphi(13\varphi-3\beta^2)(a-c)^2}{2(8\varphi-3\beta^2)^2}$

### *3.2.2 Vertical Collusion*

Under this case the leader airline and the airport maximize the sum of their profits after considering the best reply function of the follower airline, $q^F(q^L,w,I)=\frac{a-w+\beta I}{2}-\frac{q^L}{2}$, which yields the quantity $q^L(I)=\frac{a-c+\beta I}{2}$. At stage 2 the leader/airport choose $w(I)=\frac{a+c+\beta I}{2}$ and, at stage 1, they choose the optimal investment $I^{VIB}=\frac{(a-c)\beta}{2\varphi-\beta^2}$. Assumption 1 ensures that the optimal investment is always positive.

With backward substitution the equilibrium results are the following:

$q^{VIB,L}=\frac{\varphi(a-c)}{2\varphi-\beta^2}$ $q^{VIB,F}=0$ $w^{VIB}=p^{VIB}=\frac{a+c}{2}+\frac{\beta^2(a-c)}{2(2\varphi-\beta^2)}$

$\Pi^{VIB,L+A}=\frac{\varphi(a-c)^2}{2(2\varphi-\beta^2)}$ $\Pi^{VIB,F}=0$ $CS^{VIB}=\frac{\varphi^2(a-c)^2}{2(2\varphi-\beta^2)^2}$ $W^{VIB}=\frac{(3\varphi-\beta^2)\varphi(a-c)^2}{2(2\varphi-\beta^2)^2}$

It is straight forward to verify that the investment does not change the standard effects of perfect collusion: i) vertical collusion eliminates double marginalization, which increases consumer surplus and firms profits (and, consequently, social welfare); ii) vertical collusion excludes the independent downstream firm from the business.

### *3.2.3 Partial airport's profit sharing*

Here the leader airline, after considering the best reply function of the follower airline, $q^F(q^L,w,I)=\frac{a-w+\beta I}{2}-\frac{q^L}{2}$, maximizes its payoff producing $q^L(w,I)=\frac{a-w+\beta I}{2}+\frac{(w-c)\delta}{2}$. At stage 2 the airport maximizes its payoff setting the aeronautical fare at $w(I)=\frac{(1-\delta)[3(a+c+\beta I)-2c\delta]}{2(1-\delta)(3-\delta)}$ and, at stage 1, it selects the optimal investment $I^{PSB}=\frac{9\beta(a-c)}{z}$ with $z=8\varphi(3-\delta)-9\beta^2$. Once again, under assumption 1 the investment is positive.

The optimal results are the following:[19]

$q^{PSB,L}=\frac{2\varphi(3+\delta)(a-c)}{z}$ $q^{PSB,F}=\frac{\varphi(3-5\delta)(a-c)}{z}$

$w^{PSB}=\frac{4\varphi[3(a+c)-2c\delta]-9\beta^2c}{z}$ $p^{PSB}=\frac{\varphi(5a+3c)(3-\delta)-9\beta^2c}{z}$

[19] As in the previous model, to obtain the values for prices, payoffs, consumer surplus and social welfare we assume that both airlines are active in the market, that is, $\delta < 0.6$.

$$\Pi^{PSB,L} = \frac{\varphi\left[4\varphi(9+42\delta-23\delta^2)-81\beta^2\delta\right](a-c)^2}{2z^2} \qquad \Pi^{PSB,F} = \frac{\varphi^2(3-5\delta)(a-c)^2}{z^2}$$

$$\Pi^{PSB,A} = \frac{9\varphi(a-c)^2(1-\delta)}{2z} \qquad CS^{PSB} = \frac{9\varphi^2(3-\delta)^2(a-c)^2}{2z^2}$$

$$W^{PSB} = \frac{3\varphi(117\delta-78\varphi\delta-27\beta^2+13\varphi\delta^2)(a-c)^2}{2z^2}$$

Notice that, as without investment and by the same reasons, the vertical separation results are the particular case of profit sharing when δ=0; however, when δ=1, the profit sharing case does not display the vertical integration results.

*3.2.4 Comparison of the equilibrium results*

Analyzing the equilibrium results of the three possibilities regarding the vertical relation we conclude the following.

First, the leader airline can use profit sharing as a strategy to eliminate the rival airline from the market. This result is achieved as long as the share is equal or above 60%. This is exactly the same result we obtained without investment, and it has a crucial significance to competition policy. When evaluating firms' strategies that encompass coordination, the regulatory authorities must give careful attention to the degree of coordination, as it is not necessary full integration to significantly reduce market competition.

Second, comparing the investment equilibrium values we conclude that vertical integration leads to higher investment than vertical separation. This is not a surprising result: under vertical integration the leader firm is a monopolist and therefore it has a high incentive to invest in demand expansion. More interesting is to verify that profit sharing leads to greater investment than vertical integration, for high values of the profit share. This conclusion gives support to the frequent airline-airport agreements strongly justified on the incentives to invest in infrastructure improvements. Our model corroborates this argument as long as the agreements involve a significant participation on the airports profits. The above results are synthetize in the following proposition.

**Proposition 2:** *With one airport and investment, under assumption 1 the optimal investment values verify the following conditions:* $I^{PSB} > I^{VIB} > I^{VSB}$ *for* $\delta > 3/4$ *and* $I^{VIB} > I^{PSB} > I^{VSB}$ *for* $\delta < 3/4$.

As a consequence of the result synthetized on Proposition 2 it is very important to note that, at the equilibrium, the demand functions are different for each type of vertical relation due to the values of the equilibrium investment. Therefore, the appraisal of the three cases must be carefully done. When comparing the results we must take into account two effects: a demand effect due to the different demand function behind each case and a firms' behavior effect caused by the different payoffs functions of each case.

Third, the sum of firms' payoffs under vertical integration is higher than under vertical separation. This is the expected result not only because with vertical integration there is a strong demand expansion (due to the higher investment) but also because vertical integration eliminates double marginalization which has positive consequences on aggregate profits.

Additionally, the sum of firms' payoffs under vertical integration is higher than under profit sharing. This is a quite interesting result since behind this comparison there are two effects on aggregate firm's payoffs, the demand effect and the firms' behavior effect, that, under some conditions, go in opposite directions. From proposition 2 we know that when the profit share is above ¾ the equilibrium investment is higher with profit sharing than with vertical integration.

Hence, under this constraint, there is a positive demand effect: the final demand is higher with profit sharing due to the greater investment and this increases aggregate profits. However, at the same time, there is also a second effect (the behavior effect) due to the different firms' payoff functions. This second effect comes from the elimination of double marginalization that happens as a result of the coordination between the airport and the leader airline. The second effect is negative since profit sharing does not eliminate double marginalization and therefore, profits should be higher under vertical integration than under profit sharing. Moreover, we prove that the behavior effect always dominates the demand effect. Then, even when the demand effect is positive (ie, when δ > ¾), the total effect is negative and then profit sharing displays lower aggregate profits than vertical integration. When δ < ¾ both effects are negative, as profit sharing displays lower investment and does not eliminate double marginalization. All of these results are synthesized in Proposition 3.

***Proposition 3**: With one airport and investment, under assumption 1 at the equilibrium the following conditions hold:* $\prod^{VIB,L+A} > \prod^{PSB,L} + \prod^{PSB,F} + \prod^{PSB,A} > \prod^{VSB,L} + \prod^{VSB,F} + \prod^{VSB,A}$ *for all admissible values of δ.*

Proposition 3 can be better understood when we compare the aggregate payoff under profit sharing and vertical separation.[20] Profit sharing leads to higher aggregate payoffs than vertical separation, but this effect is totally due to the demand effect, as the behavior effect is zero. This clearly proves that profit sharing does not allow any elimination of the double marginalization, even when the profit share is significant.

Fourth, the leader airline and the airport have incentives to celebrate vertical agreements as long as the slope of the investment marginal cost function is not very high in relation to unitary effect of investment on demand increase.

***Proposition 4**: With one airport and investment, under assumption 1 at the equilibrium the following condition holds:* $\prod^{PSB,L} + \prod^{PSB,A} > \prod^{VIB,L+A}$ *if* $\varphi < \dfrac{12\delta - 9 - 10\delta^2}{72\delta - 36 - 52\delta^2}\beta^2$.

This result highlights the attractive features of the vertical agreements between airlines and airports as, under certain conditions, the agreement lead to higher profits than the full coordination of activities achieved with vertical integration. This positive effect of vertical agreements on the profits is due to the positive effect on the investment, and through it, on demand expansion.

Fifth, the follower airline loses with vertical agreement. This is the expected result since the most desirable situation for the follower airline is vertical separation, because there is a level playing field in the downstream market. Under vertical integration or profit sharing with δ ≥ 0.6 the follower airline is out of the market; under profit sharing with δ <0.6 the follower airline has positive profits but quite below what it would obtain under vertical separation. Notice that these are exactly the conclusion we obtained without considering investment.

***Proposition 5**: With one airport and investment, under assumption 1 the following conditions hold:* $\pi_2^{VSB} > \pi_2^{PSB} \geq \pi_2^{VIB} = 0$.

Sixth, the vertical agreement can also be the best vertical relation for consumers, depending on the parameters values. When δ < 3/5 consumer surplus is higher with vertical integration than

[20] The detailed comparison is described in the proof of Proposition 3 in the Appendix A.

with profit sharing. On the contrary, when, δ > 3/5 profit sharing benefit consumers as long as the slope of the investment marginal cost function is not too high in relation to the unitary effect of investment on demand. This result is explained by the relative increase in demand caused by the investment.

***Proposition 6****: With one airport and investment, under assumption 1 at the equilibrium the following conditions regarding consumer welfare hold:* $CS^{VIB} > CS^{PSB} > CS^{VSB}$ *if* $\delta < \frac{3}{5}$. *Otherwise,* $CS^{PSB} > CS^{VIB} > CS^{VSB}$ *for* $\varphi < \frac{3\delta}{2(3-\delta)}\beta^2$.

Finally, regarding social welfare we verify that vertical integration is better off than vertical separation. Nonetheless under profit sharing it is possible to have better or worse results than the ones obtained under vertical integration (that is $W^{PSB} > W^{VIB}$ and $W^{VIB} > W^{PSB}$), depending on the particular values of the parameters β, φ and δ.

*3.3 Conclusions from the models with one airport*

Overall, from the models with a single airport we conclude that the investment does not change the possibility of foreclosure. The follower airline is excluded from the market when vertical agreements occur, as long as the airport's profit share of the leader airline is equal or higher than 0.6. Also, the investment does not change the conclusion regarding double marginalization: vertical agreements do not eliminate double marginalization even for a large profit share.

Nevertheless, the model with investment allows the identification of several important properties for the vertical agreements analysis. Vertical agreements are the vertical relation that creates the highest incentive to invest in airport infrastructures and this strategy is attractive to the consortium leader airline/airport as long as the investment costs are not excessively high.

The follower airline is the economic agent that loses with the vertical agreements, while from consumers' and social welfare perspectives the final effects depend on the particular feature of the markets. It is possibly to find situations where consumer surplus and social welfare reach the highest values with vertical agreements but it is also possible that the best vertical arrangement is vertical integration. These results are explained by the trade-off between two contradictory effects. For one side, vertical agreements lead to the highest demand expansion, which is positive for consumer surplus and social welfare. Nonetheless, on the other side, vertical agreements do not eliminate, even partially, the double marginalization while vertical integration achieved this goal. Summing up, when evaluating vertical agreements, the competition authorities must take into consideration all of these effects and their relative weight in each particular case under evaluation.

## 4. The model with airport competition

In this section we analyze how airport competition changes the effects of vertical agreements on competition and social welfare. We consider two airports, $A_1$ and $A_2$, which offer imperfect substitutes services. The imperfect substitutability is not only due to the different location of passengers and airports (which imply travelling cost for the passengers) but also results from other airport's characteristics, such as the attributes of commercial facilities (shops, restaurants, etc), the quality of complementary services (car parking, children's facilities, public transportation to city center, etc) and the global quality of the airport services that passengers evaluate differently.[21] To take account of these features we use a horizontal differentiation model with the following inverse demand functions: $p_1 = a - Q_1 - \theta Q_2$ and $p_2 = a - Q_2 - \theta Q_1$ with $\theta \in (0,1)$, where $p_i$ (with i = 1,2) is the final price paid by the passengers to the airlines when they fly from airport $A_i$; $Q_i$ is the total traffic of airport $A_i$ and θ is the parameter that captures the degree of substitutability between airport services. Notice that if θ = 1 the passengers would consider the services of the two airports as perfect substitutes while if θ = 0 the passengers would see the airport services as independent products. Therefore, we assume 0<θ<1. Values of θ closer to zero represent deeper differentiation between airports' services.[22,23]

The downstream market consists of two airlines, the leader and the follower, that offer a homogenous product (the flight) and compete in each airport à la Stackelberg. We assume that both airlines can operate at both airports. This assumption is supported by several examples where the same airlines simultaneously operate at airports that compete directly, as it happens for instance, between the airports of Barcelona and Madrid, or between Brussels and Amsterdam (D´Alfonso and Nastasi, 2012). Barbot (2009) and D´Alfonso and Nastasi (2012) argue that airport competition also happens between airports located in the same metropolitan area as for instance, London or Rome airports. Moreover, when we take into account non-network air services, as the ones operated by charter and low cost carriers, the cost of switching all or part of the operations between airports is not impeditive of traffic reallocation (Starkie, 2002).[24]

Given the structure of the downstream market the total demand for airports 1 and 2 are, respectively, $Q_1 = q_1^L + q_1^F$ and $Q_2 = q_2^L + q_2^F$, where $q_i^h$ stands for the quantity of airline h (with h = L or F) operated at airport i (i = 1, 2).

We develop a framework with the following sequence of decisions. At stage 1 the airports decide simultaneously the aeronautical fares ($w_1$ and $w_2$); at stage 2 the leader airline set simultaneously the quantities for each airport ($q_1^L$ and $q_2^L$); at stage 3 the follower airline decide simultaneously the quantities for each airport ($q_1^F$ and $q_2^F$). All the other standard assumptions of the basic model hold.

With the above assumptions we build three models to capture the three possibilities regarding the vertical relation: vertical separation (VS), vertical integration (VI) and profit sharing agreement (PS).

### *4.1 Vertical separation*

Under this case the payoff function of each firm coincide with the corresponding profit function. Hence, the follower airline's payoff function is:

$$\pi^F = (a - q_1^L - q_1^F - \theta q_2^L - \theta q_2^F - w_1)q_1^F + (a - q_2^L - q_2^F - \theta q_1^L - \theta q_1^F - w_2)q_2^F .$$

The best reply functions for the follower airline in each airport are given by:

[21] Notice that we only analyze horizontal differentiation between airports. We are not considering situations where all passengers evaluate in the same way the quality differences.

[22] The above inverse demand functions were obtained from an utility function analogous to Dixit (1979). For more details see appendix B. Basso (2008) also uses a similar approach to incorporate horizontal differentiation between airlines' services.

[23] The spatial Hotelling model is an alternative framework to study horizontal product differentiation. With a wider interpretation of the transportation cost it is possible to include in the Hotelling model all the other features of the horizontal product differentiation, and not only the geographic location. With an infinite linear city version of the Hotelling model (as the one used by Basso and Zhang (2007) and D'Alfonso and Nastasi (2012), for instance) we obtained similar inverse demand functions to the ones we present above.

[24] There are, however, many real situations where airlines are bounded to a certain airport. This is particular important to scheduled carriers with high level of hub and spoke traffic, that benefit from agglomeration economies and hence have high cost of switching airports (Starkie, 2002).

$$q_1^F(q_1^L, w_1, w_2) = \frac{(a-w_1)-\theta(a-w_2)}{2(1-\theta^2)} - \frac{q_1^L}{2} \quad \text{and} \quad q_2^F(q_2^L, w_1, w_2) = \frac{(a-w_2)-\theta(a-w_1)}{2(1-\theta^2)} - \frac{q_2^L}{2}.$$

The leader airline's profit function is:

$$\pi^L = (a - q_1^L - q_1^F - \theta q_2^L - \theta q_2^F - w_1)q_1^L + (a - q_2^L - q_2^F - \theta q_1^L - \theta q_1^F - w_2)q_2^L.$$

Taking in account the best reply functions of the follower airline of each airport, the leader airline maximizes the profit when it produces $q_1^L(w_1, w_2) = \frac{(a-w_1)-\theta(a-w_2)}{2(1-\theta^2)}$ and $q_2^L(w_1, w_2) = \frac{(a-w_2)-\theta(a-w_1)}{2(1-\theta^2)}$. Anticipating these quantities, the airports set simultaneously the aeronautical fares that maximizes their individual profit functions given by $\pi^{A1} = (w_1 - c)(q_1^L + q_1^F)$ and $\pi^{A2} = (w_2 - c)(q_2^L + q_2^F)$. The optimal aeronautical fares are $w_1^{VSC} = w_2^{VSC} = \frac{a(1-\theta)+c}{2-\theta}$. Notice that both airports set the same fare as they face identical market conditions.

By backward substitution we obtain the optimal results under vertical separation that are described at Appendix C1.

As expected, the prices (both the passengers' prices and the aeronautical fares) are lower with airport competition than with a single airport (note that $w_1^{VSC} = w_2^{VSC} < w^{VSA}$ and $p_1^{VSC} = p_2^{VSC} < p^{VSA}$), and decreasing with θ, that is, deeper differentiation implies higher optimal prices. Also, airport competition brings higher social welfare (note that $W^{VSC} > W^{VSA}$).

### *4.2 Vertical collusion*

Vertical collusion is characterized by perfect coordination between airport 1 and the leader airline.[25] By contrast, airport 2 and the follower airline maintain the individual behavior.

The follower's airline best reply functions are the same as under vertical separation, while the payoff function of the leader airline/airport 1 is given by

$$\Pi^{L+A1} = (a - q_1^L - q_1^F - \theta q_2^L - \theta q_2^F - w_1)q_1^L + (a - q_2^L - q_2^F - \theta q_1^L - \theta q_1^F - w_2)q_2^L + (w_1 - c)(q_1^L + q_1^F).$$

The quantities that maximize the above payoff function are $q_1^L(w_2) = \frac{(a-c)-\theta(a-w_2)}{2(1-\theta)^2}$ and

$$q_2^L(w_2) = \frac{(a-w_2)-(a-c)\theta}{2(1-\theta)^2}.$$

When simultaneously choosing the aeronautical fares, airport 1 decides considering $\Pi^{L+A1}$ and airport 2 maximizes its profit function. The optimal aeronautical fares are

$$w_1^{VIC} = \frac{6(a+c)-3\theta(a-c)-(3a-c)\theta^2}{2(6-\theta^2)} \quad \text{and} \quad w_2^{VIC} = \frac{3(a+c)-2\theta(a-c)-a\theta^2}{6-\theta^2}.$$

Comparing with vertical separation we conclude that both airports set a lower fare and that the airport's 2 fare reduction is deeper. This is a quite interesting result. As a response to vertical collusion airport 2 follows a more aggressive price policy in order to protect its market position. Even though, airport 2 loses traffic and market share in relation to the vertical separation case.

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25 According to Barbot (2009) "agreements become more plausible when an airline dominates an airport and so has a large market share there."

Substituting backwards we obtain the optimal results under vertical collusion which are described at Appendix C2.

As noted previously, the aeronautical fare at airport 1 is higher than at airport 2 and sufficiently high to exclude the follower airline from airport 1 (note that $w_1^{VSC} = w_2^{VSC} > w_1^{VIC} > w_2^{VIC}$). Furthermore, the follower airline expands operations at airport 2, when comparing with the vertical separation case, although this increase does not compensate the reduction on its total traffic. As expected, the leader airline increases operations at airport 1 and decreases at airport 2 and, globally, expands its activity. Concerning the airport's operations we verify that airport 2 loses traffic both in relation to vertical separation and to the competitor airport, while the opposite happens to airport 1.

Regarding the final prices for passengers, we verify that airport's 1 price falls, partially eliminating the double marginalization. The elimination of double marginalization is not complete (note that $p_1^{VSC} > w_1^{VSC}$) due to product differentiation that gives additional market power to firms. The price at airport 2 is higher than at airport 1, and this is not a surprising result as airport 2 is not vertically integrated. Nevertheless, at airport 2 there is also a price decrease in relation to vertical separation. Then, although airport 2 is not vertically integrated, the passengers that depart from airport 2 benefit for the vertical integration in airport 1 due to market connection through the airlines' activities. Concerning the follower airline there is another interesting result: the unit margin under vertical integration ( $p_2^{VSC} - w_2^{VSC}$ ) increases in spite of the lower final price. This is due to the decrease in airport's 2 fares which is the response of airport 2 to vertical integration of its competitor. However, these changes do not avoid the decrease of the follower's airline and airport's 2 profits.

Comparing the payoffs we observe that there is an incentive for vertical collusion since the integrated firm's payoff is higher than the sum of profits of the airport 1 and the leader airline under vertical separation. On the contrary, the left alone firms are worse-off.

Evaluating the consumer welfare we conclude that passengers from airport 2 lose with vertical integration. Although they pay a lower price, the reduction of traffic causes a decrease on consumer surplus. Differently, consumers that depart form airport 1 have higher surplus as there is both price reduction and traffic increase. Overall, the effect of vertical integration on consumer surplus is positive since the effect on airport's 1 passengers is stronger.

Finally, social welfare is higher under vertical integration than under vertical separation, which is the standard result of vertical integration.

### *4.3 Partial airport's profit sharing*

Under this case the leader airline obtains part of the airport's 1 profit. Then, the best reply functions of the follower airline are identical to the ones obtained above. Knowing the best reply functions, the leader airline set the quantities considering the following payoff function $\prod^L = (p_1 - w_1)q_1^L + (p_2 - w_2)q_2^L + \delta\left[(w_1 - c)(q_1^L + q_1^F)\right]$.

The leader airline maximizes its profit with $q_1^L(w_1, w_2) = \dfrac{(a-w_1)-(a-w_2)\theta+(w_1-c)\delta}{2(1-\theta)^2}$ and $q_2^L(w_1, w_2) = \dfrac{(a-w_2)-(a-w_1)\theta-(w_1-c)\delta\theta}{2(1-\theta)^2}$.

Taking into account the above quantities, the airports set simultaneously the aeronautical fares, maximizing their payoff functions given by $\prod^{A1} = (1-\delta)\left[(w_1-c)(q_1^L+q_1^F)\right]$ and $\prod^{A2} = (w_2-c)(q_2^L+q_2^F)$, respectively.

The optimal aeronautical fares are $w_1^{PSC} = \frac{3(a+c-a\theta)-c\delta(2-\theta)}{(3-\delta)(2-\theta)}$ and $w_2^{PSC} = \frac{a(1-\theta)+c}{2-\theta}$.

Comparing with the aeronautical fares obtained under vertical separation and vertical collusion we conclude that profit sharing leads to the highest fare at airport 1. This is a strong effect of the vertical agreement explained by the fact that the leader airline/airport 1 wish to exclude the follower airline from airport 1 or, if that is too costly, they prefer to extract the highest possible upstream profit from the follower airline activities at airport 1. This result is synthetized by Proposition 7.

***Proposition 7**: With airport competition, profit sharing agreements between the leader airline and airport 1 lead to the highest aeronautical fare at airport 1, ie* $w_1^{PSC} > w_1^{VSC} > w_1^{VIC}$.

On the contrary, airport 2 sets the same aeronautical fare as under vertical separation.

Substituting backwards the optimal quantities are $q_1^{PSC,L} = \frac{(3+\delta)(a-c)}{2(1+\theta)(3-\delta)(2-\theta)}$, $q_2^{PSC,L} = \frac{(3-\delta-2\theta\delta)(a-c)}{2(1+\theta)(3-\delta)(2-\theta)}$, $q_1^{PSC,F} = \frac{(3-5\delta)(a-c)}{4(1+\theta)(3-\delta)(2-\theta)}$ and $q_2^{PSC,F} = \frac{(4\theta\delta-\delta+3)(a-c)}{4(1+\theta)(3-\delta)(2-\theta)}$.

The follower airline's quantity at airport 1 is decreasing with δ and for δ ≥ 0.6 this airline is excluded from airport 1. This is a similar result from the previous model. Hence, profit sharing agreements have a strong capacity to exclude rivals from the market, and this capacity is not affected by airport competition.

***Proposition 8:** With airport competition, vertical agreements between the airport 1 and the leader airline exclude the follower airline from this airport as long as δ ≥ 0.6.*

At airport 2 the follower's airline traffic has intermediate values between vertical separation and vertical integration case, that is, $q_2^{VSC,F} < q_2^{PSC,F} < q_2^{VIC,F}$.

Moreover, in respect to the leader's airline traffic, profit sharing amplifies the effects of vertical integration, that is, the leader's traffic at airport 1 is the uppermost and at airport 2 is the lowermost in comparison with the other two alternative vertical relations, as long as the profit share is relatively high. Then, for significant values of δ, which also ensure that the follower airline does not have any operations at airport 1, the leader airline reinforces its position at airport 1 and disinvest at airport 2, even more than under vertical integration. This creates a deeper gap between the integrated airline/airport and the non-integrated airline and airport.

***Proposition 9:** With airport competition and profit sharing, the leader airline has the highest traffic at airport 1 and the lowest traffic at airport 2 as long as* $\delta > \frac{9-3\theta^2}{9-2\theta^2}$.

It is also interesting to notice that profit sharing does not change the total traffic at each airport in relation to the vertical separation case, as long as δ < 0.6. With profit sharing the follower airline reduces (increases) its operations at airport 1 (2) and the leader airline adjustments have the opposite sign. Then, overall each airport has the same traffic as under vertical separation. By contrast, when δ ≥ 0.6 the traffic at airport 1 is lower under profit sharing than under vertical separation.

Regarding the remaining optimal values we distingue two situations according to the follower's operations at airport 1. First, we analyze the results when the follower's airline offers services at airport 1, which occurs when $\delta < 0.6$. Second, we study the results when the follower's airline is excluded from airport 1, which happens when $\delta \geq 0.6$ .

*4.4 First case: The follower airline is not excluded from airport 1*

When the follower airline operates at airport 1 the optimal values of the prices, firms' payoff, consumer surplus and social welfare are described in Appendix C.

The final prices are exactly the same as under vertical separation. This is an important result as it means that vertical agreements, as long as the follower airline is not excluded from airport 1, do not have any effects on the passengers' prices. That is, profit sharing does not allow any reduction of the double margin, in spite of the partial common interests of one airport and one airline. This is exactly the same result we obtained with a single airport. Therefore this result is quite robust and is not affected by airport competition.

Consequently, also consumer surplus and social welfare are the same as under vertical separation. Therefore, when the follower airline maintains activities at airport 1, profit sharing with airport competition have no aggregate effects in relation to vertical separation. There are individual effects, since the relative firms' payoffs change, but globally they cancelled out each other.

***Proposition 10***: *With airport competition and when the follower airline is not excluded from airport 1, profit sharing agreements do not have any effect on passengers' price, consumer surplus, aggregate payoffs or social welfare comparing with the vertical separation case.*

*4.5 Second case: The follower airline is excluded from airport 1*

The follower airline is excluded from airport 1 when $\delta \geq 0.6$. Under this restraint the passengers' price is higher at airport 2 than at airport 1. The follower airline obtains lower profits when it has activity at both airports and, on the contrary, the leader airline has higher profits as long as $\theta < \frac{5\delta - 3}{4\delta}$. Additionally, consumer surplus is higher with the exclusion of the follower airline. Social welfare can be higher or lower than under vertical integration depending on the parameters.

*4.6 Conclusions from the models with airport competition*

From the comparison of the three vertical relations cases we reach the following conclusions.

First, profit sharing excludes the follower airline from the airport that cooperates with the leader airline when the profit share is equal or above 0.6. This is the same result we obtained with a single airport. Therefore, we conclude that profit sharing has a strong capacity of foreclosure the rival airline, and this feature is independent of the existence of infrastructure investments or airport competition.

Second, with profit sharing airport 1 charges the highest aeronautical fare, making the follower airline presence at this airport quite difficult. Also, as long as the share in profits is significant, the leader/airport 1 expand their activities in airport 1 and diminish at airport 2.

Third, when profit sharing does not exclude the follower airline from airport 1 the vertical agreement does not have consequences on consumer surplus or social welfare compared with vertical separation. This is an important result for the appraisal of vertical agreements as it points out that when there are no damages on downstream competition there are also no negative effects on social welfare. Under these circumstances the evaluation of vertical agreements must focus on the firms' relative gains and losses. Quite different results emerge when profit sharing excludes the follower airline from airport 1. The negative effects on downstream market competition must be opposed with the positive effects on consumer surplus (due to the traffic expansion at airport 1) and with the effects on social welfare, which can be positive or negative depending on the particular markets features represented by the models' parameters.

Fourth, profit sharing does not eliminate the double marginalization.

# 5. Conclusions

We investigate the effects of airport's profit sharing on investment incentives, competition and social welfare. We compare three different market configurations regarding vertical relations between airports and airlines: two extreme cases, vertical separation and vertical integration, and the partial participation of the dominant airline on airport profits.

We conclude that airport's profit sharing displays the highest incentive to invest when compared to alternative vertical relations, as long as the airline share is significant. This is an interesting result which gives support the frequent justification for vertical agreements based on the incentives to enhance infrastructure investments.

Also, we conclude that airport's profit sharing excludes the independent airline from the market (or from the airport involved in the agreement in the case of airport competition) when the participation is not below 60%. This is a quite robust result that does not change with airport's investment or airports competition. This result is explained essentially by the fact that profit sharing does not eliminate double marginalization, even when the airline share in the airport profit is very high. This is an important outcome that policy authorities should take into account when evaluating vertical agreements between airports and airlines.

Moreover, we conclude that the effects of airport's profit sharing on social welfare when the independent airline is excluded from the market are ambiguous and depend on the specific features of the markets. For one side double marginalization persists but from other side there are positive effects caused by higher investment or by airport competition. Only when the independent airline is not excluded from the market and when there is airport competition the negative effects of vertical agreements on social welfare do not appear for sure.

Overall, we conclude that airport's profit sharing with a dominant airline should be carefully scrutinized by competition authorities in order to avoid undesired effects on investment and on social welfare. Our conclusions support the argument of Fu et al.(2011) that "competition and welfare effects of vertical arrangements depend on many factors including the market structures in the airline/airport markets. (…) There is a need to evaluate the costs and benefits of such airport-airline alliances on a case by-case basis". Our work contributes to the identification of some issues that must be taken into account on this evaluation.

The results of our work depend on several simplifications necessary to build theoretical models. Although the simplifications abstract from important real world features, the models provide useful insights as they highlight some crucial relations. Even though there are several aspects that worth to be considered in future research. Airport's revenues from commercial concessions are one of these points and its consideration might bring new perspectives on the effects of vertical linkages between airports and airlines. Another important topic is the airport competition between private and public airport, in line of research already developed by Basso (2008). Additionally, negative externalities from airports investments also deserve a detailed analysis, linked with the effects of airport congestion on the incentives to celebrate vertical agreements.

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## Appendix A– Proof of the propositions

**Proposition 1**: Note that $p^{VSA} = w^{PSA} = \frac{5a+3c}{8}$.

**Proposition 2:** From direct comparison of the expressions we conclude that $I^{VIB} = \frac{(a-c)\beta}{2\varphi-\beta^2}$ > $I^{VSB} = \frac{3\beta(a-c)}{8\varphi-3\beta^2}$ for every admissible value of the parameters and that $I^{PSB} = \frac{9\beta(a-c)}{z}$ > $I^{VIB} = \frac{(a-c)\beta}{2\varphi-\beta^2}$ as long as δ>3/4.

**Proposition 3**: Considering the optimal values we quantify three comparisons of the payoffs' sums. First we compare VI with VS; second we compare PS with VI, and finally, we compare PS with VS.

*A.1. Payoffs' sum under VI and VS*

Comparing the corresponding expressions we conclude that $\prod^{VIB,L+A} - (\prod^{VSB,L} + \prod^{VSB,F} + \prod^{VSB,A}) = \frac{2(a-c)^2\gamma^3}{(8\gamma-3\beta^2)(2\gamma-\beta^2)} > 0$ for all admissible values of the parameters. In order to separate the demand effect from the firms' behavior effect we identify the firms' payoffs that would exist if firms maximize the same payoff functions as under vertical separation, but considering the demand function of the vertical integration case. We denominate this artificial situation by X. Then, considering $I^{VIB} = \frac{(a-c)\beta}{2\varphi-\beta^2}$ and $\prod^L = (p-w)q_1$, $\prod^F = (p-w)q_2$

and $\prod^{A} = (w-c)(q_1+q_2) - \frac{\varphi I^2}{2}$ the payoffs would be $\prod^{X,L} = \frac{(a-c)^2\varphi^2}{8(2\varphi-\beta^2)}$, $\prod^{X,F} = \frac{(a-c)^2\varphi^2}{16(2\varphi-\beta^2)}$ and $\prod^{X,A} = \frac{(3\varphi-\beta^2)(a-c)^2\varphi^2}{4(2\varphi-\beta^2)^2}$. The difference between the sum of payoffs in situation X and the vertical separation equilibrium is the demand effect, as we are comparing two situations with different demand but the same payoffs functions. The difference between the vertical integration equilibrium and the situation X is the behavior effect, as we are comparing two situations with the same demand but different firms' payoff functions:

Demand effect =

$= (\prod^{X,L} + \prod^{X,F} + \prod^{X,A}) - (\prod^{VSB,L} + \prod^{VSB,F} + \prod^{VSB,A}) = \frac{(16\varphi - 9\beta^2)(a-c)^2\beta^2\varphi^2}{16(8\varphi-3\beta^2)^2(2\varphi-\beta^2)^2} > 0$ for all admissible values of the parameters.

Firms' behavior effect = $\prod^{VIB,L+A} - (\prod^{X,L} + \prod^{X,F} + \prod^{X,A}) = \frac{(a-c)^2\varphi^2}{16(2\varphi-\beta^2)^2} > 0$ for all admissible values of the parameters.

*A.2. Payoffs' sum under PS and VI*

Considering the optimal values we also conclude that $(\prod^{PSB,L} + \prod^{PSB,F} + \prod^{PSB,A}) - \prod^{VIB,L+A} = \frac{(a-c)^2\varphi^2\left[(18-12\delta+2\delta^2)\varphi - (18\delta-15\delta^2)\beta^2\right]}{z(2\varphi-\beta^2)} < 0$ for all admissible values of the parameters. In order to separate the demand effect from the firms' behavior effect we identify the payoffs that would exist if firms maximize the payoff functions of the profit sharing case but considering the demand function of the vertical integration case. We denominate this artificial situation by Y. Then, considering $I^{VIB} = \frac{(a-c)\beta}{2\varphi-\beta^2}$ and $\prod^{L} = (p-w)q_1 + \delta\left[(w-c)(q_1+q_2) - \frac{\varphi I^2}{2}\right]$, $\prod^{F} = (p-w)q_2$ and $\prod^{A} = (1-\delta)\left[(w-c)(q_1+q_2) - \frac{\varphi I^2}{2}\right]$ the payoffs' sum at situation Y would be $\prod^{Y,L} + \prod^{Y,F} + \prod^{Y,A} = \frac{(15\varphi-8\beta^2)(a-c)^2\varphi}{16(2\varphi-\beta^2)^2}$. The difference between the sum of payoffs of profit sharing and of situation Y is the demand effect. The difference between the payoffs of situation Y and of profit sharing is the behavior effect:

Demand effect =

$(\prod^{PSB,L} + \prod^{PSB,F} + \prod^{PSB,A}) - (\prod^{Y,L} + \prod^{Y,F} + \prod^{Y,A}) = \frac{\left[(48-112\delta)\varphi - (27-60\delta)\beta^2\right](4\delta-3)(a-c)^2\beta^2\varphi^2}{16(z(2\varphi-\beta^2)} > 0$

for δ > 3/4.

Firms' behavior effect = $(\prod^{Y,L} + \prod^{Y,F} + \prod^{Y,A}) - \prod^{VIB,L+A} - = \frac{-(a-c)^2\varphi^2}{16(2\varphi-\beta^2)^2} < 0$ for all admissible values of the parameters.

*A.3 Payoffs' sum under PS and VS*

Considering the payoffs' sum under profit sharing and vertical separation at the equilibrium, we conclude that

$(\prod^{PSB,L}+\prod^{PSB,F}+\prod^{PSB,A})-(\prod^{VSB,L}+\prod^{VSB,F}+\prod^{VSB,A})=\frac{27(a-c)^2\beta^2\varphi^2\delta\left[16\varphi(1-\delta)-(6-5\delta)\beta^2\right]}{z^2(8\varphi-3\beta^2)^2}<0$ for all admissible values of the parameters. To separate the two effects we characterize the situation Z where firms maximize the payoff functions of vertical separation with the demand function of the profit sharing case. For situation Z we have $\prod^{Z,L}+\prod^{Z,F}+\prod^{Z,A}=\frac{3(90\varphi-60\varphi\delta-27\beta^2+10\varphi\delta^2)(a-c)^2\varphi}{2z^2}$ and the effects are the following:

Demand effect =

$$(\prod^{Z,L}+\prod^{Z,F}+\prod^{Z,A})-(\prod^{VSB,L}+\prod^{VSB,F}+\prod^{VSB,A})=\frac{27\left[16\varphi(1-\delta)-(6-5\delta)\beta^2\right](a-c)^2\beta^2\varphi^2\delta}{z^2(8\varphi-3\beta^2)^2}$$

Firms' behavior effect $(\prod^{PSB,L}+\prod^{PSB,F}+\prod^{VPSB,A})-(\prod^{Z,L}+\prod^{Z,F}+\prod^{Z,A})=0$.

Hence, when we compare profit sharing and vertical separation under the same demand function we obtain the same total payoffs. Then, we conclude that profit sharing does not allow any elimination of double marginalization as the difference in total payoff is only due to the demand effect.

**Proposition 4**: From direct comparison of the payoffs the condition of proposition 4 is obtained.

**Proposition 5:** From direct comparison of the payoffs the conditions of proposition 5 are obtained.

**Proposition 6**: From direct comparison of the payoffs the conditions of proposition 6 are obtained.

**Proposition 7**: From direct comparison of the payoffs the conditions of proposition 6 are obtained.

**Proposition 8:** Note that $q_1^{PSB}\leq 0$ if $\delta \geq 0$.

**Proposition 9**: From direct comparison of the expressions we conclude that $q_2^{PSC,L}<q_2^{VIC,L}<q_2^{VSC,L}$ for $\delta>\frac{15-3\theta^2}{17-3\theta^2}$ and $q_1^{PSC,L}>q_1^{VIC,L}>q_1^{VSC,L}$ for $\delta>\frac{9-3\theta^2}{9-2\theta^2}$. Also, we verify that $\frac{9-3\theta^2}{9-2\theta^2}>\frac{15-3\theta^2}{17-3\theta^2}>0.6$ for any admissible value of θ.

**Proposition 10**: From direct comparison of the optimal values the conclusions of Proposition 10 are obtained.

## Appendix B – Demand function with product differentiation

We assume that the representative consumer has the following quadratic utility function similar to Dixit (1979):

$$U(Q_1,Q_2)=aQ_1+aQ_2-\frac{1}{2}\left[Q_1^2+2\theta Q_1Q_2+Q_2^2\right]$$

The maximization of the consumer utility function subject to the budget constraint leads to the demand functions:

$Q_1=\frac{a(1-\theta)}{1-\theta^2}-\frac{1}{1-\theta^2}p_1+\frac{\theta}{1-\theta^2}p_2$ and $Q_2=\frac{a(1-\theta)}{1-\theta^2}-\frac{1}{1-\theta^2}p_2+\frac{\theta}{1-\theta^2}p_1$.

These demand functions clearly represent that the number of passengers that fly from airport $A_1$ ($A_2$) decreases in $p_1$ ($p_2$) and increases, by a lower proportion, in $p_2$ ($p_1$), as a consequence of imperfect substitution.

# Appendix C – Optimal results for the model with airport competition

*C1. Vertical separation*

$$q_1^{VSC,L} = q_2^{VSC,L} = \frac{a-c}{2(1+\theta)(2-\theta)} \qquad q_1^{VSC,F} = q_2^{VSC,F} = \frac{a-c}{4(1+\theta)(2-\theta)}$$

$$p_1^{VSC} = p_2^{VSC} = \frac{5a+3c-4a\theta}{4(2-\theta)} \qquad \pi^{VSC,L} = \frac{(a-c)^2}{4(1+\theta)(2-\theta)^2}$$

$$\pi^{VSC,F} = \frac{(a-c)^2}{8(1+\theta)(2-\theta)^2} \qquad \pi^{VSC,A1} = \pi^{VSC,A2} = \frac{3(a-c)^2(1-\theta)}{4(1+\theta)(2-\theta)^2}$$

$$CS^{VSC} = CS_1^{VSC} + CS_2^{VSC} = \frac{9(a-c)^2}{16(1+\theta)^2(2-\theta)^2} \qquad W^{VSC} = \frac{3(a-c)^2(13+2\theta-8\theta^2)}{16(1+\theta)^2(2-\theta)^2}$$

*C2. Vertical collusion*

$$q_1^{VIC,L} = \frac{3(a-c)(2+\theta)}{2(1+\theta)(6-\theta^2)} \quad q_2^{VIC,L} = \frac{(a-c)(3-\theta-\theta^2)}{2(1+\theta)(6-\theta^2)} \quad q_1^{VIC,F} = 0 \quad q_2^{VIC,F} = \frac{(a-c)(2\theta+3)}{4(6-\theta^2)}$$

$$p_1^{VIC} = \frac{12(a+c)-3\theta(a-c)-4a\theta^2}{4(6-\theta^2)} \qquad p_2^{VIC} = \frac{3(5a+3c)-6\theta(a-c)-4a\theta^2}{4(6-\theta^2)}$$

$$\pi^{VIC,L+A1} = \frac{(a-c)^2(81+21\theta-38\theta^2-14\theta^2)}{8(1+\theta)(6-\theta^2)^2} \qquad \pi^{VIC,A2} = \frac{3(a-c)^2(1-\theta)(3+\theta)^2}{4(1+\theta)(6-\theta^2)^2}$$

$$\pi^{VIC,F} = \frac{(a-c)^2(2\theta+3)^2}{16(6-\theta^2)^2} \qquad CS^{VIC} = \frac{9(a-c)^2(25+22\theta+5\theta^2)}{32(1+\theta)^2(6-\theta^2)^2}$$

$$W^{VIC} = \frac{3(a-c)^2(270\theta-47\theta^2-104\theta^3-24\theta^4+261)}{32(1+\theta)^2(6-\theta^2)^2}$$

*C3. Profit sharing when the follower airline is not excluded from airport 1*

$$p_1^{PSC} = p_2^{PSC} = \frac{5a+3c-4a\theta}{4(2-\theta)}$$

$$\pi^{PSC,F} = \frac{(9-18\delta+12\theta\delta+13\delta^2-12\theta\delta^2)(a-c)^2}{8(1+\theta)(3-\delta)^2(2-\theta)^2} \qquad \pi^{PSC,L} = \frac{(9+18\delta-24\theta\delta-11\delta^2+12\theta\delta^2)(a-c)^2}{4(1+\theta)(3-\delta)^2(2-\theta)^2}$$

$$\pi^{PSC,A1} = \frac{9(1-\theta)(1-\delta)(a-c)^2}{4(1+\theta)(3-\delta)(2-\theta)^2} \qquad \pi^{PSC,A2} = \frac{3(1-\theta)(a-c)^2}{4(1+\theta)(2-\theta)^2}$$

$$CS^{PSC} = \frac{9(a-c)^2}{16(1+\theta)^2(2-\theta)^2} \qquad W^{PSC} = \frac{3(13+2\theta-8\theta^2)(a-c)^2}{16(1+\theta)^2(2-\theta)^2}$$