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**A COURNOT MODEL FOR ANALYSING THE EFFECTS
OF AN OPEN SKIES AGREEMENT**

**Vera Alves
Rosa Forte**

A Cournot model for analysing the effects of an open skies agreement^{*}

Vera Alves[†] and Rosa Forte[‡]

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Abstract

In the last decades there has been a gradual liberalisation of international air transport markets through the implementation of open skies agreements which seek the deregulation of the air transport industry and consequently the functioning of the market in a freer way. The objective of this work is to study the effects of an open skies agreement in order to understand if the airlines and the consumers will benefit after the market deregulation. With this purpose, we developed a Cournot model to compare the initial situation (without agreement) and the situation after the implementation of the open skies agreement.

Based on the model developed it can be concluded that the prices on international market segments where competition increases should decline after market liberalisation, thus benefiting consumers. Regarding the incumbent airlines in the market, an open skies agreement should jeopardize the airlines that fail to operate new routes after the agreement, leading to decreased profits.

Keywords: Open Skies agreement; Cournot model; Effects on prices; Firms' profits.

JEL codes: D43; D21

^{*} The authors dedicate this work to the memory of Prof.^a Doutora Cristina Barbot.

[†] Faculdade de Economia, Universidade do Porto. Email: 100432034@fep.up.pt

[‡] Faculdade de Economia, Universidade do Porto, and CEF.UP – Center for Economics and Finance at University of Porto. CEF.UP is financially supported by FCT (Fundação para a Ciência e a Tecnologia). Corresponding author. Rua Dr. Roberto Frias, 4200 – 464 Porto. Tel. 00351225571100. Email: rforte@fep.up.pt

1. Introduction

In the last decades we have been witnessing significant changes in the international air transport industry, namely due to the implementation of bilateral open skies agreements whose aim is air transport industry liberalisation. However, regarding multilateral agreements or agreements that cover a large number of countries, open skies is a recent concept, existing only for a while in a small number of countries.

According to Button (2009), open skies is a concept which emerged in the late 1970s when the United States (US) started to liberalize the domestic cargo market and the domestic passenger sector. This concept means then the liberalisation of the rules and regulations of airlines, with the aim of creating a free-market environment for the airline industry, with less state intervention. The open skies agreements include several “freedoms of the air”, whereby the agreements that include more freedoms are broader and they have more impact on the economy (ICAO, 2004).

Since the development of concepts such as open skies, we have seen a gradual liberalisation of the international air transport market that has benefited the travelling public (Button, 2009). Obviously, not all open skies agreements have had the same impact or the same importance on the international economy (Pitfield, 2009). Among the most relevant to the functioning of the global economy we found the following agreements: the European Union (EU) open skies agreement which has liberalized the air transport market among all countries of the European Community, yielding the “European Common Aviation Area” (ECAA); the open skies agreement between the EU and the US which has deserved more attention in the literature due to it being the broadest; the ASEAN open skies agreement (between ten countries in southwest Asia, although there is pressure to extend the agreement to other Asian countries such as India and China); or even the open skies agreement between the EU and Canada (Pitfield, 2009). It is also noteworthy that there are several current negotiations among countries or blocs with the objective of establishing a freer air transport market, as well as the existence of many other similar agreements all over the world (Pitfield, 2009).

In the EU, the implementation of open skies was made in several phases: 1987, 1990 and 1993 (Oum and Yu, 1995). Note that in 1987 just twelve countries were members of the European Community, therefore currently this open skies agreement is much broader, including the twenty seven members of the European Union.

Button (2009) refers that the opening up of the North Atlantic market (through the EU-US open skies agreement) is one of the major liberalisation measures since the removal of

barriers to the EU market, so it is very important to understand the effects of this agreement. Based on international trade theory, the Brattle Group (2002) emphasise that liberalisation would increase efficiency and benefit consumers in multiple ways. Also Fu et al. (2010) mention that liberalisation allows airlines to compete more efficiently, reduce prices and increase quality (e.g. in terms of flight frequency). In this way, the present investigation aims at understanding the potential economic effects of an open skies agreement, notably on competition and welfare. At this level, it is interesting to ascertain whether consumers will benefit from prices reductions. This follows from the effects of open skies agreements on competition (Fu et al., 2010). The literature suggests that these effects are positive, increasing the number of companies and the number of flights offered on the routes covered by the agreements (Booz Allen Hamilton, 2007; Fu et al., 2010).

With the purpose of examining the effects of open skies agreements we have developed a theoretical model to compare the situation pre-agreement with several situations post-agreement (including cases of competition in substitutes and complementary services), using the Cournot model with two market segments and analysing the case of such an agreement between the European Union (EU) and Brazil. The choice of this particular case relates to the fact that, to the best of our knowledge, there is no study to examine the effects of an open skies agreement between these economic areas and the fact that such an agreement is being studied, and is expected to materialise in the near future. Moreover, this agreement would affect Portugal and its national airline (TAP) since many of the flights between the EU and Brazil are flights between Portugal and Brazil.¹

This paper is organized as follows: Section 2 proceeds with a brief literature review regarding the expected effects of an open skies agreement (Section 2.1.) and some empirical evidence (Section 2.2.). In Section 3 we develop a theoretical model that allows us to study the effects of a open skies agreement: in Section 3.1. we present the assumptions and hypotheses of the model; in Section 3.2. we determine the equilibrium before the implementation of an open skies agreement; in Section 3.3. we determine the equilibrium after the implementation of an open skies agreement under three hypotheses; in Section 3.4. we analyse the effects of the agreement. Finally, in Section 4, we present the main conclusions, limitations and possible avenues of analysis in future work.

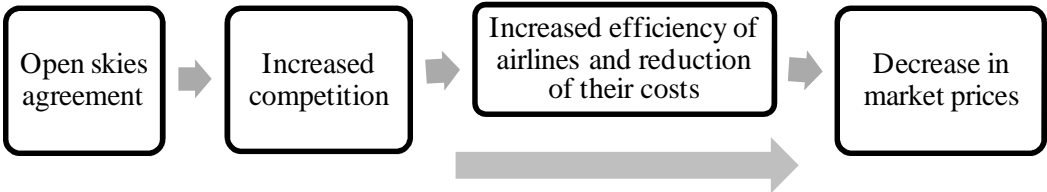
¹ "The South Atlantic was (in 2010) the most representative sector of the line network, reaching 42.2%, 4.2 pp more than in 2009, continuing to exceed the size of the sector in European network." (TAP, 2010, p. 55).

2. Effects of an open skies agreement

2.1. Expected effects

Generally, the existing literature considers that the sequence of effects caused by the implementation of an open skies policy is similar to that shown in Figure 1.

Figure 1: Effects of an open skies agreement



Source: Own elaboration according to literature review.

Some authors (Brattle Group, 2002; Sørensen and Dakes, 2005; Fu et al., 2010) consider that an open skies agreement should increase the number of airlines in the market, reflecting an increase in competition in the air transport market. This increase reflects the decrease of market restrictions, which should cause a restructuring of the air transport industry, allowing new airlines to enter liberalised segments of the market. On the other hand, according to Fu et al. (2010), this liberalisation should allow airlines to restructure and optimise their networks, becoming viable to operate routes between two locations that were not possible before due to the small number of passengers for that route. This restructuring increases the number of possible routes and the number of flights available in a given market (InterVistas, 2006; Button, 2009), thereby increasing the competition in those market segments.

According to the Brattle Group (2002), Booz Allen Hamilton (2007), and Fu et al. (2010), a second effect of an open skies agreement will be the increased efficiency of airlines and the consequent reduction of airlines costs. According to the Brattle Group (2002) the increased efficiency results from the fact that with the liberalisation more efficient airlines will replace less efficient ones or less efficient airlines may adopt a more efficient behaviour. For Booz Allen Hamilton (2007), liberalisation can result in productivity gains and consequent reduction in costs due to the ability to restructure across national borders and the possibility to make deeper alliances. Also Fu et al. (2010) consider that liberalisation increases airlines efficiency through several ways: the optimisation of an airlines network and the increased competition which force the merger or even bankruptcy of less efficient firms and the adoption of new business models and innovations.

Ultimately, some authors (Brattle Group, 2002; Adler and Hashai, 2005; Booz Allen Hamilton, 2007; Pels, 2009; Fu et al., 2010) refer that an open skies agreement should cause a price reduction in the liberalised market. According to the Brattle Group (2002), this reduction results from increased airlines efficiency and extensive cost reductions. According to Fu et al. (2010), price reduction is caused by the introduction of more efficient behaviour in airlines, which in turn results from increased competition. On the other hand, the cost reduction should stimulate price reduction in the liberalised market (Adler and Hashai, 2005; Booz Allen Hamilton, 2007; Pels, 2009). Thus, according to the referred authors, an open skies agreement should lead to price reduction resulting from the increased competition, cost reduction and increased efficiency. These effects are a well-known result of the literature of oligopoly models.

It is noted, however, that the effects mentioned above are not automatic. There are several factors that can hinder the achievement of these effects, such as: some strategic behaviour that incumbents can adopt with the purpose of preventing or hindering the entry of airlines to the market (e.g. code share agreements (Brueckner, 2001),² the restructuration of networks and frequent flier programs (Agarregabiria and Ho, 2010)), natural monopolies (Agarregabiria and Ho, 2010), limited airports' capacity (so that not all airlines can start flights at the same time) (Barbot, 2004), among others.

2.2. Some evidence regarding the effects of open skies agreements

To complement this study and better understand the effects of an open skies agreement, we will present some evidence regarding the effects of the agreement found in air transport markets.

Cosmas et al. (2010) analysed the effects of open skies agreements on service levels in transatlantic aviation markets. Measuring transatlantic service levels in terms of passenger enplanements, number of city pairs, departures and the number of carriers providing transatlantic service (the latter can be considered one indicator of the level of competition in the market) the authors conclude that open skies agreements between European countries and the US have resulted in both increases and decreases in service levels. For example, with regard to the number of competitors, of the 22 countries with US open skies agreements in place by 2007, only two demonstrated overall increases in the number of competitors and five

² Code share agreements or code share alliances are agreements established between airlines in which airlines agree on sell flights operated by the partner, allowing a coordination of prices and schedules (Brueckner, 2001).

demonstrated overall reductions. Cosmas et al. (2010) also obtained several inconclusive cases.

According to Cristea and Hummels (2011), since 1993 the US has signed more than 90 bilateral open skies agreements. During this period in which there was a gradual liberalisation in the US international air market the number of passengers in this market has increased due to the appearance of new routes and also due to air traffic growth on existing routes. This increase will be due both to the increasing of the frequency and to changes in prices charged by airlines (Cristea and Hummels, 2011). Note, however, that changes in the regulation of this industry require time for the international markets to adjust and meet new equilibrium levels. Thus, airlines will require time to reorganise their networks (Cristea and Hummels, 2011).

Studying the effects of bilateral open skies between the US and its partners, conducted between 1992 and 2007, Cristea and Hummels (2011) used 599,533 observations, which covered the period between 1993 and 2008. The sample relates to 50,000 routes between pairs of airports, one of them always being a US airport, and there are about 12 observations for each route. The authors found evidence that the implementation of an open skies agreement should lead to a significant increase in outbound air traffic. According to Cristea and Hummels (2011), five or more years after the agreement is signed, this traffic should be about 18% higher in liberalised markets, compared with non-liberalised markets. This increase is explained in part (40%) by the introduction of new nonstop routes to the liberalised international markets and 60% of this increase will be due to the growth in traffic on the routes previously offered. The traffic from the US to countries signatories of an open skies agreement is expected to be 11.3% higher on average than the traffic on routes similar but whose target markets are regulated (Cristea and Hummels, 2011). This increase will be due to improvements in the quality of services such as the increased frequency of flights or better coordination of flight schedules. On the contrary, the impact of such an agreement in the volume of incoming traffic in the US is negligible, almost nil suggesting, once again, the need of time for market and airlines to readjust (Cristea and Hummels, 2011).

Besides the reason given by the authors, one might question the reason for the imbalance between the change in volume of traffic in and out. Another factor that can cause this imbalance is the fact that North American airlines are more efficient than the airlines of countries with which the US concluded open skies agreements. In fact, Oum and Yu (1995) argue that before the EU deregulation European airlines were considered inefficient and although European airlines have increased their efficiency since 1987, they continued in 1993 to be less efficient than North American companies. According to Oum and Yu (1995), also

Asian airlines were in 1993, substantially less efficient than American competitors. This may have forced the European and Asian airlines to reduce or maintain their quantities. These findings suggest that efficiency asymmetries can lead to agreements that benefit the more efficient companies, who operate less costly and therefore can offer better prices, to the detriment of less efficient companies. Agreements can, therefore, introduce asymmetric effects, benefiting some companies while hurting others.

With regard to prices charged by airlines, Cristea and Hummels (2011) find evidence that the liberalisation of an air transport market should lead to a small direct effect (decrease of 1.6% on average) due to factors such as increased competition or cost synergies caused by the formation of airline alliances. Such synergies arise mainly from better coordination of services, through restructuring of networks. In addition to this decrease in prices (regardless of the initial level of prices), the authors also found strong evidence that the demand for international flights is expected to increase. Cristea and Hummels (2011) conclude that passengers travelling to the US should pay prices about 4% lower, due to the liberalisation of the market, while passengers who start their trip in the US will not see the prices of their flights changed significantly. The effect of an Open Skies agreement for these passengers is insignificant and close to zero. So it takes some time for the benefits derived from a liberalisation of air transport markets to affect the prices of flights to other countries (Cristea and Hummels, 2011). However, and according to the same authors, liberalisation of an air transport market should lead, in the longer term, to lower prices of flights to regulated markets by about 32% due to the direct effect on the price, the effect of service quality and the effect of the airlines' networks restructuring.

In summary, the study of Cristea and Hummels (2011) suggests that the implementation of an open skies agreement leads to an increase in traffic and a decrease in market prices. However, it takes some time (five years or more) for all the benefits from the adoption of such an agreement to actually occur. However, this econometric study was based on a sample of forecasts. For this reason, there are limitations to this analysis, such as the fact that they had not contemplated strategic behaviour, such as collusion, alliances, or other behaviour of incumbent firms aimed at preventing the entry of new firms to the market.

3. A Cournot model for analysing the effects of an open skies agreement

3.1. Assumptions and hypotheses

The present study aims at studying the effects of open skies agreements on prices and airlines profits. Thus, we develop a theoretical model to compare the situation pre-agreement with several post-agreement situations (including cases of competition in substitutes and complementary services), using the Cournot model with three market segments and analysing the case of an open skies agreement between the EU and Brazil.³ To the best of our knowledge there are no models for open skies agreements, so we base our model in two models of code share, developed by Brueckner (2001) and Bilotkach (2007). Note that the major difference between the two situations is that in the case of Open Skies a larger number of companies can operate a given route, while in the case of code share the number of companies is the same, but an airline operates flights that may also be sold by another airline. In the case of code share there is no increased competition, but the quantities can increase and prices decrease. It is in this aspect that the two situations become similar.

Brueckner (2001) aims at understanding the effects of a substitute code share agreement while Bilotkach (2007) addresses the complementary partnerships.⁴ In both studies the authors used the Cournot model with multiple market segments. Brueckner (2001) presents a model with two firms operating in various market segments (16 but competing in a single segment, the interhub market (baseline situation). The hypotheses tested by Brueckner (2001) relate to the implementation of a code share agreement between the two airlines and in the second hypothesis also take into account the economies of scale resulting from this partnership. Moreover, Bilotkach (2007) presents a model with only three market segments (one domestic and two international) and three airlines operating. It is noteworthy that these airlines are not equal. While in the initial situation firm 1 is domestic and operates in the three market segments, firm 2 is also domestic but operates only domestic flights in the domestic segment, and firm 3 is international and cannot operate flights on the domestic route, operating thus in only one market segment (Bilotkach, 2007). The Bilotkach (2007) hypothesis aimed at testing the effects of code share agreements (partnership between firms 2 and 3) and semi-complementary (partnerships between firms 1 and 2 or 1 and 3).

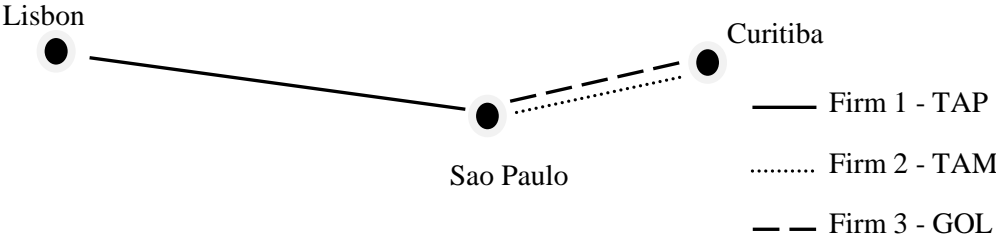
³ It is noteworthy that there is still no open skies agreement between the EU and Brazil. However, an agreement between these two markets is being studied.

⁴ Substitute code share concerns partnerships between airlines in parallel services, that is, substitute routes (Brueckner, 2001). Complementary code share relates to partnerships between airlines in complementary services, so to routes that complement each other (Bilotkach, 2007).

However, the objective of the present study concerns the analysis of the effects of an open skies agreement and not a code share partnership, so that the model used and the hypotheses tested are not the same as mentioned above. Although we also use the Cournot model, the situations to test are quite different, the objective of this study being to analyse if an open skies agreement, allowing the entry of new airlines in the international markets liberalised and thus increasing competition, will result in lower prices and an increase in consumer surplus. Therefore, the hypotheses tested relate to the entry of airlines in certain market segments and the implementation of a collusion between two airlines, one of which is the incumbent. Some of the differences of the model used in this study lie in the variables used. On the one hand, here there is not a total cost function that includes economies of density, as in the two models analysed, but, for reasons of simplification, we assume constant marginal costs of each airline, represented by c .⁵ On the other hand, the inverse demand function of a particular airline (or price) is defined as a function of the traffic satisfied by its competitors (Cournot competition), which also does not occur in the two models mentioned above.

The network admitted in this model is intended to represent the international market between Portugal and Brazil, and consists of three market segments (Lisbon - Sao Paulo, Sao Paulo - Curitiba and Lisbon - Curitiba) according to Figure 2. Thus, our study aims at analysing the impact of a hypothetical open skies agreement between the EU and Brazil, having been chosen a complementary route (Sao Paulo - Curitiba) which has considerable traffic.⁶ It is assumed that in this market only three airlines (TAP, TAM and GOL) operate, the first being a Portuguese airline and the last two Brazilian airlines.⁷

Figure 2: Network structure before the implementation of the open skies agreement



Source: Own elaboration

⁵ And also because in the case of code share there is a firm that operates flights of two airlines, which can lead to economies of density, while in the case of open skies it is the competition between firms that will lead to lower prices, rather than the costs.

⁶ Curitiba, with about 1.8 million inhabitants and with a distance of 359 kilometers from Guarulhos, is (following Manaus) the second largest Brazilian city among the cities that TAP does not offer direct flights.

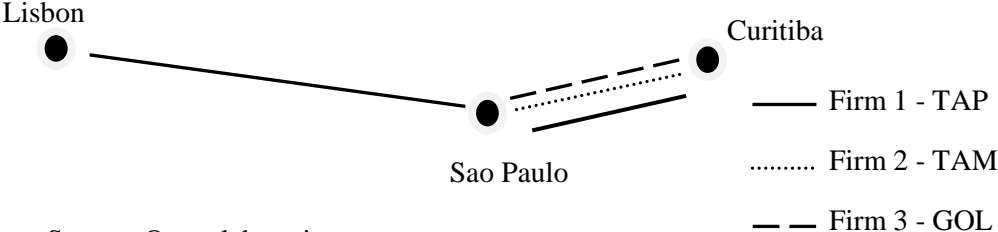
⁷ Although several airlines (TAM, GOL, Webjet and TRIP) operate this route on a regular basis, to simplify this number was reduced to two firms.

As we can see from Figure 2, in the initial situation TAP (firm 1) is present in the market segment between Lisbon and Sao Paulo (international route), while TAM (firm 2) and GOL (firm 3) operate flights between Sao Paulo and Curitiba, and the routes Lisbon - Sao Paulo and Sao Paulo - Curitiba are complementary services.⁸ We can see, therefore, that none of the airlines operate on the route Lisbon - Curitiba. Thus, a passenger wishing to undertake a journey between Lisbon and Curitiba would have to buy two tickets, traveling with firm 1 in the market segment Lisbon - Sao Paulo and changing planes in Sao Paulo. In the market segment Sao Paulo – Curitiba the passenger may choose to travel with the airline 2 or 3. Hence, in this scenario, the route Lisbon - Curitiba is an interline market. Thus, the market Lisbon - Sao Paulo is a monopoly of one firm, while the market Sao Paulo - Curitiba is an oligopoly where firms 2 and 3 operate.

To understand the impact of the effects of an Open Skies agreement, we test three hypotheses:

Hypothesis 1 (H1): firm 1 enters the market segment Sao Paulo - Curitiba, allowing the firm to be present in all three market segments (the international segments Lisbon - Sao Paulo and Lisbon - Curitiba and the domestic segment Sao Paulo - Curitiba). So while firm 1 is the only one to operate international flights (monopolies), market competition in the market Sao Paulo - Curitiba increases (Figure 3).

Figure 3: Network structure after the implementation of the open skies agreement, under H1

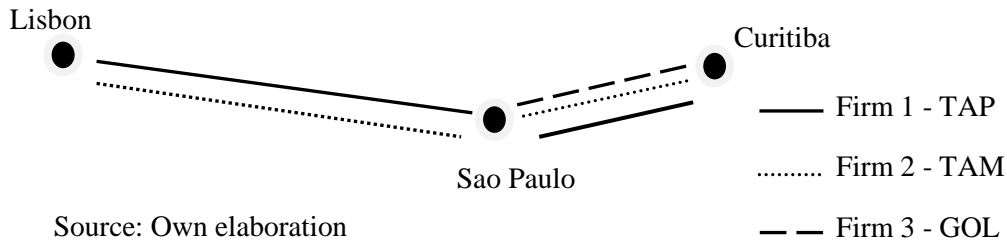


Source: Own elaboration

Hypothesis 2 (H2): firm 1 enters in the market Sao Paulo - Curitiba and firm 2 enters in the market Lisbon - Sao Paulo. Thus, some competition is introduced in the market Lisbon - Curitiba (compared with H1), this route being operated by firms 1 and 2. Moreover, firm 3 continues to operate flights only in the domestic route, Sao Paulo – Curitiba (see Figure 4).

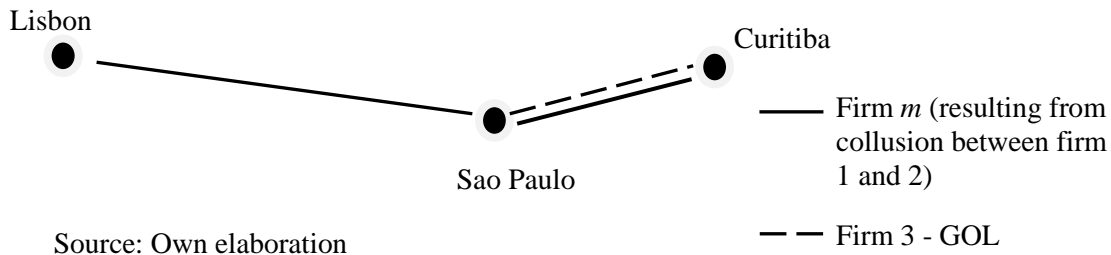
⁸ From Figure 2, we also notice that the route between Lisbon and Sao Paulo (long course) is quite longer than the Brazilian domestic route (short / medium-haul).

Figure 4: Network structure after the implementation of the open skies agreement, under H2



Hypothesis 3 (H3): Collusion between firms 1 and 2 in order to operate flights in the market Lisbon - Curitiba, offering to consumers the two complementary services (Lisbon - Sao Paulo route and Sao Paulo - Curitiba route). With the collusion, firms involved should jointly make decisions regarding the definition of the quantities to provide for both, so these airlines should agree on the quantities to maximise the joint profit (see Figure 5).

Figure 5: Network structure after the implementation of the Open Skies agreement, under H3



From these hypotheses, we intend to understand the effects of an open skies agreement at the level of prices, profits of airlines and also investigate whether consumers will be favoured by the implementation of the agreement. In this way we start by determining the equilibrium in the initial situation, i.e. before the agreement (Section 3.2.), and then we analyze the situation after the implementation of the agreement under the three hypotheses presented (Section 3.3.). According to the literature we are interested in comparing the consumer surplus, which can be done by comparing the prices or quantities, and the corporate profits.

3.2. Equilibrium before the implementation of an open skies agreement

To understand the impact of the effects of an open skies agreement, we used the following variables: price, denoted by p , quantities represented by x , y and z (where x represents the demand for the route between Lisbon and Sao Paulo, y is the demand for the route between Sao Paulo and Curitiba, and z is the demand for the route Lisbon - Curitiba), marginal costs, designated by c , and total profits of each firm, represented by π .

In the initial situation, that is without an open skies agreement, firm 1 operates flights only in the market Lisbon - Sao Paulo (LG), while the route Sao Paulo - Curitiba (GC) is operated by firms 2 and 3. In this case, this is a game played in 2 stages. In the first stage, firm 1 determines prices or quantities to offer in the market LG, and the firm anticipates the price charged by the other two companies in the market GC. It is noteworthy that it makes no difference if firm 1 determines prices or quantities because this airline is monopolist in this market. In the second stage, firms 2 and 3 compete in quantities (Cournot competition), in the market Sao Paulo – Curitiba (GC), knowing the price for the market Lisbon - Sao Paulo. Thus, in the first stage of this game the reverse demand function in the market segment LG, p_L , will be used :

$$p_L = a - x_1 \quad (1)$$

Where a is the reserve price in the market LG and x_1 is the total traffic on this route (which will be served only by firm 1). In the second stage, the reverse demand function for the market segment GC, p_C , is given by:

$$p_C = b - y_2 - y_3 \quad (2)$$

Where b represents the reserve price in the market GC, y_2 and y_3 represent the demand for this segment (GC) satisfied by firms 2 and 3, respectively. Due to the difference in distances of the two routes, since Lisbon - Sao Paulo is long-haul and GC is short / medium haul, we assume that $a > b$. We also assume that $b > c$ (and consequently, $a > c$) otherwise firms would not have an incentive to produce.

Note that, in the initial situation, there is no airline flying the entire route Lisbon – Curitiba (LC), so the price in this market, designated by p_{LC} , is given by the sum of p_L and p_C .

In regards to the airlines profits, they are given by the functions π_1, π_2 and π_3 (profits of firm 1, 2 and 3, respectively), that is:

$$\pi_1 = (p_L - c)x_1 \quad (3)$$

$$\pi_2 = (p_C - c)y_2 \quad (4)$$

$$\pi_3 = (p_C - c)y_3 \quad (5)$$

In the first stage of the game, firms 1, 2 and 3 compete on price for the segments LG and GC, complementary of LG. In the second stage, firms 2 and 3 compete in quantities in the GC market. Thus, in the market LG firm 1 demand is composed of two types of consumers: those

who fly only LG (with the reverse demand $p_L = a - x_{1L}$) and those who fly LG and then GC (with reverse demand $p_L + p_c = a + b - x_{1C}$), that is:

$$x_1 = x_{1L} + x_{1C} = 2a + b - p_c - 2p_L \quad (6)$$

Substituting (6) into equation (3) we obtain the following expression for the profit function of firm 1:

$$\pi_1 = (p_L - c)(2a + b - p_c - 2p_L) \quad (7)$$

Firm 1 maximizes its profit on price, getting the firm 1 best reply function $p_L(p_C)$:

$$p_L = \frac{1}{2}a + \frac{1}{4}b + \frac{1}{2}c - \frac{1}{4}p_C \quad (8)$$

Regarding the GC market, total demand in this market (y) is the sum of two components: the market demand of LC in the segment GC ($y_{2L} + y_{3L} = a + b - p_c - p_L$) and market demand of GC ($y_{2C} + y_{3C} = b - p_c$).⁹ Thus:

$$y_2 + y_3 = a + 2b - 2p_c - p_L \quad (9)$$

Solving equation (9) in order to p_C we obtain:

$$p_C = \frac{1}{2}a + b - \frac{1}{2}p_L - \frac{(y_2 + y_3)}{2} \quad (10)$$

Replacing (10) in (4) and (5) (firms 2 and 3 profits, respectively) and maximising the quantities, we obtain the following best reply function for firm 2 and 3 (equations (11) and (12), respectively):

$$y_2 = \frac{1}{2}a + b - c - \frac{1}{2}y_3 - \frac{1}{2}p_L \quad (11)$$

$$y_3 = \frac{1}{2}a + b - c - \frac{1}{2}y_2 - \frac{1}{2}p_L \quad (12)$$

Solving the system composed by equations (11) and (12) we obtain:

$$y_2 = y_3 = \frac{1}{3}a + \frac{2}{3}b - \frac{2}{3}c - \frac{1}{3}p_L \quad (13)$$

Finally, we obtain the total demand in the GC market, y :

$$y = y_2 + y_3 = \frac{2}{3}a + \frac{4}{3}b - \frac{4}{3}c - \frac{2}{3}p_L \quad (14)$$

Replacing (14) in equation (10) we get:

$$p_C = \frac{1}{6}(a + 2b + 4c - p_L) \quad (15)$$

⁹ Note that $y_2 = y_{2C} + y_{2L}$ and $y_3 = y_{3C} + y_{3L}$.

Equation (15) represents a kind of best reply function of market Sao Paulo – Curitiba to market Lisbon – Sao Paulo.

Solving the system resulting from equations (8) and (15) we obtain:

$$p_C = \frac{1}{23}(2a + 7b + 14c) \quad (16)$$

$$p_L = \frac{1}{23}(11a + 4b + 8c) \quad (17)$$

Equations (16) and (17) are the equilibrium solutions for prices. In this way, p_{LC} is given by:

$$p_{LC} = p_C + p_L = \frac{1}{23}(13a + 11b + 22c) \quad (18)$$

Replacing (17) in equation (13) we obtain:

$$y_2 = y_3 = \frac{2}{23}(2a + 7b - 9c) \quad (19)$$

Replacing (16) and (19) in equation (4) or (5) we obtain firms' 2 and 3 profits:

$$\pi_2 = \pi_3 = \frac{2}{529}(2a + 7b - 9c)^2 \quad (20)$$

Finally, regarding firm 1, by substituting (16) and (17) in equation (6) we get:

$$x_1 = \frac{2}{23}(11a + 4b - 15c) \quad (21)$$

Replacing (17) and (21) in equation (3) we obtain firm's 1 profits:

$$\pi_1 = \frac{2}{529}(11a + 4b - 15c)^2 \quad (22)$$

To sum up, from the calculations made for this baseline scenario we obtain the equilibrium prices for the various markets and the profits of the three firms, which are shown in Table 1, which also presents these variables for the three hypotheses considered with implementation of the open skies agreement. These are explored in the next Section.

3.3. Equilibrium under open skies agreement

Hypothesis 1 (H1)

As mentioned previously, the hypothesis H1 relates to the entry of firm 1 in the segment GC, everything else is held constant (Figure 3). In this scenario it is assumed that firms 2 and 3 are not prepared to operate flights on international routes (because they do not have sufficient conditions to operate this type flights, for example, they have no aircraft with enough size, or they do not have slots or supporting infrastructure in Lisbon). Thus, the route Lisbon - Sao

Paulo remains a monopoly of firm 1 and this firm becomes the only airline to offer flights to Lisbon - Curitiba. Note that Lisbon - Sao Paulo and Lisbon - Curitiba are two different products because the route Lisbon - Curitiba is not limited to the route Lisbon - Sao Paulo, it also contains the route Sao Paulo - Curitiba, therefore being the set of two complementary services. On the other hand, firm 1 can also to carry other passengers of the route Sao Paulo - Curitiba. In other words, firm 1 offers three services: Lisbon - Sao Paulo, Lisbon - Curitiba (selling a single ticket) and Sao Paulo - Curitiba, where the first two are operated as a monopoly and the latter in competition with the other two firms.

This hypothesis will be examined in a game in two stages. In the first stage firm 1 determines the price (or quantity, for the reasons given above) in the segments LG and Lisbon - Curitiba, anticipating the quantity (and also the price) of the segment GC and incorporate it in its best reply function. In this case, the prices of Lisbon - Sao Paulo and Lisbon - Curitiba are independent of the prices of Sao Paulo - Curitiba. At this stage of the game, demand of market LG , $p_L(x_1)$, is still given by equation (1) but the reverse demand function for the market Lisbon - Curitiba (which is operated only by the firm 1) is given by:

$$p_{LC} = a + b - z_1 \quad (23)$$

Where a and b have the same meaning mentioned above and z_1 is the quantity demanded (traffic) of the route Lisbon – Curitiba (LC) which is satisfied by firm 1.¹⁰

In the second stage, which regards the choice of the quantities offered in the market segment GC, the three firms compete in quantities. So, in this case, the reverse demand function of the market segment GC is given by:

$$p_c = b - y_1 - y_2 - y_3 \quad (24)$$

y_1, y_2 and y_3 represent the traffic (demand) of the route Sao Paulo - Curitiba satisfied by firms 1, 2 and 3, respectively. Moreover, profits of firm 2 and 3 are given, respectively, by the functions (4) and (5), while the profit of firm 1 is given by:

$$\pi_1 = (p_L - c)x_1 + (p_{LC} - c)z_1 + (p_c - c)y_1 \quad (25)$$

In the first stage of the game, firm 1 determines the price (or quantity) in the segments LG and LC anticipating its quantity and so the price of the GC segment, while in the second stage firm 1 competes in quantities (Cournot competition) with firms 2 and 3 in the market GC.

Replacing (1), (23) and (24) in the equation (25), firm 1 profit is given by:

¹⁰ Note that $p_L < p_{LC} < p_L + p_c$ (p_{LC} is the price for the segment LC).

$$\pi_1 = (a - x_1 - c)x_1 + (a + b - z_1 - c)z_1 + (b - y_1 - y_2 - y_3 - c)y_1 \quad (26)$$

As the market LG is a monopoly, there is no difference in maximising profit in price or quantity, so firm 1 maximises its profit in the three quantities, obtaining:

$$x_1 = \frac{1}{2}a - \frac{1}{2}c \quad (27)$$

$$z_1 = \frac{1}{2}a + \frac{1}{2}b - \frac{1}{2}c \quad (28)$$

$$y_1 = \frac{1}{2}b - \frac{1}{2}c - \frac{1}{2}y_2 - \frac{1}{2}y_3 \quad (29)$$

As markets LG and LC are independent of the GC market, now we get the solutions for the quantities of these markets and respective prices. In fact, replacing (27) in the equation (1) and (28) in the equation (23) we get the following prices:

$$p_L = \frac{1}{2}a + \frac{1}{2}c \quad (30)$$

$$p_{LC} = \frac{1}{2}a + \frac{1}{2}b + \frac{1}{2}c \quad (31)$$

Replacing (27) and (28) in equation (26) and simplifying we obtain firm 1's profit:

$$\pi_1 = \frac{1}{4}(a - c)^2 + \frac{1}{4}(a + b - c)^2 + (b - y_1 - y_2 - y_3 - c)y_1 \quad (32)$$

Additionally, replacing (24) in equation (4) and (5) we obtain firm 2 and 3 profits, respectively, that operate in the segment GC:

$$\pi_2 = (b - y_1 - y_2 - y_3 - c)y_2 \quad (33)$$

$$\pi_3 = (b - y_1 - y_2 - y_3 - c)y_3 \quad (34)$$

Each firm maximises its profit (given by equations (32), (33) and (34)) in quantities, so we obtain the best reply functions for firm 1, 2 and 3, respectively:

$$y_1 = \frac{1}{2}b - \frac{1}{2}c - \frac{1}{2}y_2 - \frac{1}{2}y_3 \quad (35)$$

$$y_2 = \frac{1}{2}b - \frac{1}{2}c - \frac{1}{2}y_1 - \frac{1}{2}y_3 \quad (36)$$

$$y_3 = \frac{1}{2}b - \frac{1}{2}c - \frac{1}{2}y_1 - \frac{1}{2}y_2 \quad (37)$$

Solving the three best reply function we obtain the following quantities:

$$y_1 = y_2 = y_3 = \frac{1}{4}b - \frac{1}{4}c \quad (38)$$

Replacing (38) in equation (24) we obtain the price of the market GC:

$$p_C = \frac{1}{4}(b + 3c) \quad (39)$$

Replacing (38) in equations (32), (33) and (34) we obtain the profits of firm 1, 2 and 3, respectively:

$$\pi_1 = \frac{1}{4}(a - c)^2 + \frac{1}{4}(a + b - c)^2 + \frac{1}{16}(b - c)^2 \quad (40)$$

$$\pi_2 = \frac{1}{16}(b - c)^2 \quad (41)$$

$$\pi_3 = \frac{1}{16}(b - c)^2 \quad (42)$$

Hypothesis 2 (H2)

The second hypothesis tested (see Figure 4) concerns the entry of firm 1 in the route Sao Paulo - Curitiba and the entry of firm 2 in the international route (assuming that only firm 3 is not prepared to operate flights on this route). Therefore, firms 1 and 2 compete in the market LG and Lisbon - Curitiba, while in the market CG the three airlines compete. In this case, we have a game in two stages. In the first stage firms 1 and 2 compete in quantities (Cournot competition) in the segments LG and Lisbon - Curitiba, anticipating their quantities and thus the price of the segment GC. For this reason, in the first stage there are two market segments with two demand functions: the inverse demand function in the segment LG (p_L) and the inverse demand function in the segment Lisbon - Curitiba (p_{LC}), which are given by equations (43) and (44), respectively.

$$p_L = a - x_1 - x_2 \quad (43)$$

$$p_{LC} = a + b - z_1 - z_2 \quad (44)$$

Where a and b have the meanings stated above, x_1 and x_2 represent the demand of the market LG satisfied by firm 1 and 2, respectively, and z_1 and z_2 represent the demand in the market Lisbon - Curitiba met by firms 1 and 2, respectively.

Moreover, in the second stage the three firms compete in quantities in the segment GC. As this scenario is the same as shown in the route Sao Paulo – Curitiba in the hypothesis H1, demand will be given by equation (24). In this scenario the profit functions of firms 1 and 3 are given, respectively, by equations (25) and (5), while the profit of firm 2 is given by:

$$\pi_2 = (p_L - c)x_2 + (p_{LC} - c)z_2 + (p_C - c)y_2 \quad (45)$$

Replacing (43) and (44) in equations (25) and (45) we obtain the profit function of firm 1 and 2, respectively:

$$\pi_1 = (a - x_1 - x_2 - c)x_1 + (a + b - z_1 - z_2 - c)z_1 + (b - y_1 - y_2 - y_3 - c)y_1 \quad (46)$$

$$\pi_2 = (a - x_1 - x_2 - c)x_2 + (a + b - z_1 - z_2 - c)z_2 + (b - y_1 - y_2 - y_3 - c)y_2 \quad (47)$$

These two airlines maximise profits in the quantities, obtaining the following best reply functions:

$$x_1 = \frac{1}{2}a - \frac{1}{2}c - \frac{1}{2}x_2 \quad (48)$$

$$x_2 = \frac{1}{2}a - \frac{1}{2}c - \frac{1}{2}x_1 \quad (49)$$

$$y_1 = \frac{1}{2}b - \frac{1}{2}c - \frac{1}{2}y_2 - \frac{1}{2}y_3 \quad (50)$$

$$y_2 = \frac{1}{2}b - \frac{1}{2}c - \frac{1}{2}y_1 - \frac{1}{2}y_3 \quad (51)$$

$$z_1 = \frac{1}{2}a + \frac{1}{2}b - \frac{1}{2}c - \frac{1}{2}z_2 \quad (52)$$

$$z_2 = \frac{1}{2}a + \frac{1}{2}b - \frac{1}{2}c - \frac{1}{2}z_1 \quad (53)$$

Solving a system with the six best reply function we obtain:

$$x_1 = x_2 = \frac{1}{3}a - \frac{1}{3}c \quad (54)$$

$$y_1 = y_2 = \frac{1}{3}b - \frac{1}{3}c - \frac{1}{3}y_3 \quad (55)$$

$$z_1 = z_2 = \frac{1}{3}a + \frac{1}{3}b - \frac{1}{3}c \quad (56)$$

Replacing (54), (55) and (56) in equations (43), (24) and (44) we obtain the prices in the market LG (p_L), GC (p_C) and LC (p_{LC}), respectively:

$$p_L = \frac{1}{3}(a + 2c) \quad (57)$$

$$p_C = b - y_1 - y_2 - y_3 \quad (58)$$

$$p_{LC} = \frac{1}{3}(a + b + 2c) \quad (59)$$

Replacing (54), (55), (56) and (58) in equations (46), (47) and (5) we obtain the profits for firms 1, 2 and 3, respectively:

$$\pi_1 = \frac{1}{9}(a - c)^2 + \frac{1}{9}(a + b - c)^2 + (b - y_1 - y_2 - y_3 - c)y_1 \quad (60)$$

$$\pi_2 = \frac{1}{9}(a - c)^2 + \frac{1}{9}(a + b - c)^2 + (b - y_1 - y_2 - y_3 - c)y_2 \quad (61)$$

$$\pi_3 = (b - y_1 - y_2 - y_3 - c)y_3 \quad (62)$$

Maximising firms' profits in, respectively, y_1 , y_2 and y_3 , we get three best reply functions:

$$y_1 = \frac{1}{2}b - \frac{1}{2}c - \frac{1}{2}y_2 - \frac{1}{2}y_3 \quad (63)$$

$$y_2 = \frac{1}{2}b - \frac{1}{2}c - \frac{1}{2}y_1 - \frac{1}{2}y_3 \quad (64)$$

$$y_3 = \frac{1}{2}b - \frac{1}{2}c - \frac{1}{2}y_1 - \frac{1}{2}y_2 \quad (65)$$

Solving the system with the three best reply functions we obtain:

$$y_1 = y_2 = y_3 = \frac{1}{4}(b - c) \quad (66)$$

Replacing (66) in equation (58) we obtain the price in the market:

$$p_c = \frac{1}{4}(b + 3c) \quad (67)$$

Replacing (66) in equations (60), (61) and (62) we obtain the profits of firms 1, 2 and 3, respectively:

$$\pi_1 = \pi_2 = \frac{1}{9}(a - c)^2 + \frac{1}{9}(a + b - c)^2 + \frac{1}{16}(b - c)^2 \quad (68)$$

$$\pi_3 = \frac{1}{16}(b - c)^2 \quad (69)$$

Hypothesis 3 (H3)

The H3 hypothesis concerns the scenario where firms 1 and 2 collude and therefore make the decisions relating to their quantities together in order to maximise joint profit. In the initial scenario, these two firms were taking independent decisions, maximising their individual profit. Thus, there is only competition in the market GC, where firm m (firm resulting from the collusion between firms 1 and 2) and firm 3 compete. In this case, there are two firms (as was the case in the initial situation), but one of them (firm 2) provides this service in conjunction with the complementary service Lisbon - Sao Paulo supplied by firm 1. In the case of the route Lisbon - Curitiba, although firms 1 and 2 are present there is no competition, so it is a monopoly of airline m . Again, this is a game in 2 stages. In the first stage, firm m determines prices (or quantities) in the segments LG and Lisbon - Curitiba, anticipating the quantity and also the price in the segment GC. Thus, the inverse demand function in the segments LG and Lisbon - Curitiba are given, respectively, by the equations (70) and (71).

$$p_L = a - x_m \quad (70)$$

$$p_{LC} = a + b - z_m \quad (71)$$

Where x_m is the demand satisfied by firm m in the market segment LG and z_m is the demand satisfied by firm m in the market Lisbon - Curitiba. Moreover, in the second stage, the two airlines (firm m and 3) compete in quantities (Cournot competition) in the route Sao Paulo - Curitiba and therefore choose the quantity to offer in this market segment. Thus, the reverse demand of the market segment GC is given by:

$$p_C = b - y_m - y_3 \quad (72)$$

y_m and y_3 represent the demand, in the market segment GC, satisfied by firm m and 3, respectively. The profit of firm m (firms 1 and 2) is given by:

$$\pi_m = (p_{LC} - c)z_m + (p_L - c)x_m + (p_C - c)y_m \quad (73)$$

Where the variables take identical meanings to those mentioned above. Assuming that firms 1 and 2 share the profits equally, each one will receive half of π_m . The profit of firm 3 continues to be given by equation (5).

Replacing (70), (71) and (72) in equations (73) and (5) we obtain the profit functions:

$$\pi_m = (a + b - z_m - c)z_m + (a - x_m - c)x_m + (b - y_m - y_3 - c)y_m \quad (74)$$

$$\pi_3 = (b - y_m - y_3 - c)y_3. \quad (75)$$

Maximizing firm m 's profit in quantities, we obtain the following best reply functions:

$$z_m = \frac{1}{2}a + \frac{1}{2}b - \frac{1}{2}c \quad (76)$$

$$x_m = \frac{1}{2}a - \frac{1}{2}c \quad (77)$$

$$y_m = \frac{1}{2}b - \frac{1}{2}c - \frac{1}{2}y_3 \quad (78)$$

Consequently, replacing (76) and (77) in equation (74) we obtain:

$$\pi_m = \frac{1}{4}(a + b - c)^2 + \frac{1}{4}(a - c)^2 + (b - y_m - y_3 - c)y_m \quad (79)$$

Maximising firm m 's profit and firm 3's profit (equations (79) and (75), respectively) we obtain:

$$y_m = \frac{1}{2}b - \frac{1}{2}c - \frac{1}{2}y_3 \quad (80)$$

$$y_3 = \frac{1}{2}b - \frac{1}{2}c - \frac{1}{2}y_m \quad (81)$$

Solving (80) and (81) we get:

$$y_m = y_3 = \frac{1}{3}b - \frac{1}{3}c = \frac{1}{3}(b - c) \quad (82)$$

Replacing (76), (77) and (82) in equations (70), (71) and (72) we obtain the prices for the markets LG, LC and GC, respectively:

$$p_L = \frac{1}{2}(a + c) \quad (83)$$

$$p_{LC} = \frac{1}{2}(a + b + c) \quad (84)$$

$$p_C = b - y_1 - y_2 = \frac{1}{3}(b + 2c) \quad (85)$$

Replacing (82) in equations (79) and (75) we obtain the profits of firm m and 3, respectively:

$$\pi_m = \frac{1}{4}(a + b - c)^2 + \frac{1}{4}(a - c)^2 + \frac{1}{9}(b - c)^2 \quad (86)$$

$$\pi_3 = \frac{1}{9}(b - c)^2 \quad (87)$$

Note that the profit of firm m concerns the two firms that collude. Supposing that the firms divide profits equally, each firm obtain:

$$\pi_1 = \pi_2 = \frac{1}{8}(a + b - c)^2 + \frac{1}{8}(a - c)^2 + \frac{1}{18}(b - c)^2 \quad (88)$$

3.4. Effects of an open skies agreement

After the calculations performed in the previous Section we obtain the results for prices and profits of airlines for the baseline situation and under the three hypothesis tested which are synthesised in Table 1. We also present between brackets the impact on the price and airline profits resulting from the implementation of the open skies agreement.

When comparing the results for the initial situation and the results of hypothesis H1 we conclude that prices on routes Lisbon - Curitiba (p_{LC}) and Sao Paulo - Curitiba (p_C) should decrease. Thus, the entry of an international airline in the market Sao Paulo - Curitiba (domestic) and consequently on the route Lisbon - Curitiba, that is, increased competition on routes Lisbon - Curitiba and Sao Paulo - Curitiba, should lead to a decrease in prices on these routes. However, the effect on prices in the market Lisbon - Sao Paulo (p_L) is not obvious as in the previous cases. In the case of this market segment, the findings in regard to price evolution between the base situation and the scenario presented by hypothesis H1 depend on some variables. Thus, for the same value of a , that is, for the same reserve price on the market LG, if airlines are not efficient, having high marginal costs (c), and if b (reserve price in the market GC) is very low relatively to a due to, for example, the segment GC being short and having a lot of substitutes (other means of transportation to accomplish the same journey), the

price in the market LG may increase after the open skies agreement. Note that since in this market segment the open skies agreement does not introduce additional competition, there is no pressure to reduce the price.

Table 1: Equilibrium prices and firms' profits under the four scenarios

	Prices	Firms' profits
Before liberalisation	$p_L = \frac{1}{23}(11a + 4b + 8c)$	$\pi_1 = \frac{2}{529}(11a + 4b - 15c)^2$
	$p_C = \frac{1}{23}(2a + 7b + 14c)$	$\pi_2 = \frac{2}{529}(2a + 7b - 9c)^2$
	$p_{LC} = \frac{1}{23}(13a + 11b + 22c)$	$\pi_3 = \frac{2}{529}(2a + 7b - 9c)^2$
Under H1	$p_L = \frac{1}{2}(a + c) (?)$	$\pi_1 = \frac{1}{4}(a - c)^2 + \frac{1}{4}(a + b - c)^2 + \frac{1}{16}(b - c)^2 (\uparrow)$
	$p_C = \frac{1}{4}(b + 3c) (\downarrow)$	$\pi_2 = \frac{1}{16}(b - c)^2 (\downarrow)$
	$p_{LC} = \frac{1}{2}(a + b + c) (\downarrow)$	$\pi_3 = \frac{1}{16}(b - c)^2 (\downarrow)$
Under H2	$p_L = \frac{1}{3}(a + 2c)$	$\pi_1 = \frac{1}{9}(a - c)^2 + \frac{1}{9}(a + b - c)^2 + \frac{1}{16}(b - c)^2 (?)$
	$p_C = \frac{1}{4}(b + 3c) (\downarrow)$	$\pi_2 = \frac{1}{9}(a - c)^2 + \frac{1}{9}(a + b - c)^2 + \frac{1}{16}(b - c)^2 (\uparrow)$
	$p_{LC} = \frac{1}{3}(a + b + 2c) (\downarrow)$	$\pi_3 = \frac{1}{16}(b - c)^2 (\downarrow)$
Under H3	$p_L = \frac{1}{2}(a + c) (?)$	$\pi_1 = \frac{1}{8}(a + b - c)^2 + \frac{1}{8}(a - c)^2 + \frac{1}{18}(b - c)^2 (\uparrow)$
	$p_C = \frac{1}{3}(b + 2c) (\downarrow)$	$\pi_2 = \frac{1}{8}(a + b - c)^2 + \frac{1}{8}(a - c)^2 + \frac{1}{18}(b - c)^2 (\uparrow)$
	$p_{LC} = \frac{1}{2}(a + b + c) (\downarrow)$	$\pi_3 = \frac{1}{9}(b - c)^2 (\downarrow)$

Legend: \uparrow - increase; \downarrow - decrease; ? – ambiguous effect

Source: own calculation

It is noteworthy that, as expected, the price of a journey between Lisbon and Curitiba will be lower under the hypothesis H1, since the entire route (Lisbon - Curitiba) is offered by the same airline. This result is in line with the conclusions drawn by Cournot (1838), that is, in the case of two complementary goods (route Lisbon - Sao Paulo and Sao Paulo - Curitiba) being produced by a single firm, the prices will be lower and the quantities higher. This results from the process concerning the dual margin / marginalization in complementary goods that is with the internalisation of the two complementary services in the same firm the

double margin ceases to exist, benefiting consumers. In this case, firm 1 offers two complementary services or a trip for the entire route. The decrease in price for the market Lisbon - Curitiba is beneficial to consumers, which is also consistent with the conclusions of Cournot (1838). One of Cournot's main conclusions relates to the fact that consumer surplus is higher when two complementary goods are produced by the same firm rather than being produced by different companies. With regard to profits, the firm that produces the two complementary goods will have higher profits than the sum of the profits of the two firms, when the complementary goods are produced by two different firms (Cournot, 1838).

When comparing the results for firms' profits we can conclude that the profit of firm 1 is expected to increase under hypothesis 1, compared with the situation without an open skies agreement. However, the same does not occur with the profits of firms 2 and 3, since these are expected to decline after the entry of firm 1 in the market GC. This decline will be due to increased competition and lower prices in this market segment.

From this we can draw two important conclusions for the effects of open skies agreements: On the one hand, if there are time lags for new airlines to operate all routes of the market, while others can, firms that cannot compete on the new routes will be affected negatively because they see their profits decrease. The same happens if there are temporal gaps of airlines in designing and implementing their strategies. Moreover, it is noticed that in general consumers should benefit after an open skies agreement. This occurs in segments Sao Paulo Curitiba and Lisbon - Curitiba due to a decrease in ticket prices in these markets. However, in the segment Lisbon – Sao Paulo, which remains a monopoly of firm 1, prices can increase, according to the conditions mentioned above (efficiency and reserve price). Please note that this price increase is not caused by any efficiency gap, but because the airlines are all inefficient.

Comparing the results between the initial situation and the hypothesis H2 we realize that prices in the three market segments decrease after the implementation of an open skies agreement, thus benefiting consumers in all markets. These findings confirm the expected effects presented in the literature. As expected, increasing competition in the market LG leads to a reduction in price. In the market Lisbon - Curitiba, the price decrease is due to the process of double margin of complementary goods mentioned above, to which must be added the fact that in this hypothesis there is competition in this market which did not happen in the baseline scenario (before the open skies agreement). In the market segment GC, despite the effect via complementary products, there are three airlines in this market so also this segment is witnessing increased competition that will result in a decrease in the price.

With regard to airline profits, the effects of liberalisation of the international market are not uniform. While the profit of firm 2 increases (under the hypothesis H2), firm 3 is hampered by market deregulation, seeing its profit decline (contrary to expectations). As is known, the profit of firm 3 depends on the price of market GC, which, for the reasons given above, should decrease. Thus, it is expected that, despite the liberalisation of the international market, the entry of firm 1 in the market GC (and consequent increased competition) and the entry of firm 2 in the market LG, and hence the entry of firms 1 and 2 in the market Lisbon - Curitiba, harm firm 3, leading to a reduction in its profit. Finally, the profit of firm 1 increases if a (the reserve price in the market LG) is not much higher than b (reserve price in the market GC). This result is due to the trade-off between the complementarity effect (double marginalization, mentioned above) regarding firm 1 and the effect of the existence of competition, as firm 2 also operates in this market. The effect of double marginalization exerts a pressure on the profit of firm 1 to increase, but the existence of competition should introduce a pressure to decrease the profit of this firm. Thus, if a is not much higher than b , that is if the market size of GC is not too small in relation to market size of LG, the effect of the internalization of complementarities prevails, increasing the profit of firm 1. If the market GC is very small relative to the market LG (a to much higher than b) then the effect of the existence of competition prevails, and in this case the profit of firm 1 does not increase.

When comparing the results of the initial situation with the results of hypothesis H3, it can be concluded that once again the prices in the market segments Sao Paulo - Curitiba and Lisbon - Curitiba decrease while the effect in the price of the segment Lisbon - Sao Paulo is not clear. In the case of the market Lisbon - Curitiba, the price decrease is related to the fact that consumers go to pay a single price. At first, without the open skies agreement, firm 1 competed with firms 2 and 3 in complementary services (Lisbon - Sao Paulo and Sao Paulo - Curitiba) and therefore had double marginalization. But the liberalisation of the international market leads to the internalisation of the two complementary services in the "same firm" (though in collusion) thus prices decrease and consumers are benefited, for the reasons given above. It is noted that the literature does not mention this fact, hence it is a new result of this study. In the case of the Sao Paulo - Curitiba market, the price decreases, benefiting consumers in this market segment, which is in line with the effects expected from the literature which predict that the implementation of an open skies agreement will benefit consumers. With regard to market Lisbon - Sao Paulo, price evolution between the base situation and the scenario presented by hypothesis H3 is similar to that of hypothesis H1: for the same value of a (the reserve price on the market LG), if airlines have high marginal costs

(*c*), and if *b* (reserve price in the market GC) is very low relatively to *a*, the price in the market LG may increase after the open skies agreement.

Analysing these results of airlines' we can conclude that in this case, after the liberalisation of the market, the profits of firms 1 and 2 increase. This increase was expected since the goal of the collusion is to maximise the joint profits of the companies, but also adds the effect of the elimination of double marginalization in complementary products, which allows an increase in profits of both airlines. Finally, the profit of firm 3 decreases after the open skies agreement. Thus, it is expected that, despite the liberalisation of the market, the collusion between firms 1 and 2 harms firm 3. Again it is clear that the airlines that stay out of the liberalisation process, by failing to operate new routes after the open skies agreement, will be affected negatively due to the reduction of their profits.

In short, through the model developed and the hypotheses examined, it was found that, as expected according to the literature, the prices of the routes Lisbon - Sao Paulo and Lisbon - Curitiba (international routes) should decrease, thus benefiting consumers of these markets, particularly when liberalisation increases competition in the market, as is the case analyzed in hypothesis 2.

Regarding airlines, although the trend appears to be an increase in the profits of those that are able to enter new routes after the agreement, the airlines that do not have the ability to compete for new routes will be affected, seeing their profits shrink, which contradicts the effects expected in the literature.

4. Conclusions

Since the 1970s we have witnessed a gradual liberalisation of the air transport market through the implementation of open skies agreements. The literature on these agreements (Brattle Group, 2002; Fu et al., 2010) identifies several effects that tend to occur as a result of liberalisation, such as increased competition, lower costs, increased efficiency and lower prices. However, there are several factors that can prevent the achievement of the expected effects of such an agreement, such as strategic behaviour adopted by incumbents, the restructuring of networks and frequent flier programs, limited airports' capacity, among others.

In this study we have also analysed some evidence concerning the effects of an open skies agreement, from which it is understood that it takes time for the effects of such agreement to

fully materialise. According to Cristea and Hummels (2011) this period will be at least five years, the time required for the market to readjust to the new conditions and reach the new equilibrium.

From the theoretical model developed and the hypotheses studied we can conclude that after the implementation of an open skies agreement prices should decline on international routes where there is an increase in competition, thus benefiting consumers in these markets. This decrease in prices and increased consumer surplus is in agreement with that expected by the literature and is also due to the effect of double marginalization. Under the hypothesis H1 (entry of firm 1 in the market Sao Paulo - Curitiba), consumers should benefit due to the decrease in prices in the segments Sao Paulo – Curitiba and Lisbon - Curitiba. However, in the segment Lisbon - Sao Paulo prices may increase because this market segment remains a monopoly of firm 1. Under the assumption H2 (entry of firm 1 in the market Sao Paulo - Curitiba and entry of firm 2 in the market Lisbon – Sao Paulo), an open skies agreement would lead, as expected, to a decrease in prices in all markets, which benefits consumers of all routes. Under the hypothesis H3 (collusion between firms 1 and 2), liberalisation of an international market tends to benefit consumers. Although in the market segment Lisbon - Sao Paulo prices may increase, harming consumers, in the international route Lisbon - Curitiba the consumer surplus is expected to increase due to the decrease in ticket prices in this market. It should be noted that the literature does not mention this decrease in market prices in the markets Lisbon - Curitiba (for a case of collusion between two airlines), so this effect it is a new result of this study.

With regard to airline profits, the results obtained show a tendency for an increase in profits of airlines that get into new routes after the agreement. However, airlines that do not have the ability to compete for new routes after the liberalisation of an international market should be negatively affected, seeing their profits decline. Under the hypothesis H1, the profit of firm 1 (which operates more routes after the agreement) should increase, however the opposite should occur with firms 2 and 3. Therefore, if there are time lags for new airlines to operate all routes of the market, while others can do it, companies that cannot compete on new routes will be affected negatively, watching their profits decrease. The same happens if there are temporal unevenness of airlines designing and implementing their strategies. Under the hypothesis H2 an open skies agreement leads to an increase in profit for firm 2. However, the liberalisation of the international market lead to decreased profits for firm 3 and profits of firm 1 may increase or decrease. This result for the profit of firm 1 is due to the trade-off between the effect of complementarity (double marginalization) and the effect of the

existence of competition, as firm 2 also operates in this market. Thus, if the effect of double marginalization is greater than the effect of the existence of competition, the profit of firm 1 increases. Under the hypothesis H3, profits of firms 1 and 2 increase after the liberalisation of the international market. However, once again, firm 3 (the firm that doesn't have the ability to operate more routes after the open skies agreement) will be harmed due to the reduction of their profits.

Thus, some of the effects of liberalisation of the international market are influenced by market conditions and they will not occur in all scenarios analysed. However, it is expected that in general an open skies agreement benefit consumers and harm the airlines that do not have the capacity to operate flights on new routes. These results have important implications, particularly for TAP, the Portuguese airline. If this airline is able to operate new routes, that is, routes between airports in Brazil (domestic airports), it will benefit by an increase in its profits, since currently it does not operate such flights.

Regarding the limitations of this study it is important to highlight the fact that the multilateral open skies agreements or those between blocks of countries are still quite recent, so there has been little time to conduct empirical findings in order to validate the existing theoretical arguments. Moreover, there is little theoretical analysis on the liberalisation of air transport markets, which is also a limitation of this study because it is not possible to compare our results with those of other authors.

As for future work, some of the suggestions here relate to the model. It will be important and interesting to study other cases, such as the existence of greater competition in the market before the implementation of the agreement. Moreover, it seems appropriate that after enough years, empirical studies are carried out with the aim of determining whether in fact there is a decrease in prices and if this does not occur only at the time when companies readjust to the new market conditions. It will also be important to analyse what happens to supply and demand, particularly studying the response of demand to changes in supply.

Finally, it should be noted that this study is a pioneering work, since to the best of our knowledge there is little literature (theoretical or empirical) focusing on this subject and, particularly, there is no model of Open Skies. The model developed here can thus serve as a starting point for future work in this area.

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