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# Single Till or Dual Till at airports: a Two-Sided Market Analysis

Estelle Malavolti\*

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## Abstract

Big airports profits are more and more often coming from commercial activities such as retailing. However, commercial services are relatively far from the original mission of the airport: providing airlines with aviation services such as ground handling, terminal management or airside operations, and being regulated for that because of an obvious dominant position with respect to airlines. For this reason, one can advocate for the separation of the two activities, i.e. for a dual till approach, in which only the aeronautical activity is regulated. We, instead, suggest that a single till regulation, in which the total profit of the airport is examined, is relevant because it allows to take into account the externalities existing between retailing and aeronautical services. Using a two-sided market approach (Armstrong 2006, Rochet-Tirole 2003, 2006), we show that the airport is a platform which makes the shops and the passengers meet. The retailing activity depends on how many passengers are circulating and connecting at the airport, as well as the time they spent in the airport, while passengers value the least connecting time as possible. We show that the aeronautical tax can be either higher or lower under single till depending on whether the impact of the passengers demand or of the waiting time is the more important for the shops.

*Keywords:* two-sided market, network externalities, air transport economics.

*JEL codes:* L11, L12, L89.

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# 1 Introduction

The commercial activity of big airports is becoming more and more important: The share of the commercial profits in their total profits has increased a lot. It represents 60% of the profits for Fraport, Frankfurt airport, meaning that it is more important than the core activity of the airport: providing airlines with aeronautical services. Commercial revenues increased by 9% for the now privatized Aeroports de Paris. In 2007, the commercial activity accounted for 26% of Schiphol Group (Amsterdam)'s revenues and 34% of the operating result.

The investment strategies of airports are thus taking into account this aspect: when deciding to extend the capacity of an airport (by building new terminals for example), airport managers include the space for new shops. For instance, the extension of Beijing airport, which surface represents 1.3 million square meters, which stands for 1.6 times the surface of the original terminal, while the number of passengers is supposed to double (in the short run).

However, commercial services are relatively far from the original mission of an airport: providing airlines with aviation services such as ground handling, terminal management or airside operations, and being regulated for that because of an obvious dominant position.

How should airports manage both the aeronautical and the commercial activities? Should we separate the two activities? Are the kind of questions we address in this paper.

Our paper offers an original interpretation of the problem with the use of two-sided market. The airport is indeed a platform which makes passengers and shops meet. Shops are interested in having passengers wandering in the airport while waiting for a connecting flight. They will be more willing to pay for a space at the airport if there are a lot of passengers travelling and if they are in connection and wait sufficiently for this connection. Then the airport could be tempted to decrease the passenger tax in order to make people travel more. However there exists a side effect on passengers demand: The airline could choose a too high waiting time caused by a low aeronautical tax, and thus make passengers travel less. We show that if the airport consider the two activities as being related it de facto internalizes effects which are complex and playing in different directions. We show that if the externality on passengers is high enough, the aeronautical tax is set at a lower

level: Passengers are subsidized to travel, i.e., they pay a lower ticket price and wait less, by shops, which pay a higher rent for the space. On the contrary, if the marginal impact of the waiting time on shops demand is high enough, the aeronautical tax is set at a higher level: Less passengers travel and they wait more, which allows the airport to make more profit on the shops side.

Our paper relates to the economics of media markets as well as to the literature on two-sided markets. Rochet and Tirole (2006) attempt to build a general framework for two-sided markets and give a definition: A market is said to be two-sided when the volume of transactions on both sides is affected by a change in the price of one side of the market, keeping the total price constant. This means that the price structure affects the profits and the economic efficiency<sup>1</sup>. The literature on two-sided markets builds on two branches of the literature: Firstly, the literature on network externalities (Katz and Shapiro (1985,1994), Farrell and Saloner (1985)) and more specifically on indirect externalities (e.g. Chou and Shy (1990)) and secondly the literature on multi-product pricing. In our paper, externalities are present in that shops are both interested in having more passengers and having them waiting a long time for their connection. However, intermediaries are needed in this context because passengers do not internalize their positive impact on retailers<sup>2</sup>. As a consequence, the price structure matters, which is not considered in the classical network externalities literature. On the contrary, the literature on multi-product pricing focuses on price structure but forgets about externalities. Because the sides of the market need one each other to exist, the problem can indeed be considered as a problem of pricing in the case of complementary goods: If the price of the ticket decreases, the demand for space increases. However, this is forgetting about the externality exerted by the shops on consumers, through their sensitivity with respect to the connecting time. <sup>3</sup>.

The media industry is one of the first application of two-sided market: viewers want

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<sup>1</sup>The paper by Baxter (1983) first introduced the notion of interdependence of demands for an antitrust case concerning banks interchange fees. Armstrong (2006) and Parker and Van Alstyne (2005) are general papers which set out the notion of two-sided markets and derive general results. Evans and Schmalensee (2007) give a practical description for two-sided markets and a lot of examples of multi-sided businesses.

<sup>2</sup>Caillaud and Jullien (2003) study the role of intermediaries when there are indirect externalities

<sup>3</sup>For an explanation of the price theory of two-sided markets, see Rochet and Tirole (2006) and Weyl (2006).

to watch programs and dislike the announcements they carry, whereas advertisers see audience as potential consumers <sup>4</sup>. Generally, what authors show is that it makes sense that advertisers subsidize the TV consumers because of the presence of externalities. Our paper builds on this literature in a sense but the application is completely different. We use a classical framework as presented in Rochet and Tirole (2006) with usage externalities: the retailers are sensitive to the number of passengers wandering in the airport. To the difference to Rochet and Tirole (2003) or Armstrong (2006), we do not model competition between platforms, as an airport is de facto in a monopolist situation with respect to airlines and shops, but fully model the consumers side as in Crampes et alii (2006). Besides we model the fact that airlines choose nonetheless the ticket price but also the connecting time for passengers. This allows to take into account a side effect of the presence of shops: They are interested by having more passengers, i.e. passengers demand exert a positive externality on shops. However, shops are also interested in the time spent by these passengers in the airport: The more the waiting time, the more the shops demand. This may lead the airport to try to increase the waiting, creating a negative externality on passengers.

The paper is organized as follows: Section 2 sets out the model and derive the general results while in Section 3, we discuss a numerical example. Section 4 concludes and provide some insights in terms of welfare analysis<sup>5</sup>.

## 2 A two-sided market model

Airports are “economic catalysts” as they have “two groups of customers who need each other in some way; but who can’t capture the value from their mutual attraction on their

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<sup>4</sup>See Anderson and Gabszewicz (2005) and Evans and Schmalensee (2007) for a detailed review. Other interesting papers are Gabszewicz, Laussel and Sonnac (2004) for an analysis of advertising under free-to-air, or Peitz and Valletti (2007) for an analysis of the advertising intensity and the content programming of free-to-air and pay-tv. Crampes, Haritchabalet and Jullien (2006) model endogenous entry in a model where platform compete for advertising resources.

<sup>5</sup>For general analysis of welfare in two-sided markets, see for instance Anderson and Coate (2005) or Ambrus and Reisinger (2005) for a specific analysis of media market. Nocke, Peitz and Stahl (2004) focuses on platform ownership and find that if network externalities are important, a monopolistic platform is socially preferred.

own; and rely on the catalyst to facilitate value-creating reactions between them” (Evans and Schmalensee 2007). According to Evans and Schmalensee (2007), catalysts do exist for a while but will play an increasingly important role in our economies due to technological changes and the reduction of the communication costs. There are several examples of catalysts, for instance, Rochet and Tirole (2004) mentioned Videogame platforms, which need to attract gamers in order to convince game developers to design games to their platform and need games in order to induce gamers to buy and use their videogame console; payment card systems, which need to attract both merchants and cardholders; TV networks, portals, newspapers, which compete for advertisers as well as audience.

An airport plays the role of a platform which makes passengers and shops meet. Shops need to be present at the airport to reach passengers. Shops will address their demand directly to the airport. To contrast, passengers buy tickets by an airline, which decides of both a ticket price and a connecting time. The airline has to pay an aeronautical tax set by the airport. Finally, the airport chooses the rent for the space and the level of the aeronautical tax, up to a certain level (it is regulated by a price cap)<sup>6</sup>.

## 2.1 The Aeronautical Activity

Consider would-be passengers who express a (total) demand for travel  $N(p, t)$ . It is function of the price of the ticket  $p$ , which is set by the airline and of the connecting time  $t$ . We assume that demand is decreasing in the price  $p$  and in the connecting time  $t$ , and that the cross derivative is negative

$$\frac{\delta^2 N(p, t)}{\delta p \delta t} < 0$$

This assumption is made to take into account that the price of the ticket and the connecting time are imperfect substitutes for passengers: I may accept to wait a longer time if the price is really low. On the contrary, if the price is high, I tolerate it only if the connecting time is very low as well.

We consider an airline in a monopolist situation because in hub airport one airline is often in a dominant position. The airline takes as given the aeronautical tax  $a$  imposed by the airport. This tax is proportional to the number of passengers  $N(p, t)$ . The airline

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<sup>6</sup>We do not model the regulator as such. We left this for further research.

sets both the price of the ticket which will be paid by the consumers and the connecting time, i.e.. the time spent by passengers in the airport between two connecting flights. The connecting time  $t$  has no price as such but allows the airline to save some production costs. Given  $C(N, t)$  the production cost, we then assume that  $\frac{C(N, t)}{\delta N} \geq 0$  and that  $\frac{C(N, t)}{\delta t} \leq 0$ . The program of the airline is thus as follows

$$\underset{\{p, t\}}{Max} \quad \Pi = (p - a)N(p, t) - C(N, t)$$

The first order conditions then gives the following equations:

$$\frac{\delta \Pi}{\delta p} = 0 \Leftrightarrow \frac{p - a - \frac{\delta C}{\delta N}}{p} = \frac{1}{\epsilon_{N/p}} \quad (1)$$

$$\frac{\delta \Pi}{\delta t} = 0 \Leftrightarrow p - a - \frac{\delta C}{\delta N} = \frac{\delta C / \delta t}{\frac{\delta N}{\delta t}} \quad (2)$$

Equation (1) tells us that the monopolist mark-up of the airline has to be equal to the inverse of the direct price elasticity, denoted by  $\epsilon_{N/p}$ , which is a classical result. More interestingly, the second equation explains that the difference between the price and the cost (which includes variable  $t$ ) is function of the gain in terms of cost by an increase in the connecting time, measured by  $\frac{\delta C}{\delta t}$  and of its cost in terms of demand. When computing the ratio (1)/(2), we obtain the following expression:

$$p = \epsilon_{N/p} \left( - \frac{\frac{\delta C}{\delta t}}{\frac{\delta N}{\delta t}} \right)$$

The couple  $(p, t)$  is determined such that the price of the ticket equals an expression which stands for the monopolist trade-off between saving costs when increasing  $t$  and loosing passengers because of a higher connecting time, weighted by the the direct elasticity of the demand with the price. An explicit solution for the price and the connecting time is expressed in the next section.

The monopolist internalizes the fact that the connecting time influences the demand and the price and the connecting time are imperfect substitutes to serve a certain level of demand. On the contrary, the airline forgets that it has an influence on the aeronautical tax through the choice of  $t$ . The airport, playing its role of platform, is the one who will internalize the effect.

## 2.2 The Commercial Activity

Shops are present in the airport. They are numerous and in competition (perfect) for the occupation of the space in the airport. They express a demand which is naturally decreasing in the rent  $r$  paid to occupy the space. Their demand is also function of the number of passengers who wander in the airport as well as of the connecting time of these passengers. Indeed, the more number of passengers and the more likely the sell. However, the sell is also explained by the time passengers spend in the airport, waiting for their next plane. Thus, demand for space from shops is decreasing in the price  $r$  and increasing in  $t$  and  $N$ . From the shops point of view, they are interested in fact by a mix between passengers and having them waiting sufficiently longer in the airport. The connecting time and the passengers are imperfect substitutes for the retailers. We define  $s$  the demand for space from shops.  $s$  has the following characteristics:  $s = s(r, N, t)$  with, for all  $r, N, t$

$$\begin{aligned}\frac{\partial s}{\partial r} &< 0 \\ \frac{\partial s}{\partial N} &\geq 0 \\ \frac{\partial s}{\partial t} &\geq 0.\end{aligned}$$

## 2.3 The Platform

The airport is a platform which will make the link between both the commercial and the aeronautical activities. It will set both the aeronautical tax  $a$  and the space rent  $r$  in order to maximize the joint profit of the two activities. We assume that the (production) cost of the airport is linked to the demand of passengers (and not chargeable to each of the activity). To make things simpler, we further assume that these costs are proportional to passengers demand (parameter  $\gamma$ , with  $\gamma > 0$ ). We consider fixed cost and denote them  $CF$ . The program of the airport can thus be written

$$\begin{aligned}Max_{\{a\}} \quad \Pi_{\text{airport}} &= aN + rs - \gamma N - CF \\ s.t. \quad s &= s(r, N, t) \quad , \\ N &= N(p, t) \quad , \\ p &= p(a) \quad , \\ t &= t(a) \quad .\end{aligned}$$

The FOC, taking into account the constraints, i.e. considering that  $N(\cdot)$  is a function of  $a$ , write

$$\frac{\delta \Pi_{\text{airport}}}{\delta a} = 0 \Leftrightarrow N(a) - (a - \gamma)N'(a) + rN'(a)\frac{\delta s}{\delta N} + rt'(a)\frac{\delta s}{\delta t} = 0 \quad (3)$$

$$\frac{\delta \Pi_{\text{airport}}}{\delta r} = 0 \Leftrightarrow r\frac{\delta s}{\delta r} + s = 0 \quad (4)$$

Where  $t'(a)$  (respectively  $N'(a)$ ) denotes the total derivative of the waiting time (resp. the passengers demand) with respect to the passenger tax  $a$ . Equation (4) can be rewritten as follows

$$r = -\frac{s}{\delta s \delta r}.$$

If the shops demand is sensitive to the rent, the level of the rent will be naturally lower. The level of  $a$  is determined so as to take into account several effects: the first effect,  $N(a) - (a - \gamma)N'(a)$ , corresponds to the impact of  $a$  on the pricing of the ticket. Indeed, increasing  $a$  will have an impact on the choice of the airline  $(p, t)$ . If the airport were considering independently the two activities, this effect would be the only one present to determine  $a$ , i.e. the impact of  $t$  on passengers demand would have been the sole impact taken into account. The second impact,  $rN'(a)\frac{\delta s}{\delta N}$ , measures the externality exerted by passengers demand on shops activities but weighted by the indirect impact of the aeronautical tax on the passengers demand. The sign of this effect depends on how passengers demand reacts to  $a$ . The last effect,  $rt'(a)\frac{\delta s}{\delta t}$ , takes into account the impact of the connecting time  $t$  on shops profit. The sign of this last effect depends on the impact of the aeronautical tax on the waiting time. To measure the total effect and determine whether the aeronautical tax  $a$  is lower or higher than with a situation in which the airport considers independently the two activities, one need to determine the impact of the tax on the ticket price and on the connecting time.  $a$  is part of the marginal cost of the airline. As such, as the mark-up  $(\frac{p-a-\frac{\delta C}{\delta N}}{p})$  is the margin above the marginal cost (represented by  $\frac{\delta C}{\delta N}$ ), the ticket price  $p$  should be increasing with the aeronautical tax, i.e.,  $p'(a) \geq 0$ . The connecting time  $t$  is a substitute to the ticket price to satisfy the passengers demand, as such, the aeronautical tax  $a$  should have the same impact, i.e.,  $t'(a) \geq 0$ . Hence, both the ticket price and the waiting time are increasing with the aeronautical tax. As the passengers demand is assumed to be decreasing in both the waiting time and the ticket price, we conclude that it is decreasing with the aeronautical tax, i.e.,  $N'(a) \leq 0$ . We can then re-interpret the

first order conditions.

Now that  $N'(a) \leq 0$  and knowing that the first part of the FOC, i.e.,  $N(a) - (a - \gamma)N'(a)$  is monotonically decreasing in  $a$ , adding  $rN'(a)\frac{\delta s}{\delta N}$  which is a negative term (for all  $a$  and  $r$ ) means that the solution in  $a$  should be lower than if the two activities were considered independently. Since passengers demand is affected negatively by a change in the aeronautical tax, increasing the tax means having less passengers, which means having less demand for space too. The sign of the last effect, measured by  $rt'(a)\frac{\delta s}{\delta t}$ , is opposite. Indeed,  $t$  is increasing in  $a$ , so as the effect of the connecting time on the space demand  $\frac{\delta s}{\delta t}$ . Then,  $rt'(a)\frac{\delta s}{\delta t}$  is positive for all  $a$  and  $r$ . Comparing with a situation in which the commercial and aeronautical activities are independent, this effect tends to increase the level of aeronautical tax. Since the connecting time is positively affected by the aeronautical tax, increasing the tax means having a higher connecting time chosen by the airline, which in turn means having more demand from shops. We thus cannot conclude on the global effect, i.e., on the choice of the aeronautical tax by the airport. The aeronautical tax tends to be lower if the (negative) effect on passengers demand is high enough. It is higher if the effect on the connecting time is high enough. To conclude on the effect, one needs to give expression for both the passengers and the shops demands. The choice of  $a$  has an impact on the choice of  $r$  through the shops demand. If the two-sided aeronautical tax is lower, this means that the impact of  $a$  on the shops demand is negative. Indeed

$$\frac{ds}{da} = N'(a)\frac{\delta s}{\delta N} + t'(a)\frac{\delta s}{\delta t}.$$

The demand for shops being decreasing with  $a$ , the price for space is higher in the two-sided market situation. The aeronautical tax and the rent are impacted differently by the two-sidedness of the market.

We sum up these results in the following proposition:

**Proposition 1** *The aeronautical tax  $a$  is set lower and the rent  $r$  is set higher in the case of two-sided market if the partial impact of passengers demand  $N$  on shops demand  $s$  is more important than the partial impact of the connecting time  $t$  on shops demand  $s$ .*

The airport thus internalizes the two contradictory effects when choosing its prices. To be able to measure the effects, let us consider a numerical (simple) example.

### 3 Numerical example

Let us define specific functions for our problem. For example, we define passengers demand function as follows

$$N(p, t) = \bar{u} - p - \alpha t - \beta tp.$$

where  $\bar{u}$  is the net utility derived if the consumers do not travel, we normalize it to unity. Parameter  $\alpha$  measures the direct impact of the connecting time on passengers utility. We assume that this impact is lower than the one of the direct price, i.e.  $\alpha < 1$ . Parameter  $\beta$  measures the cross effect between  $p$  and  $t$  for the passengers.  $\beta$  is positive to take into account the fact that if the waiting time (respectively the ticket price) is high, the marginal impact of the ticket price (resp. the waiting time) on passengers demand is even higher in absolute value. Linearity is assumed to obtain simple results.

We interpret the role of the connecting time as a means for the airline to decrease its marginal cost. The cost of producing travel  $C(N, t)$  is for example chosen to be as follows

$$C(N, t) = (c - t)N.$$

Where  $c > 0$  is the unit cost.

The demand for space is expressed as follows:

$$s(N, t, r) = \kappa N + \lambda t - r.$$

Let us now solve for the equilibrium values of  $p$ ,  $t$ ,  $a$  and  $r$ , with the corresponding quantities  $N$  and  $s$ . Solving first the airline program allows to state the following lemma.

**Lemma 1** *The difference between the two instruments  $p$  and  $t$  available to the airline is constant*

$$p - t = \frac{1 - \alpha}{\beta}$$

**Proof.**

From the FOC of the airline we obtain that

$$\frac{t}{p} = \frac{\epsilon_{N/t}}{\epsilon_{N/p}}.$$

Which simplified to the following expression

$$p - t = \frac{1 - \alpha}{\beta}.$$

■ The difference between the price of the ticket and the connecting time is held constant by the airline because of the linearity of the demand essentially. It is nevertheless interesting to notice that the more the cross effect between the two instruments (measured by  $\beta$ ) and the less the difference, while the more the direct impact (measured by  $1 - \alpha$ ), the more the difference. It is interesting to notice that the impact of the aeronautical tax is identical for both instruments

$$\frac{dp}{da} = \frac{dt}{da}.$$

Solving for the first order conditions stated in the previous section we obtain the following expressions for the price of the ticket, the connecting time and the number of passengers at the equilibrium:

$$\begin{aligned} p^{TS} &= \frac{-4\alpha + (-1+a+c)\beta + \sqrt{(-1+a+c)^2\beta^2 + 16\alpha(1+\beta)}}{4\beta} \\ t^{TS} &= \frac{-4 + (-1+a+c)\beta + \sqrt{(-1+a+c)^2\beta^2 + 16\alpha(1+\beta)}}{4\beta} \\ N^{TS} &= \frac{8 - 8\alpha - (-1+a+c)^2\beta - (-1+a+c)\sqrt{(-1+a+c)^2\beta^2 + 16\alpha(1+\beta)}}{8} \end{aligned}$$

**Lemma 2** *At the equilibrium, the ticket price  $p^{TS}$  and the connecting time  $t^{TS}$  varies positively with respect to the aeronautical tax. Passengers demand  $N^{TS}$  varies negatively w.r.t. the aeronautical tax.*

**Proof.**

When derivating  $p^{TS}$  w.r.t.  $a$ , one obtains that it depends on the sign of

$$(\sqrt{(-1+a+c)^2\beta^2 + 16\alpha(1+\beta)}) - (1-a-c)\beta.$$

Two cases have to be considered. If  $a \geq 1 - c$ , then the ticket price is increasing with  $a$  (if supposedly,  $c < 1$ ). On the contrary, if  $a < 1 - c$ , then the expression has the following form:

$$\sqrt{A + B^2} - B^2$$

, where  $A = 16\alpha(1 + \beta) > 0$  and  $B = (1 - a - c)\beta > 0$  and we can directly conclude that it is always positive (for all  $a$ ). We conclude that  $p$  is increasing in  $a$ , so as to  $t$ . As  $N(p, t)$  is decreasing w.r.t. both  $t$  and  $p$ , then it is decreasing in  $a$ . ■

If the aeronautical tax is set at a lower level, we can conclude that the ticket price and the connecting time are lower than if the activities were treated separately. At the equilibrium, the number of passengers is higher: More people travel.

**Lemma 3** *Under our assumptions, the aeronautical tax is lower if the airport considers the two sides of the market*

$$a^{TS} < a^0.$$

**Proof.**

Considering the FOC on  $a$ , what matters is the sign of  $ds/da$ . Computing  $ds/da$  leads to the following expression:

$$-8\alpha(1 + \beta)\kappa - (-B + \sqrt{B^2 + A})(-B\kappa - \lambda),$$

where  $B = 1 - a - c$  and  $A = 16\alpha(1 + \beta)$ .  $A > 0$ , while we cannot conclude for  $B$  since  $a$  is endogenous.

In the case  $B$  is positive, then the global expression is negative, thus  $ds/da < 0$ , implying that  $a^{TS} < a^0$ .

If  $B < 0$ , but  $\lambda$  is sufficiently important, then the global effect is also negative. ■ The aeronautical tax being lower when the market is considered to be two-sided, we can now derive the impact on the other equilibrium variables. Indeed, as the ticket price and the connecting time are increasing in  $a$ ,  $p^{TS} < p^0$  and  $t^{TS} < t^0$ , implying that more passengers travel at the equilibrium. The shops demand is lower, because  $ds/da < 0$ , and, from the first order conditions, shops pay a higher rent.

## 4 Conclusion

The airport is a platform which takes into account the externalities existing between the commercial activity and the aeronautical activity. As shops are sensitive to both the waiting time and the number of passengers present at the airport, two contradictory effects have been determined: the aeronautical tax is lower if the shops are more sensitive to the number of passengers. We conclude as well that separating the two activities, i.e. considering the double till regulation, is synonymous of forgetting the externalities potentially existing between the two sides of the market. What we aim to value now is to try to estimate empirically if there are some externalities, and, if so, what effect is the most important on shops demand.

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