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A model of complementary dual-market airport operations to assess the effect of Canada's airport rent formula.

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ABSTRACT

Many airports around the world have undergone changes in governance structure, with a significant number moving from government ownership and operation to partial or full privatization. In contrast, airports in Canada have been devolved from government control to not-for-profit airport authorities. This paper develops a model in which an airport has both aviation and non-aviation activities and where demand complementarities exist between these markets. The model provides an analysis of aviation charges, and output under for-profit and non-profit governance structures, and in the case of non-profit airports, the model is used to assess the impact of Canada's recently revised airport rent formula, implemented as an ad valorem tax.

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1 Introduction

At the present time, governance structures of airports around the world vary significantly and although it appears that partial or full privatisation of airports has become the preferred model for many countries, Canada's airports remain as not-for-profit organizations that lease airport land and assets from the federal government. Under their lease agreements, Canadian National Airport System (NAS), airports are required to pay land rent to the government over the 60 year term. NAS airports paid rent in 2006 that amounted to 24% of their costs and although airport rents have declined in absolute terms, the total amount of rent paid per passenger has risen steadily from $3.43 in 1998 to $4.75 in 2005.[1]

In May of 2005, the federal government announced a new airport rent formula that was to simplify previously complex rental agreements. The formula was to provide large rent savings to airports over the terms of their leases via a common rental rule applied to all airports in the system. The rent formula (as shown in table 1) was implemented as a stepped series of percentage shares of gross revenues; in other words, as an ad valorem tax. This mechanism was chosen over a number of other alternatives, including a per-passenger (excise) tax.

Table 1
Canadian NAS Airport Rent Formula introduced in 2005

Gross Revenues	Rent paid
On the first $5 m	0%
On the next $5 m	1%
On the next $15 m	5%
On the next $75 m	8%
On the next $150 m	10%
On any amount over $250 m	12%

Source: http://www.tc.gc.ca/mediaroom/releases/nat/2005/05-h098e.htm

What is the economic rationale for the chosen airport tax mechanism the economic implications for the air transportation sector? This paper develops a simple model of dual-market airport

[1] Source: Cherniavsky and Dachis (2007).

operations that can help assess the effects of the airport rent formula (ad valorem tax) and compare it with an equivalent excise tax. The model draws on prior work by Starkie and Yarrow (2000) and Starkie (2002) in highlighting demand complementarities between aeronautical and non-aeronautical operations. The basic model developed in section 2 and in section 3 the model is extended to assess the impacts of equivalent ad valorem and excise taxes under Canada's not-for-profit airport governance structure. Section 4 considers the development of the airport rent mechanism in light of the analysis and some brief concluding remarks are offered in section 5.

2 Airports as dual-market enterprises

The business of operating a commercial airport can be usefully separated into aeronautical and non-aeronautical activities. Aeronautical activities refer to the services offered to aircraft that land and take-off from the airport, including landing, aircraft parking, aircraft gates, terminal services, ticketing desks, refuelling and de-icing. Non-aeronautical services include retail and hospitality concessions at the airport and parking. Importantly, there is complementarity between these activities: increased air transport movements lead to passenger volumes, which increases non-aeronautical revenues.

The implication of complementary dual markets for a profit-seeking airport is the existence of an incentive to lower aeronautical prices as a means of increasing non-aeronautical revenues and overall profits users). Importantly, this dual-market aspect of airport operations exists independently of an airport's governance structure. That is, the concept of complementary dual markets applies equally to airports with different objective functions, such as Canada's not-for-profit airport authorities.

A simple theoretical model of a dual-market airport

Two output measures that relate to airport operations are the number of passengers (enplaning and deplaning) and the number of air transportation movements (ATMs). While in reality there are many types of ATMs (aircraft of differing weights and passenger capacities), a reasonable simplification is to model airports as charging a single aeronautical price for a 'representative ATM' (RATM) in much the same way as we might consider a representative individual in consumer choice theory. A *representative* ATM can be thought of as a weighted average over

all the types of aircraft landing at the airport in proportion to their share of total ATMs.[2] The aeronautical price is a decision variable for the airport, given a demand for RATMs from airlines whereby demand is inversely related to the aeronautical price. When the cost of using an airport declines then at the margin, more RATMs will be demanded by airlines because some portion of lower airport costs can be passed on to their passengers via lower fares. Lower fares increase passenger demand for air transportation services to and from the airport either by increasing demand on existing routes or by creating newly profitable routes.

On the groundside (non-aeronautical activities), we can link the number of RATMs with the number of passengers using the airport. Again in the interests of simplification, we assume that the demand for non-aeronautical goods and services by terminal users is constant, representing average non-aeronautical spending per RATM.

Let x and P represent the number of RATMs and the aeronautical price per RATM. Let the airport's marginal cost of providing aeronautical services be constant (c) per RATM and let F represent fixed costs associated with airside investments. On the groundside, let R represent a constant amount of expenditure on non-aeronautical goods by terminal users per RATM. As a simplification I we can assume that the (constant) marginal cost and the fixed costs of non-aeronautical goods are zero. If follows that a profit-maximising airport will choose P to maximise:

$$\pi = [\mathrm{P(x)} - \mathrm{c} + \mathrm{R}]\mathrm{x} - \mathrm{F} \qquad (1)$$

From the first order conditions we have:

$$(\mathrm{P} - \mathrm{c}) = -\mathrm{x}\frac{\delta P}{\delta \mathrm{x}} - \mathrm{R} \qquad (2)$$

or

$$\mathrm{P} = -\mathrm{x}\frac{\delta P}{\delta \mathrm{x}} - \mathrm{R} + \mathrm{c} \qquad (3)\ [3]$$

Equation (3) indicates that the interaction between airside and groundside markets results in a lower aeronautical price than would exist without the demand complementarity, and if R is sufficiently large, a profit-maximising airport will set aeronautical prices below operating costs.

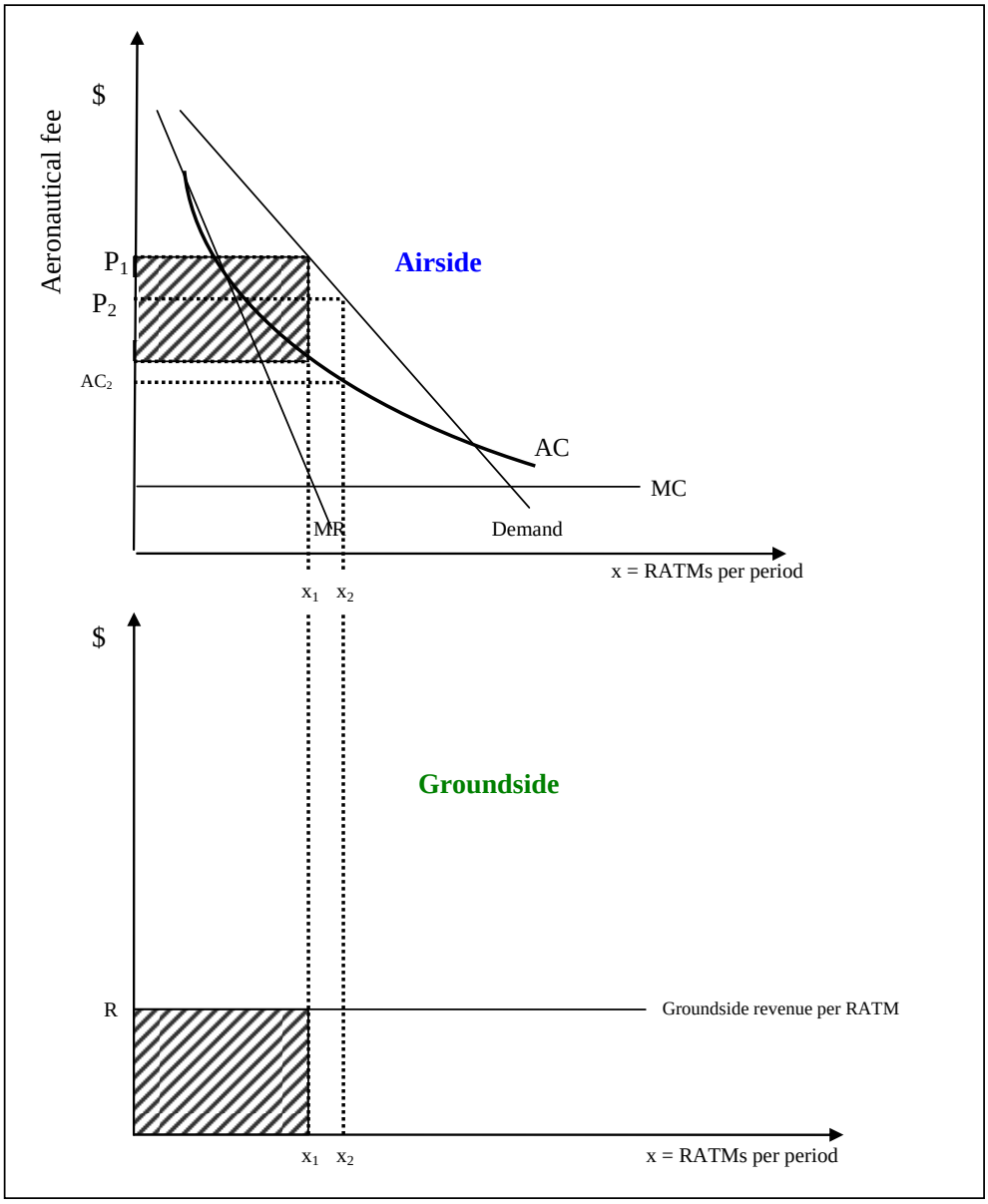
[2] As a simplified example, if 50% of ATMs were B737-700 aircraft with a capacity of 149 passengers and the remaining 50% of ATMs were B767-400ER aircraft with a capacity of 375 passengers, the *representative* ATM at the airport would be an aircraft with a capacity of 262 passengers.

[3] A more general treatment of non-aeronautical demand would set R as a function of both the composite non-aeronautical price and the aeronautical price. The result is the same: the aeronautical price is diminished because of demand complementarity.

Figure 1 illustrates the for-profit, dual market model. Lowering the airside price below P_1 (where MR = c) to P_2 causes an increase in airside demand to x_2 which in turn causes terminal users and groundside profits to increase proportionately. The airport now makes airside profits equal to $x_2(P_2\text{-}AC_2)$ and x_2R on the groundside.[4]

Figure 1

A profit-maximizing airport trades-off airside profits for groundside profits



[4] Note that the more price-elastic is airside demand, the more there is to be gained by the airport lowering aeronautical prices in order to boost terminal users and groundside profits. Intuitively, in the extreme case of perfectly price-inelastic airside demand, lowering the airside price has no effect on the demand for RATMs and therefore airside profits will decline, with no offsetting increase in groundside profits.

Airside pricing at a not-for-profit airport

If a not-for-profit airport sets its aeronautical price on a cost recovery basis independently of groundside activities, the price per RATM will just equal average cost per RATM. However this will create groundside profits, and in order to fulfill its not-for-profit mandate, the airport will either have to spend the groundside profits lower aeronautical prices below average cost.[5] If groundside profits are used to cross-subsidize aeronautical prices then the airport will set:

$$P(x) = \frac{\mathrm{F}}{\mathrm{x}} + c - R \qquad (4)$$

Figure 2 shows a dual market airport as a not-for-profit enterprise, when aeronautical prices are cross-subsidized by groundside profits. The airport lowers the airside price to P_2, thereby encouraging the demand for air movements to increase to x_2. This creates a loss on the airside shown as *area 1* in figure 4. However, the increased air traffic generates groundside profits (*area 2*), which exactly offset the airside losses. One can see that the dual market effect for not-for-profit airports has the potential to create economic welfare for airlines (and perhaps for passengers) through lower aeronautical prices compared to for-profit airports.[6]

3 Economic effects of ad valorem and excise taxes on a not-for-profit airport

The context for this extension of the model is the literature on tax incidence of indirect taxes and while the effects of indirect taxes on competitive (price-taking) firms are well known and understood, there is far less written on tax incidence for (price-setting) firms in oligopoly or monopoly market structures. Less still has been written concerning the incidence of indirect taxes when firms are not-for-profit enterprises.

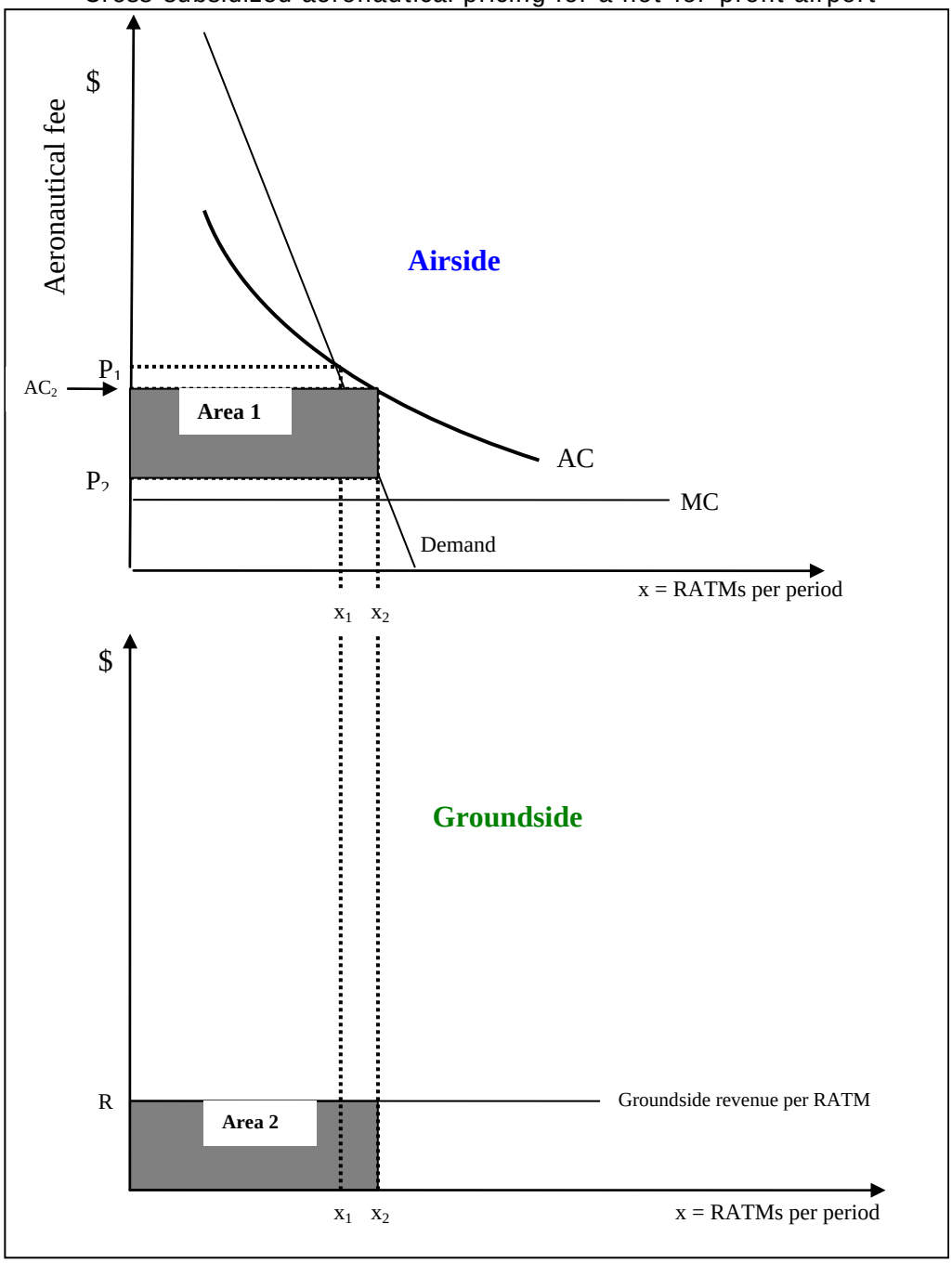
Taxing a dual market airport

To consider the effects of rents collected as either excise or ad valorem taxes on a not-for-profit airport with complementarity airside and groundside markets and where the airport uses groundside operating profits to cross-subsidize aeronautical prices.

[5] Spending such profits could be viewed both positively (repayment of accumulated debt) or negatively (unnecessary additional capital spending – so called 'gold-plating').
[6] The benefits of lower aeronautical prices for airlines can indirectly cause an increase in consumer welfare, to the extent that competition encourages airlines to pass along the cost savings through lower airfares.

Figure 2

Cross-subsidized aeronautical pricing for a not-for-profit airport



Under an excise tax of $t per-RATM, the firm's profit function becomes:

$$\pi = (P(x) + R - k)x - F \tag{5}$$

where $k \equiv c + t$ becomes the airport's *effective* marginal cost.

Under a not-for-profit structure, the airport sets (5) equal to zero to set its price such that

$$P(x) = \frac{F}{x} + k - R \tag{6}$$

Now consider a (percentage) ad valorem tax on revenues. The airport's net revenue becomes:

$$(1-\gamma)[P(x) + R] \tag{7}$$

where $\gamma \in [0,1]$ is the ad valorem tax rate.[7]

Profits are now:

$$\pi = (1-\gamma)[P(x) + R - \frac{c}{1-\gamma}]x - F \tag{8}$$

To compare the effects of the two taxes, we can equate the impact of each mechanism on marginal cost by setting $k = c + t = \frac{c}{1-\gamma}$.[8]

This allows us to simplify (8) to:

$$\pi = (1-\gamma)[P(x) + R - k]x - F \tag{9}$$

By enforcing the zero profit constraint, the airport's aeronautical price under the ad valorem tax becomes

$$P(x) = \frac{F}{(1-\gamma)x} + k - R(x) \tag{10}$$

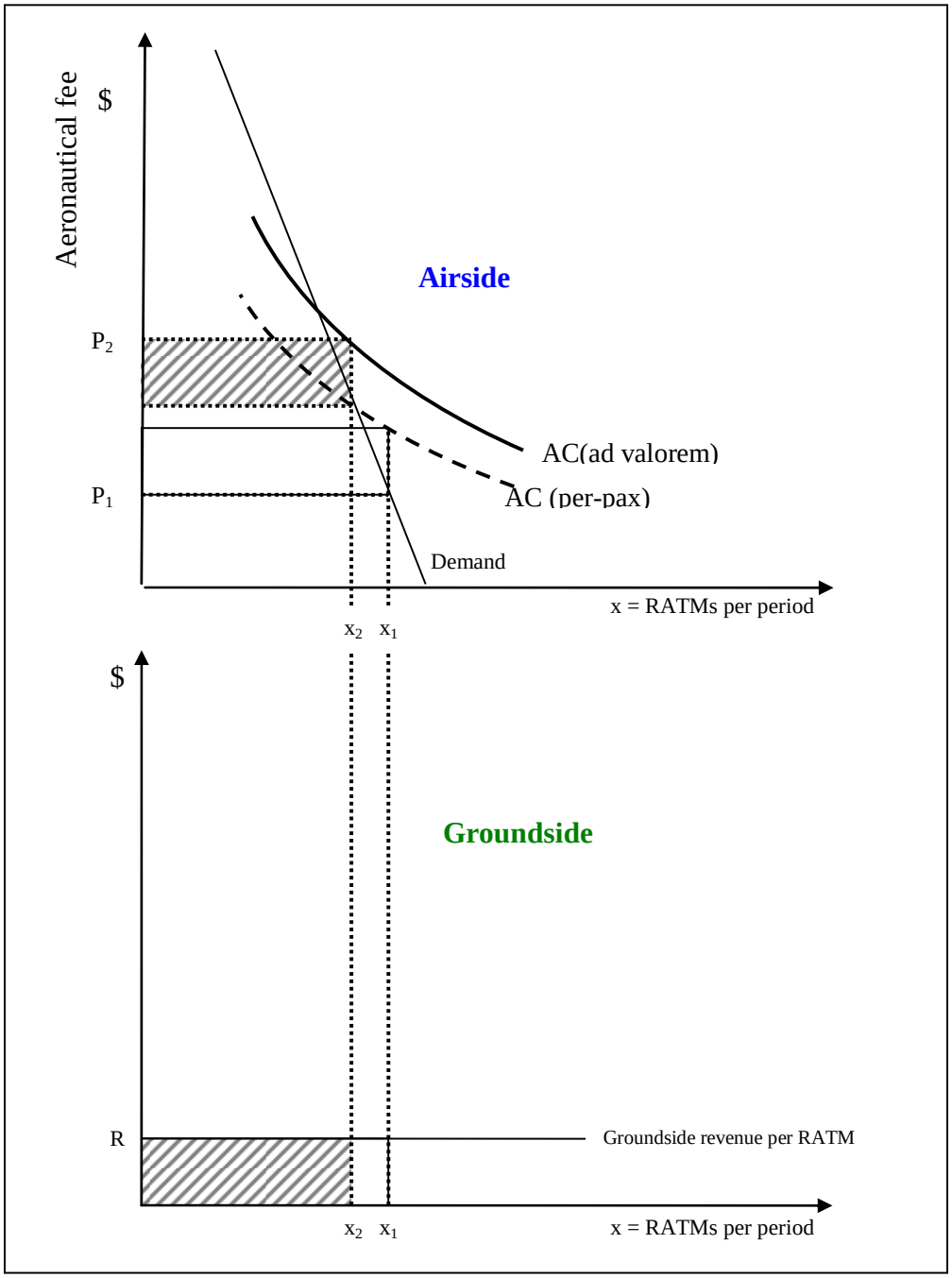
Comparing (10) with (6), we see that the ad valorem tax causes a larger increase in the aeronautical price compared with an equivalent per-pax (excise) tax. This effect is exacerbated by the demand complementarity – as the aeronautical price increases, the decline in RATMs (x) also reduces the groundside profits available to cross-subsidize airside charges. The effects of both the ad valorem and per-pax tax mechanisms can be illustrated (see figure 3) via their

[7] This differs from the usual representation of an ad valorem tax as a percentage mark-up on a firm's product price. However following Anderson et al (2001) this is reconciled in the following way. If airline customers were to pay an ad-valorem tax of v% on the airport's aeronautical charge, the total price would be $(1+v)P$. It follows that the net revenue per RATM received by the airport is $1-\gamma$, where $\gamma = v/1+v$.

[8] Equivalently, $t = \frac{\gamma}{1-\gamma}c$.

effect on the average cost curve for the airport. In each case the tax shifts up the average cost curve, but does so to a greater extent under the ad valorem tax. As a consequence, aeronautical charges will be higher and consumer surplus (on the airside) will be smaller under the ad valorem mechanism.

Figure 3
Effect of equivalent ad valorem and per-pax excise taxes
on a not-for-profit, dual-market airport



Comparing tax yields

The tax yield under an excise tax is:

$$Y_t = tx_1 = c(\frac{\gamma}{1-\gamma})x_1 = \gamma kx_1 \quad (11)$$

while under an equivalent ad valorem tax, the yield is:

$$Y_\gamma = \gamma[P(x_2) + R(x_2)]x_2 \quad (12)$$

where $x_1 > x_2$

Substituting (10) for $P(x_2)$ in (12) we obtain:

$$Y_\gamma = \gamma[\frac{F}{(1-\gamma)x_2} + k]x_2 \quad (13)$$

So the difference in tax yields is:

$$Y_t - Y_\gamma = \gamma k(x_1 - x_2) - \frac{\gamma}{1-\gamma}F \quad (14)$$

Expression (14) cannot be signed without more explicit information on demand and the extent of fixed costs. However if demand for RATMs was sufficiently price inelastic and fixed costs were sufficiently high, then the ad valorem tax yield will exceed that of the excise tax.

It should be noted that the above analysis implicitly assumes that there is no adverse competitive (cross-price) effect on demand for RATMs when the airport raises its airside price. Specifically, if Canadian airports compete with foreign airports (that are not subject to the revenue tax) then the effect of the tax will be to make Canadian airports relatively more expensive. The degree to which demand will shift in (or fail to shift out) over time will depend upon the degree to which airlines and air travelers regard airports as substitutes. For example, airport authorities in Toronto and Vancouver acknowledge that Buffalo Niagara Airport competes for passengers with Toronto Pearson and that Seattle Airport competes for passengers with Vancouver. While there is almost no recent empirical estimates of cross-price demand elasticities for air travel, some recent estimates of inter-airline cross-price elasticities

in the US suggest that we might reasonably expect cross price elasticity to be between 0.23 – 0.67.[9]

4 Airport policy and airport rent in Canada

In his 2005 speech announcing a new rent formula for Canada's airports, (then) Minister of Transport, Jean-Claude Lapierre stated:

> The bottom line — every one of the 21 rent-paying airports across Canada will benefit financially every year that they are to pay rent over the life of their leases. Under the old system, they were scheduled to pay $13 billion. This will be reduced to $5 billion over the course of existing leases. This represents a reduction of $8 billion, or more than 60 per cent. In addition, the new rent formula will address concerns related to fairness and equity among airports of similar size and activity. The original process of negotiating lease arrangements resulted in 21 separate deals, each with its own peculiarities.[10]

As the quotation indicates, the new rent formula was promoted as an improvement because it simplified previously complex agreements between Transport Canada and the airports, provided overall reductions in rent payments over the next 50 years and created a common approach to all NAS airports by way of a consistent and equitable payment scheme.

However, very little economic analysis has been made public to justify the government's choice of an ad valorem tax mechanism rather than an excise tax. The decision does not appear to have been based on the likely effects on aeronautical charges, number of passengers, air movements or consumer welfare. One rare indication of Transport Canada's views is offered in a 1999 review document which provides the agency's perspective of 'pros and cons' in comparing the two potential rent mechanisms. The table indicates that from Transport Canada's perspective, the advantages of each mechanism are similar except for a perceived additional advantage of the ad valorem tax: that it is the best option from an equity standpoint. The rationale offered for this conclusion is that the public would *perceive* airports paying the same fixed percentage rate of revenues as equitable.

However, the ad valorem rent formula is applied to gross revenues before interest, depreciation and property taxes, which increases the *effective after-tax cost of debt* for Canada's not-for-

[9] See Peters (2006). Very little econometric work has been done to estimate the cross-price elasticity of demand for air travel. This is an area where more research is required to under stand the short and longer run implications of relative price changes between potentially competing airports.
[10] http://www.tc.gc.ca/mediaroom/speeches/2005/2005-05-09.htm

profit airports.[11] Since not-for-profit airports fund infrastructure investments almost exclusively with debt, the rent formula places a much higher burden on airports where large investments are required or have been mandated. In the case of Canada's largest airport; Toronto Pearson International infrastructure investments (many of which were mandated when the airport was devolved from government control) resulted in interest and financing charges of $334.5 million in 2005. Given a 12% ad valorem tax on gross revenues, Toronto airport would need to raise $380 million in revenues to pay these charges.

Table 2
Transport Canada Assessment of Options for an airport rental formula

Rental Option	Advantages	Disadvantages
Flat amount per passenger (could increase over time)	• variability of rent with number of passengers provides flexibility to deal with good and bad times • incentive to reduce costs • administratively simple	• as the rates per passenger would vary among airports, there could be difficulties with public perceptions of equity (e.g., rate could be higher for airport X than for airport Y, because of the higher proportion of long-haul international traffic at the former) • pressure from CAAs to make changes across the system
Fixed percentage of revenues	• variability of rent with revenues provides some flexibility to deal with all phases of business cycle • incentive to reduce costs • likely to require least amount of administrative effort (only slightly less than passenger option) and provide earliest availability of final figures • likely to be the best option from the standpoint of equity among airports and public perceptions of equity among airports (i.e., percentage could be the same for all airports).	• revenue recognition remains an issue for rent determination purposes

Source: Transport Canada (1999), P30.

When considering a flat per-passenger charge, Transport Canada's review states that a disadvantage is the possibility that rates would vary across airports, creating "difficulties" with public perceptions of equity. This critique suggests that from the government's perspective, a viable uniform per-passenger charge would offer lower yields at larger (international) airports than Transport Canada would deem appropriate. More generally it suggests that the government's approach to selecting a rent mechanism involved a target revenue yield that they felt would be more easily attained by the ad valorem formula. In this context, it is worth noting that the air transportation sector is a net contributor to the federal treasury – something that is not true for other travel modes. For example, in 2006, the combined levels of government

[11] See Cherniavsky and Dachis (2007).

(federal, provincial and municipal) collected $1096.8 million from the air transportation industry in Canada and spent $781.4 million resulting in a net income of $315.4 million. By contrast, in the same year, Via Rail contributed $5.1 million to government revenues while receiving $190.3 million in government spending.

The analysis in section 3 weakly supports the notion that an ad valorem tax would result in a higher tax yield compared with an equivalent per-pax tax. As indicated in equation (14), the ad valorem mechanism's potential to provide higher tax yields rests upon the relative size of fixed costs (F). Thus, airports with higher fixed costs (related to required infrastructure investments) will likely generate higher tax yields under the ad valorem mechanism. But as already stated, this creates an inequity in tax incidence although it is somewhat hidden from public perceptions. In contrast, a per-passenger charge designed to raise an equivalent yield would be more visible and could be publicly perceived as a direct tax by the federal government on air travellers themselves.

5 Concluding remarks

One aspect of the rent formula that has not been explicitly modelled here is the incentives provided by the rent formula with respect to 'gold-plating' investments. Such incentives are more linked to the not-for-profit status of airports, than to the existence of airport rent, nevertheless, in the context of the model gold plating could be represented by inefficiently high fixed costs which would result in a higher aeronautical price. In this case, the results of the model still hold: an ad valorem tax will generate a higher aeronautical price compared to an equivalent excise tax for given (inefficiently high) fixed costs, irrespective of the incentives that generated them. Also, consider an extended analysis in which airports make investments that affect the magnitude of groundside spending (R). In this case, a tax on each and every dollar of revenue, the ad valorem tax would represent an additional drag on the incentive to generate groundside revenues. By comparison, the airport would be the full residual claimant on any additional revenues generated by each passenger after payment of a per-passenger (excise) tax.

This paper has developed a simple model of airport operations that highlights demand complementarities between airside and groundside activities. The analysis allows for a comparison of aeronautical pricing under different governance structures and provides a means of assessing the economic consequences of the Canadian federal government's latest airport

rent formula. The model indicates that compared with an equivalent per-passenger (excise) tax the current ad valorem tax on not-for-profit airports results in higher aeronautical prices, a smaller number of air movements and a decline in consumer welfare as experienced by airlines and passengers.

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