



Economics of Aviation Security

Istanbul Technical University
Air Transportation Management, M.Sc. Program
Aviation Economics and Financial Analysis
Module 15
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Outline

Economic Perspectives on Aviation Security

1. Aviation security as a “public franchise” system

- Multi-level Interdependent outcomes and incentives

2. Production technology and costs

- Layers, substitutes, complements, efficiency

3. Benefit-cost analysis

- A search for meaningful metrics in resource allocation problems

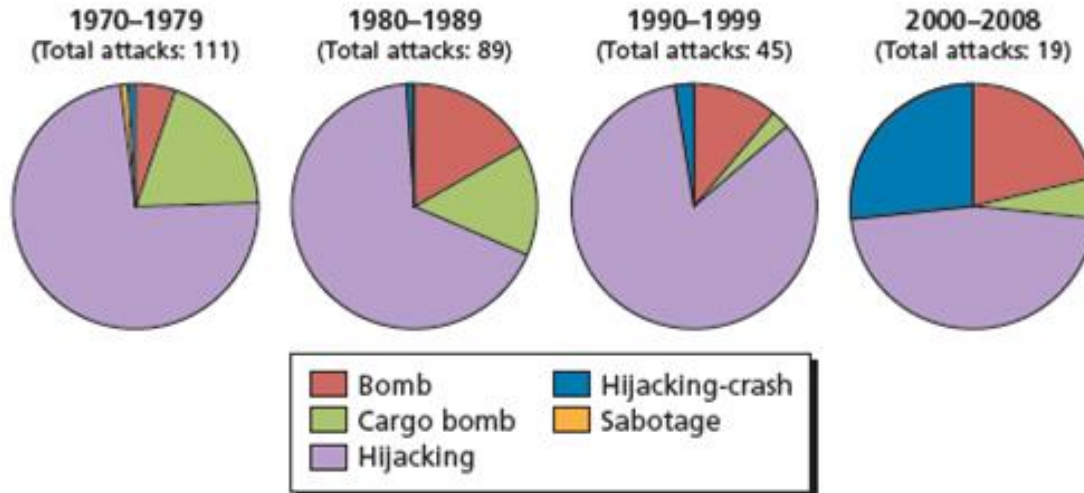
4. Public goods and government financing

- Who should pay for aviation security?

5. Charges and revenues in aviation security

- Are current ‘avsec’ charges to passengers and airlines comparable across airports around the world?

Types of Attacks Inside Aircraft, by Time Period



SOURCE: RAND Database of Worldwide Terrorism Incidents.

- Since 9-11 2001, massive changes to aviation security design, governance implementation and financing
 - New investments in technology
 - New Organizations – e.g. CATSA, DHS
 - New security implementation – e.g. TSA
 - New financing requirements – government spending, passenger security charges

Aviation security as a “public franchise” system

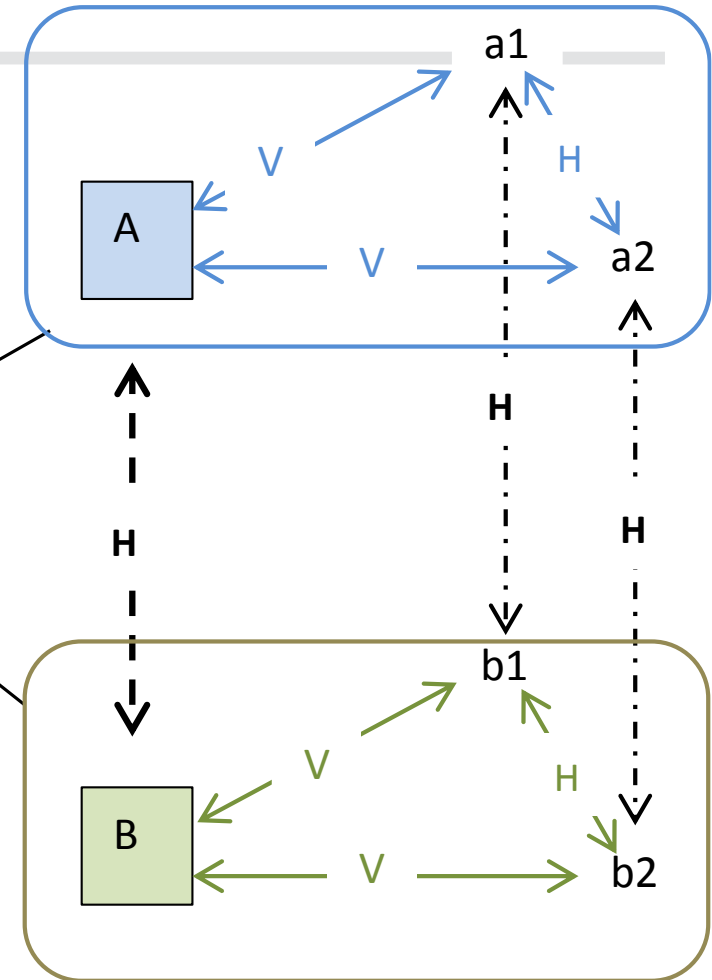
Multi-level Interdependent outcomes and incentives



		B	
		Strong enforcement	Weak enforcement
A	Strong enforcement	α_1, β_1	α_2, β_2
	Weak enforcement	α_3, β_3	α_4, β_4

International Standards

		b_i	
		High Security Level	Low Security Level
a_i	High Security Level	a_{i1}, b_{i1}	a_{i2}, b_{i2}
	Low Security level	a_{i3}, b_{i3}	a_{i4}, b_{i4}



Production technology and costs

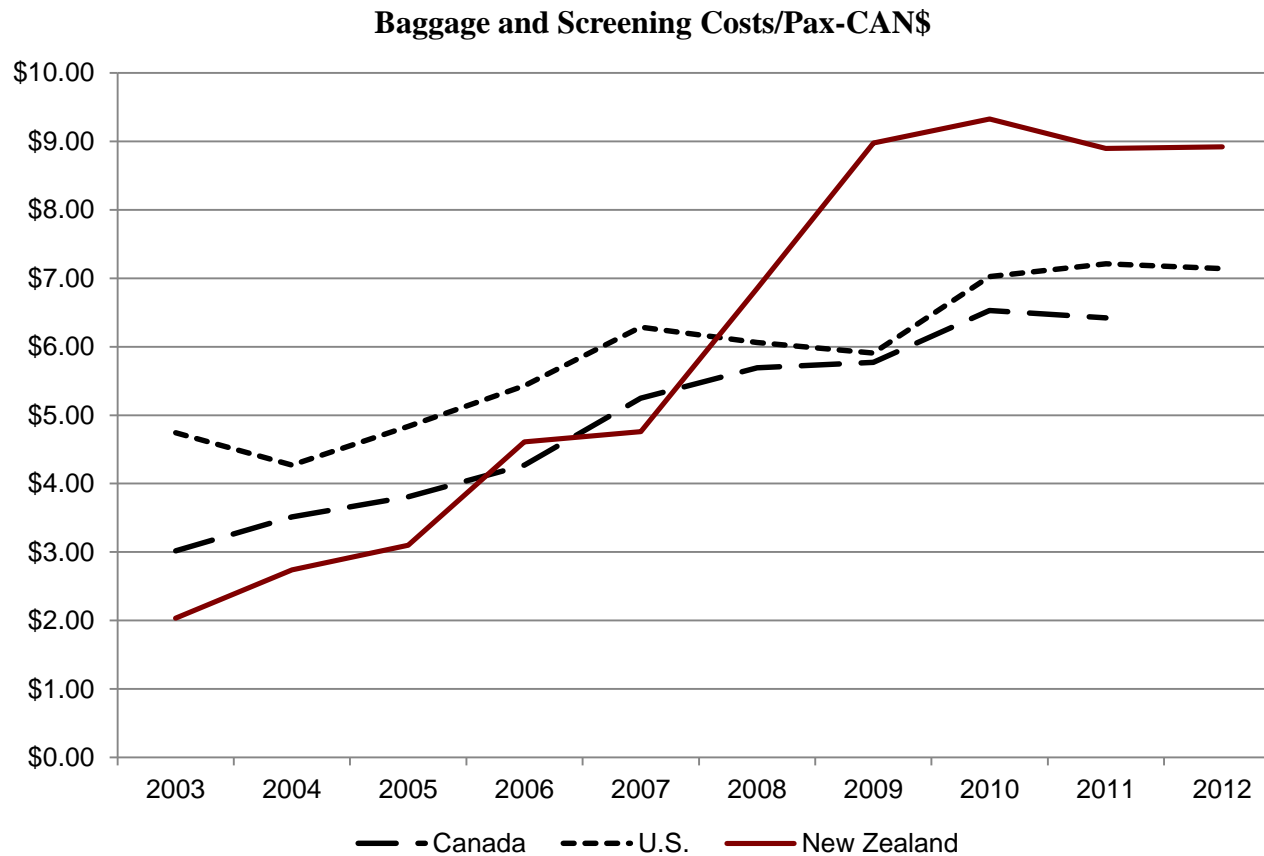
Layers, substitutes, complements, efficiency



Understanding Cost Relationships

- Observe variation in cost across countries in delivery of security services, why?
 - Are there cost economies with size?
 - Does traffic mix affect cost? International passengers?
 - Does who deliver the product matter?
 - Does quality of service vary?
 - Are there requirements to deliver to small markets?

Variable Costs – Various Countries



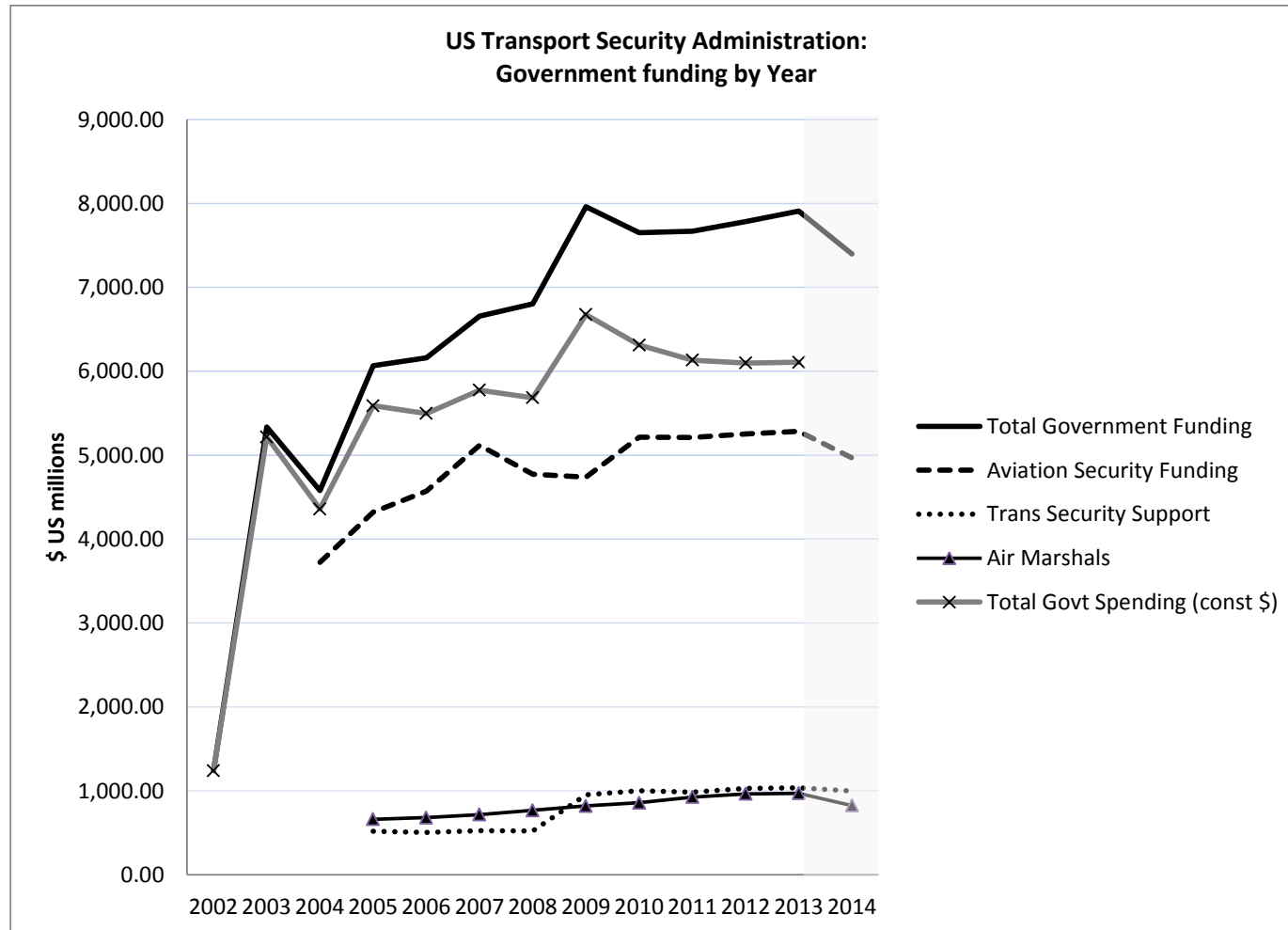
Regression of Total Operating Plus Capital Expenses by Country

Dep Variable	Total Cost (Operating & Capital expenses)			
	Linear		Logarithmic	
	Coeff.	t-stat	Coeff.	t-stat
Intercept	-977746.5322	-2.26	6.5450	4.27
US	-2550111.729	-0.46	1.3863	4.23
Australia	-338973.7915	-0.87	0.0330	0.52
Passengers	11.79159616	1.44	0.2384	-0.74
Time	167301.4341	3.06	0.0400	7.04
R SQ	0.96		0.98	
F-statistic	90.81		680.86	

Regression of Passenger Screening & Boarding Costs by Country

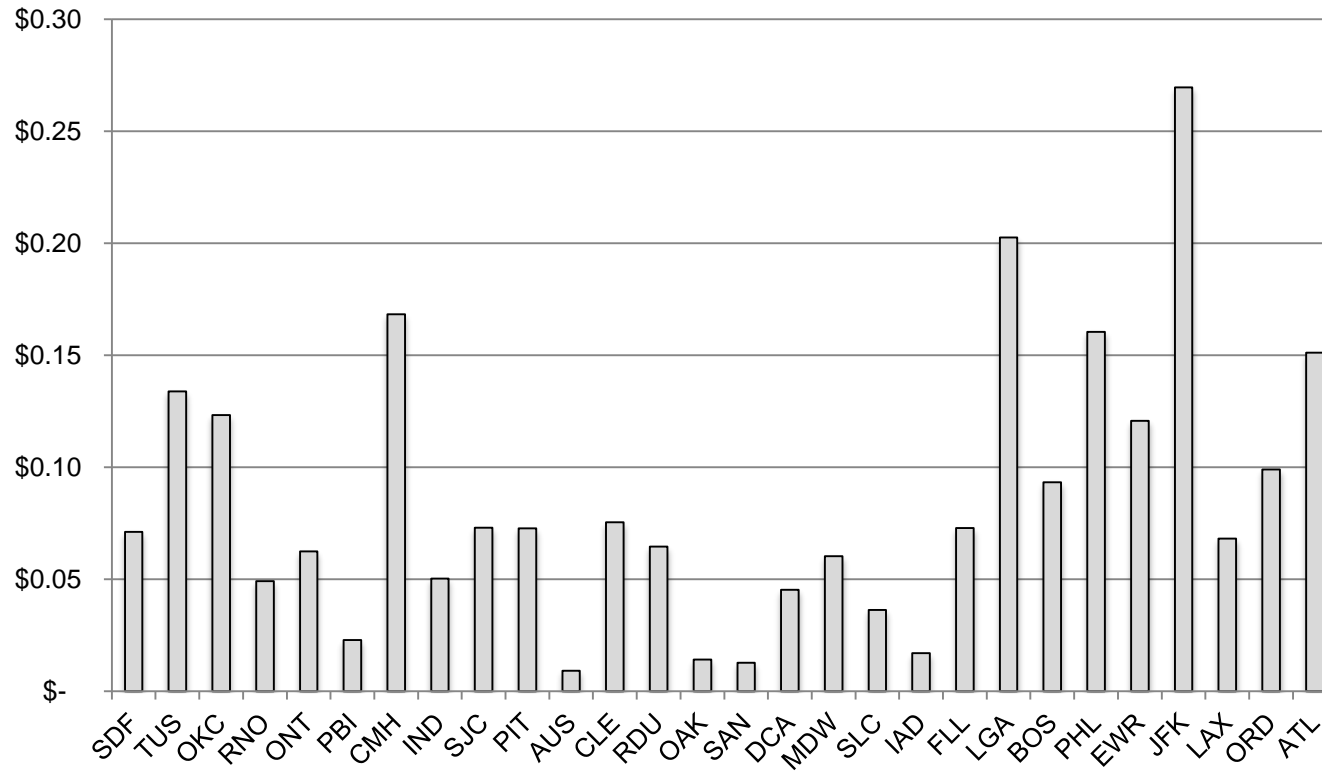
Dep Variable	Passenger boarding and screening costs			
	Linear		Logarithmic	
	Coeff.	t-stat	Coeff.	t-stat
Intercept	-780375.0384	-3.79	-3.6176	-3.29
US	-2269669.527	-0.86	-0.8080	-3.43
New Zealand	71298.54	0.38	-0.3909	-8.62
Passengers	9.56	2.46	0.8645	8.08
Time	73758.85	2.84	0.0225	5.52
R SQ	0.98		0.98	
F-statistic	216.53		691.63	

The Rising Costs of Aviation Security: USA



Cost Variation Across US Airports

Cost per Passenger – airport add-on security charge



Estimate of Cost per Passenger – US Airports 2009-2011

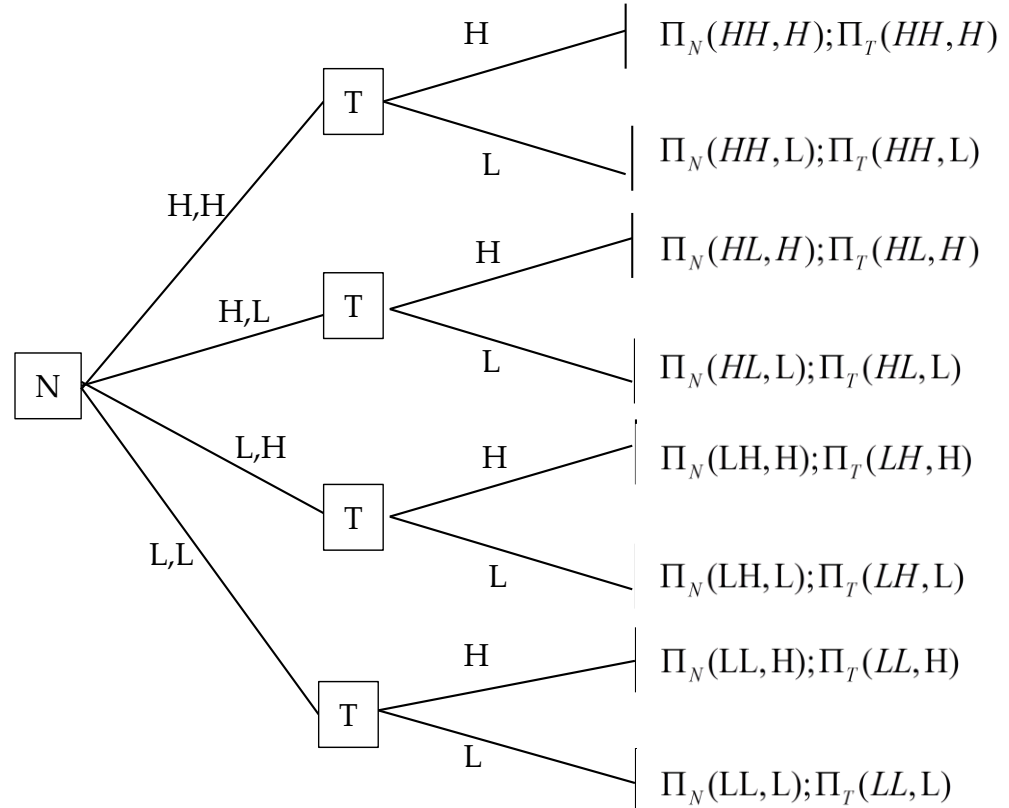
Dep Variable	Total Cost			
	Linear		Logarithmic	
	Coeff.	t-stat	Coeff.	t-stat
Intercept	-711188.47	-1.87	0.9996	0.86
Pax	0.139	9.65	0.7033	4.18
Percent Pax Intl	5024776.67	2.22	0.1103	2.12
2009	-6300.39	-0.01	-0.0734	-0.73
2010	-64427.57	-0.14	-0.0636	-0.65
Size	-837686.93	-1.17	0.3428	2.24
R SQ	0.86		0.82	
F-statistic	39.51		26.25	

Estimate of Cost per Passenger (Airport + Federal Govt) – US Airports 2009-2011

Dep Variable	Total Cost			
	Linear		Logarithmic	
	Coeff.	t-stat	Coeff.	t-stat
Intercept	-5841560.60	-2.36	1.0415	149.92
Pax	10.76	48.06	0.9978	412.69
Pax Squared	1.9296E-09	0.83		
Percent Pax Intl	10851280.92	0.88	0.0007	2.18
2009	17496102.01	8.08	0.0331	50.88
2010	2414704.00	1.12	0.0046	7.30
Size Dummy	1077045.53	0.28	0.0031	3.40
R SQ	0.98		0.98	
F-statistic	706.98		629.72	

A strategic game – calculating payoffs

- A two player game theory model
- 2 Players:
Nation, Terrorist
- Nation chooses a security effort level (e) and a level of efficiency (α)
- Terrorist chooses effort level (t)
- In a discrete choice setting, e, α and t can be set high or low



How to determine payoffs?

- Let security effort level (e) cost $c(e)$ and let $0 < e < 1$
- Let level of efficiency (α) cost $z(\alpha)$ and let $0 < \alpha < 1$
- Let terror effort level (t) be such that $0 < t < 1$
- Let S = a benchmark index of perfect welfare
- Let K = maximum indirect costs of security
- Let X = maximum direct costs of a successful attack
- We can now define a payoff for Nation:

$$\Pi_N = \underbrace{e.S}_{\text{Benefits of security}} - \underbrace{(1-\alpha).eK}_{\text{Indirect costs of security}} - \underbrace{(1-\alpha)\frac{t}{t+e}X}_{\text{Expected direct costs of terror incident}} - c(e) - z(\alpha)$$

Benefit-cost analysis

A search for meaningful metrics in resource allocation problems



What is the output measure from security services?

Benefit Cost

$$V = \sum_{t=0}^T \frac{B_t - C_t}{(1+r)^t}$$

$$B_t = (p_{-s} - p_s)k$$

p_{-s} = the probability of attacks per year prior to the implementation of a security measure.

p_s = the (reduced) probability of attacks per year after the implementation of a security measure.

k = the value of lives and assets likely to be destroyed in successful attacks per year

Cost Effectiveness

$$CE_i = C_i/E_i$$

$EC_i = E_i/C_i$ outcome effectiveness per unit cost

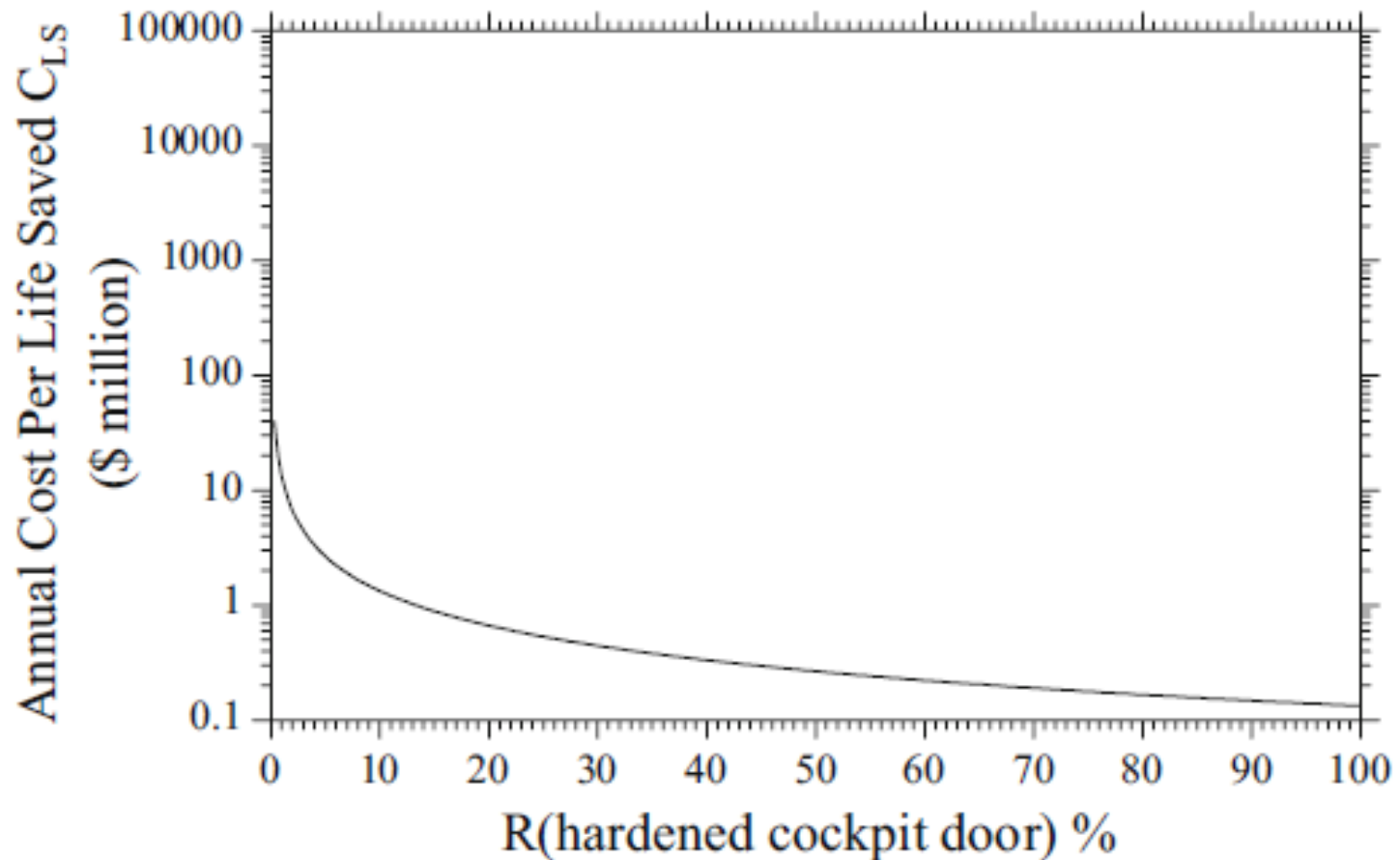
Minimize C_i

Subject to $E_i > \bar{E}$

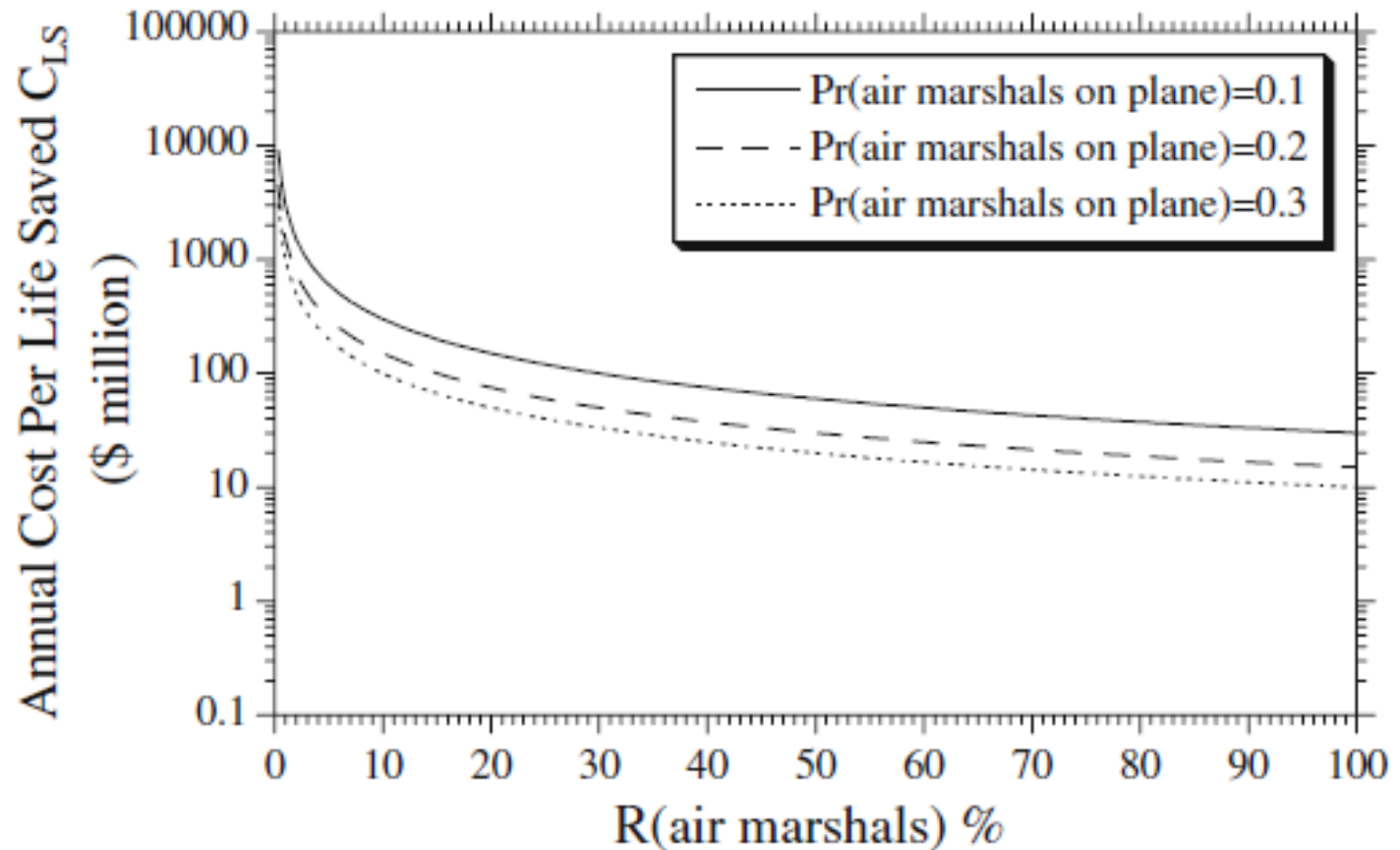
Minimize CE_i

Subject to $E_i > \bar{E}$

Sensitivity of annual cost per life saved to risk reduction attributable to hardened cockpit doors



Sensitivity of Annual Cost per Life Saved to Risk Reduction

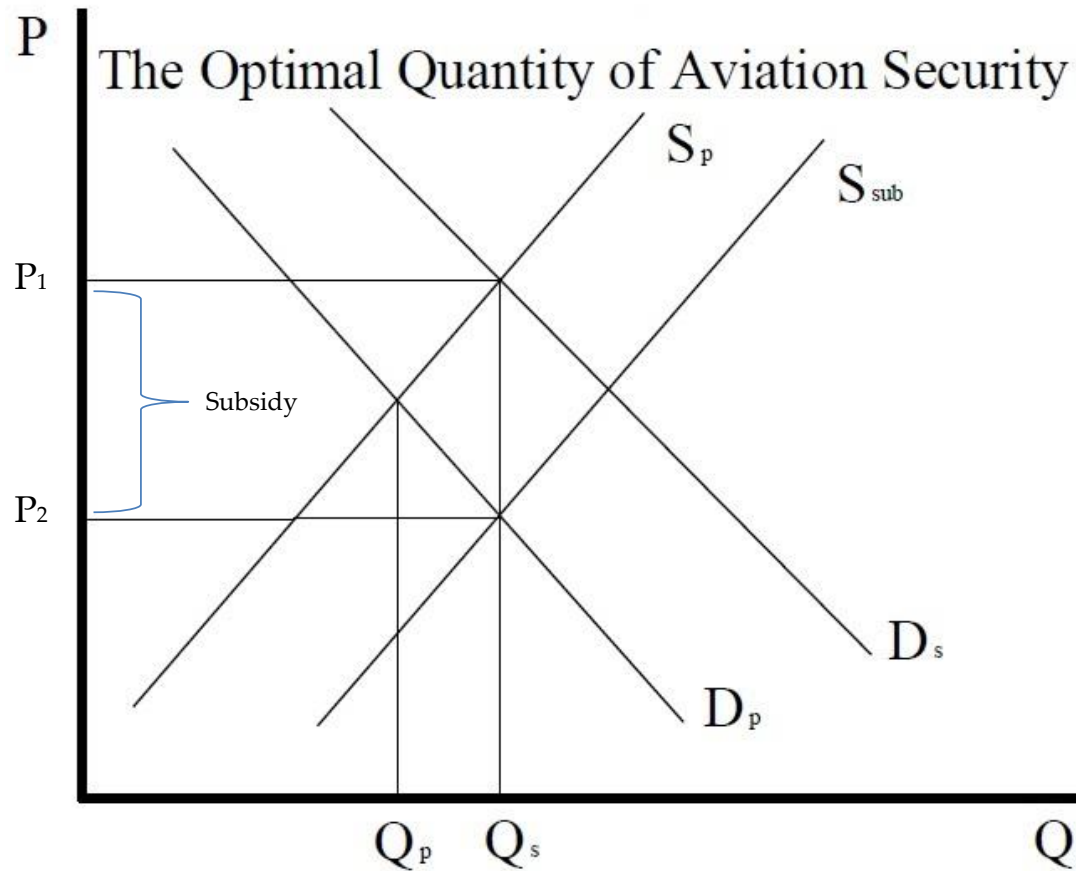


Public goods and government financing

Who should pay for aviation security?



Aviation Security as a Public Good



Milton Freedman on education as a public good:

"A stable and democratic society is impossible without widespread acceptance of some common set of values and without a minimum degree of literacy and knowledge on the part of most citizens. Education contributes to both. In consequence, the gain from the education of a child accrues not only to the child or to his parents but to other members of the society; the education of my child contributes to other people's welfare by promoting a stable and democratic society."

Friedman (1955).

Friedman, Milton. "The role of government in education." (1955).

“The ATSC is payable by air travellers, who principally and directly benefit from the Canadian air travel system.”

NCASP (Government of Canada, 2013), p3.

Do university students ‘principally and directly benefit’ from education?

Direct and Indirect Costs Measured in Estimate of 9-11 Impact

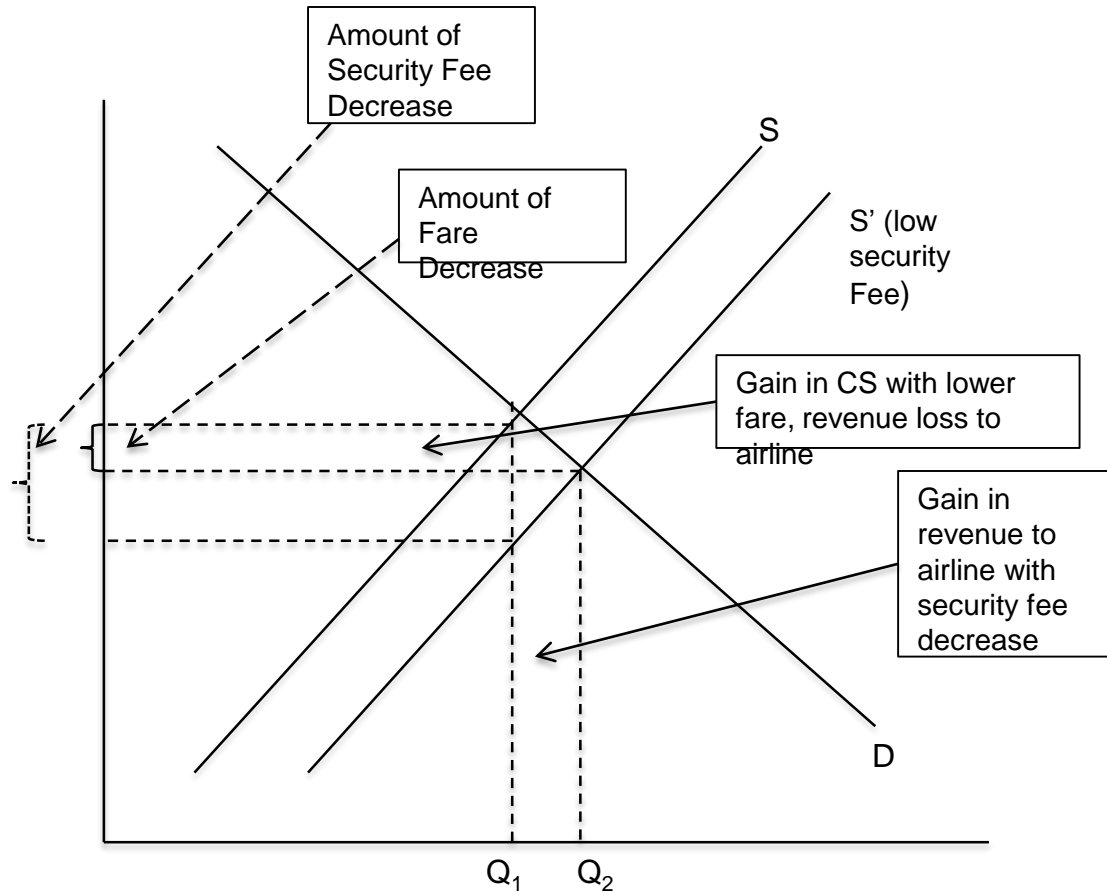
Direct Costs	Indirect Costs
Human lives	Lost Employee Income and Business Profits
Property loss	* Days bussiness closed or services cut back because office infrastructure damage or destroyed
* Buildings	* Other firms that depend on those that are closed or cut back
* Technology and Fixtures	
* Subway Stations	
* Phone and Power Utilites	
Response to the Emergency	Reduced Tax Revenues
* Emergency Management (including loss of equipment)	Delays to Travelers and Commuters
* Debris Removal	
* Building Stabilization	
Health Effects, Injuries, and Emotional Distress	
Temporary Living Assistance	

Source: New York City Partnership and Chamber of Commerce. (2001). Working together to accelerate New York's recovery: Economic impact analysis of the September 11th attack on New York City. Retrieved May 12, 2005, from <http://www.nycp.org/reports/ImpactS>

Estimated total of these costs = \$83 billion US

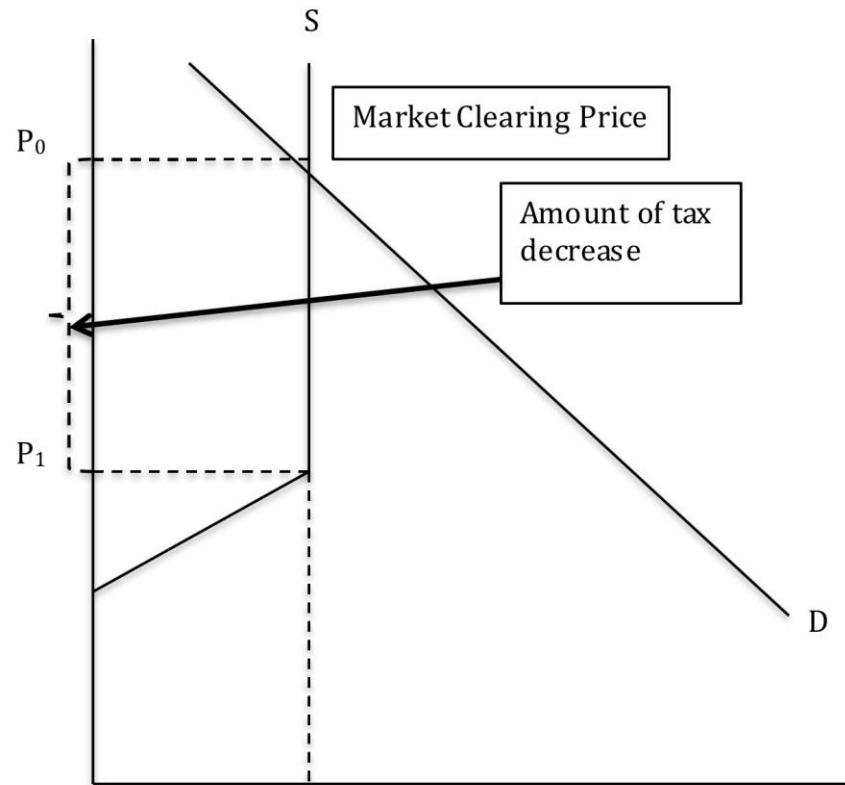
What happens when Taxes/Fees Go Up (or down)?

Competitive Case



What happens when Taxes/Fees Go Up (or down)?

Non-Competitive/Oligopolistic Case



Estimating (some of) economic welfare losses as a result of the ATSC in Canada: A case study for 2011

We can use estimates of the price sensitivity of demand for air travel to estimate declines in passengers as a result of the ATSC

We use average fares and passenger numbers for

- Domestic, transborder and international passengers
- Discount fares, business/full-fare economy

We control for connecting passengers

Results

- In 2011 there were approx 690,000 fewer air travellers flying to/from and within Canada as a result of the ATSC
- Deaths/injuries may have increased if modal substitution to automobile

In 2011 there were approx 690,000 fewer air travelers flying to/from Canada as a result of the ATSC

This translates into foregone revenues of approx **\$227 million** for airlines.

We also are able to calculate a measure of one part of “social welfare loss”

- The dollar value of losses in economic wellbeing suffered by consumers

This part of the social welfare loss for 2011 estimated to be **\$2.2 billion**

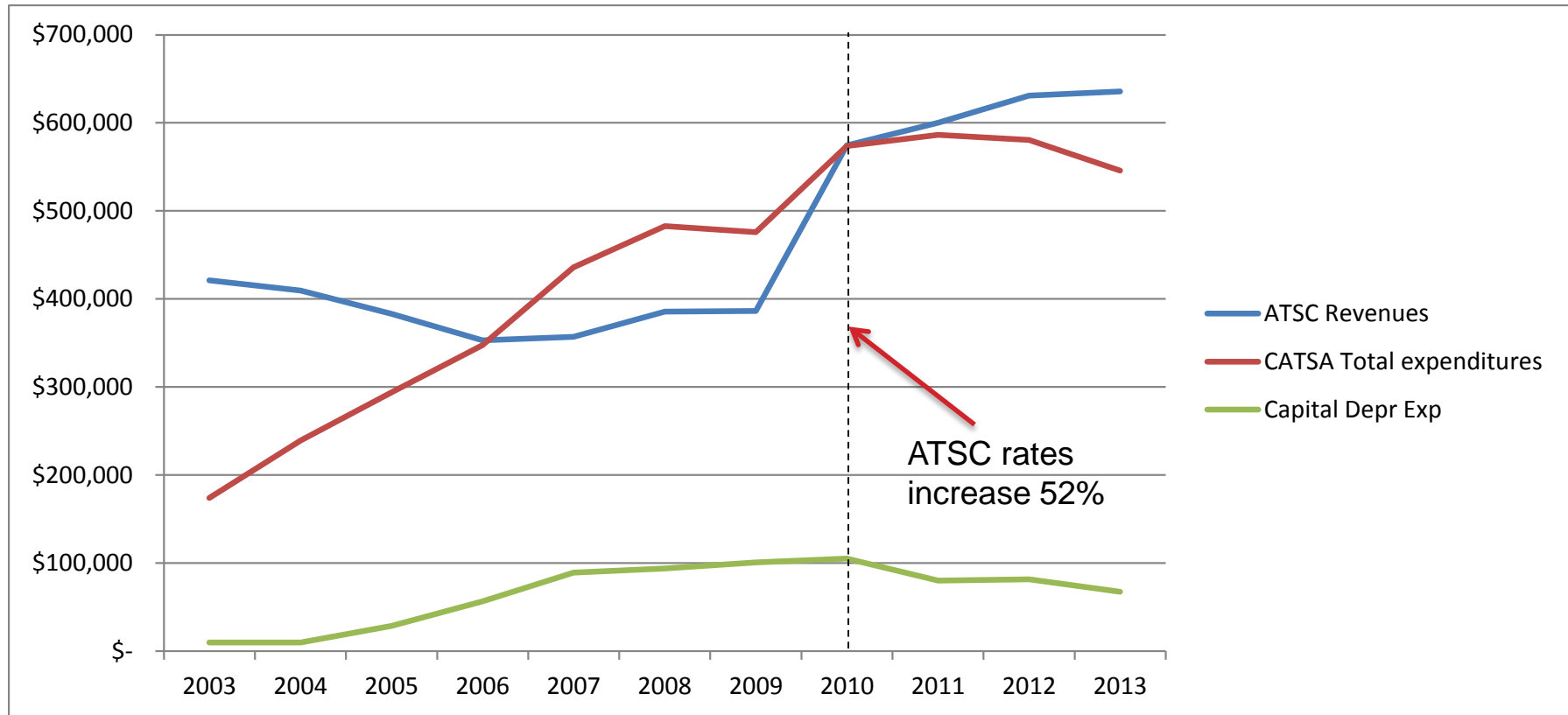
- Does not include other relevant indirect losses to passengers and airlines of delays, inconvenience and declines in economic activity.

Charges and revenues in aviation security

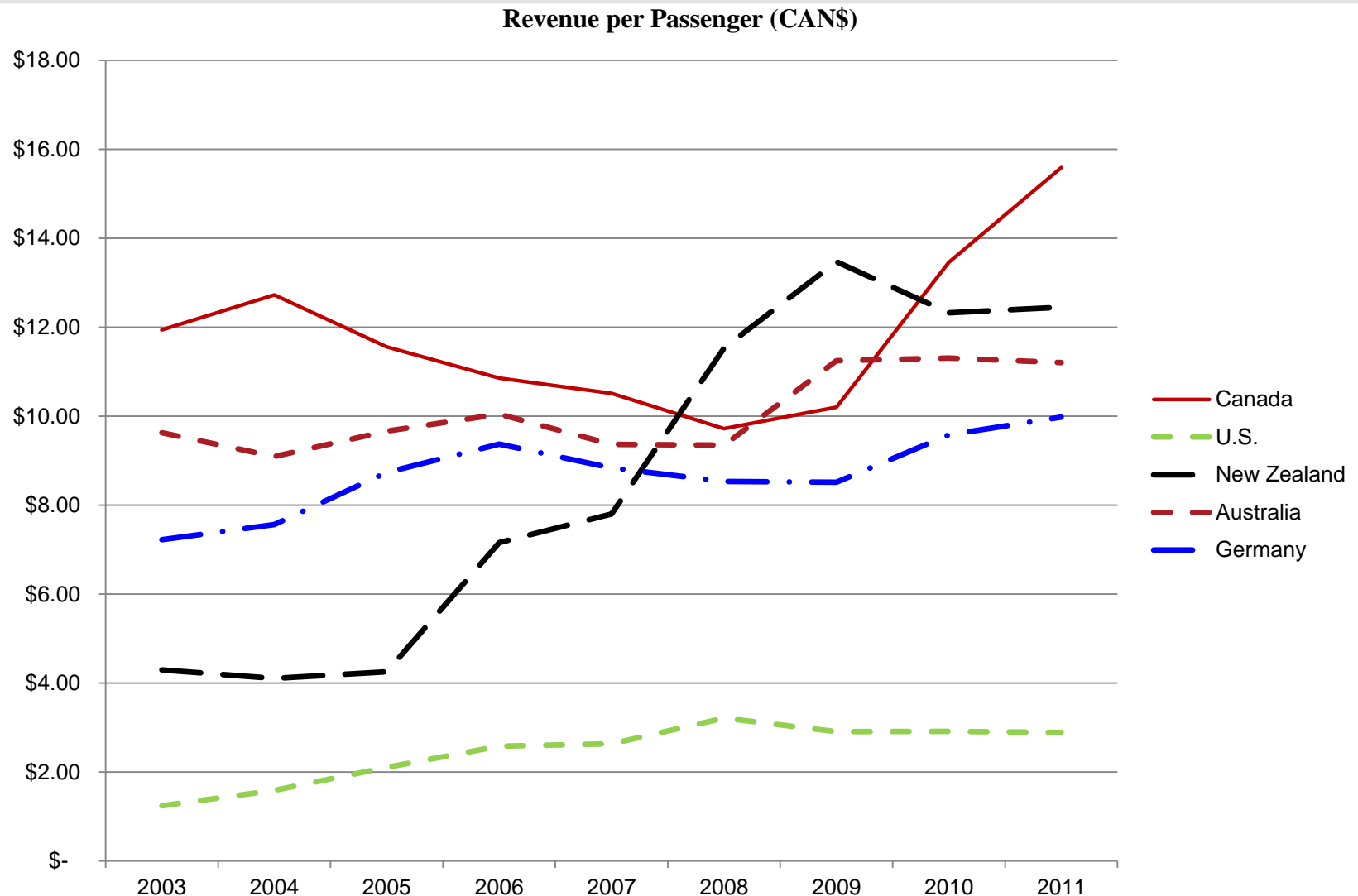
Are current 'avsec' charges to passengers and airlines comparable across airports around the world?



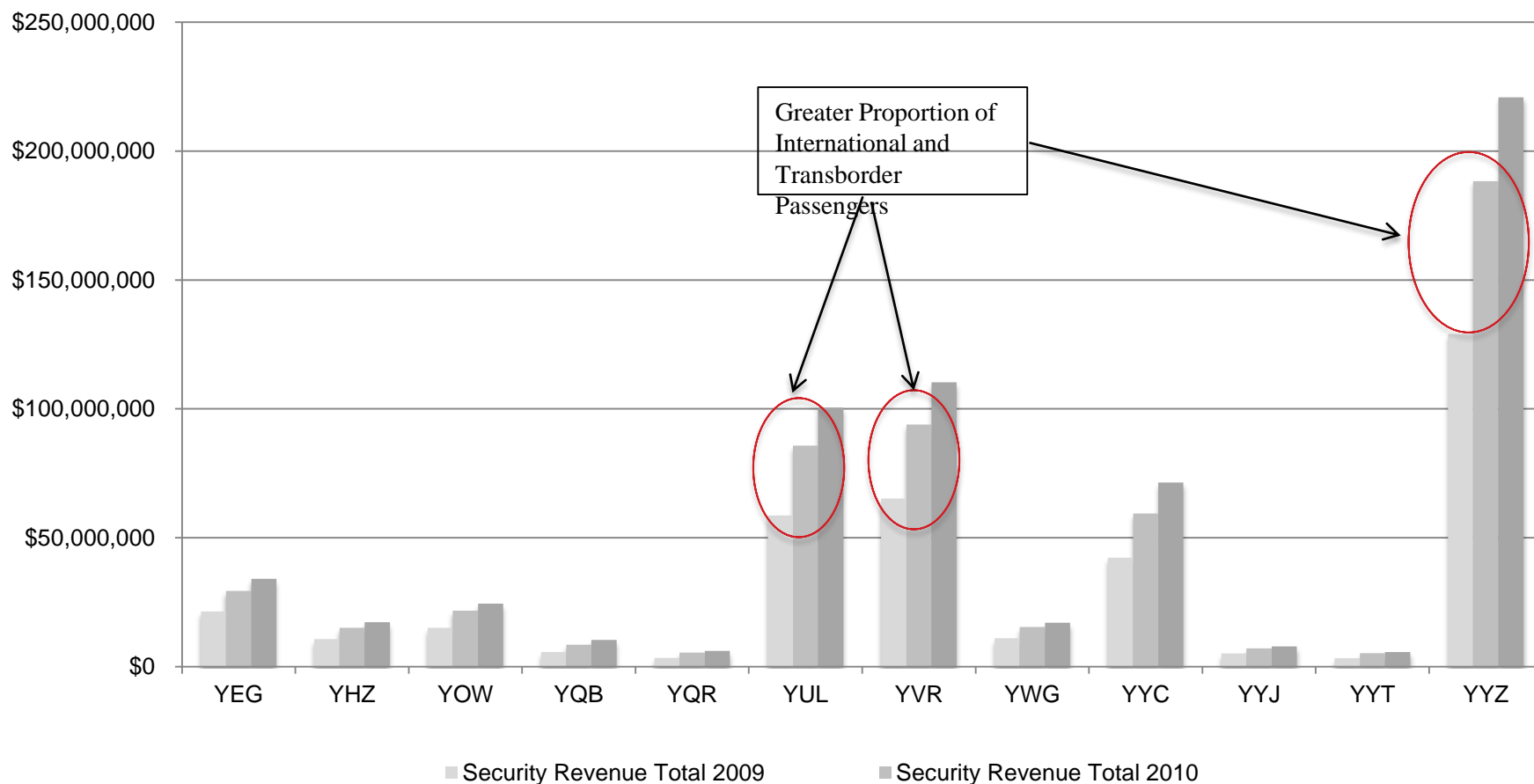
CATSA expenditures and ATSC revenues by year



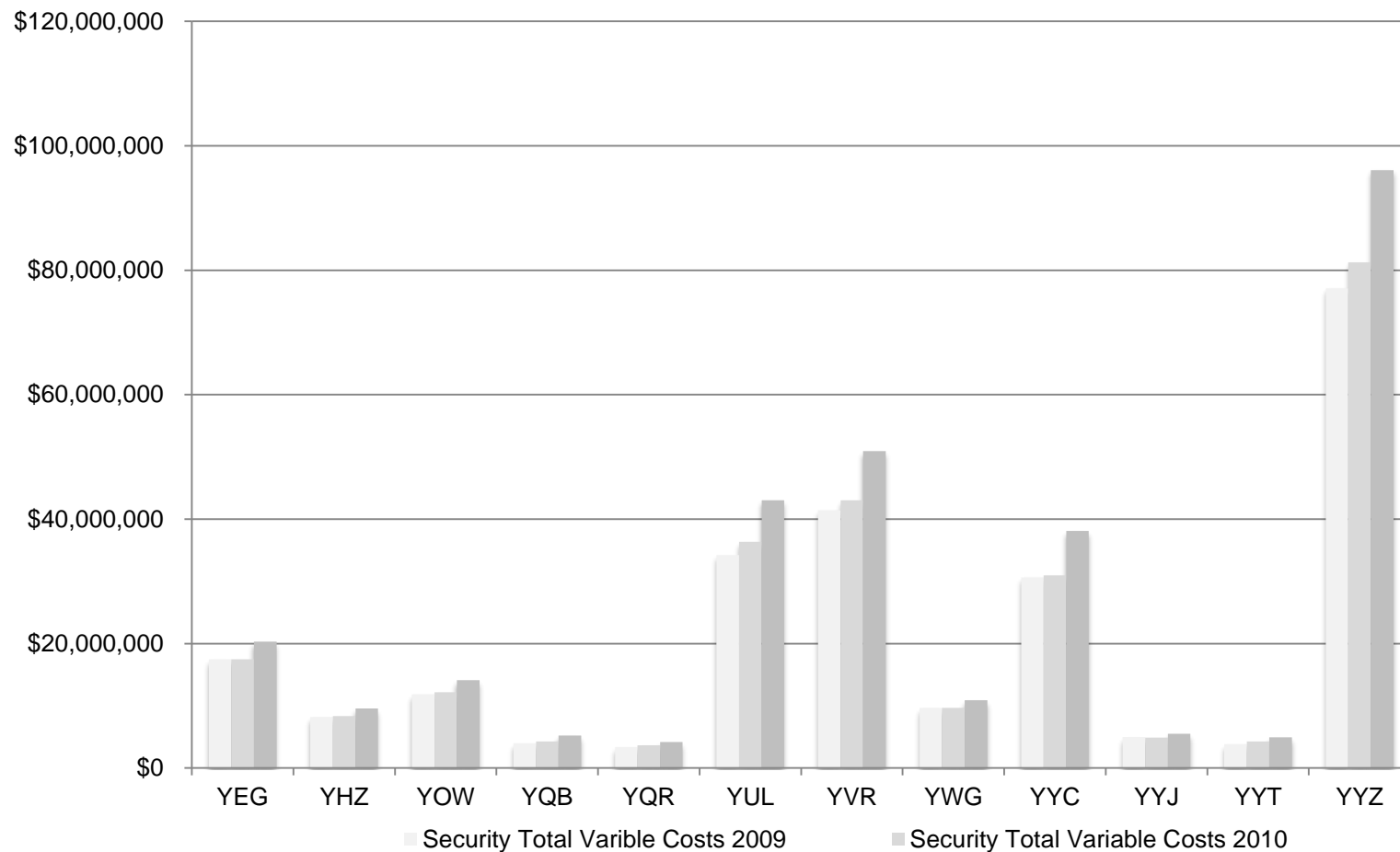
Revenue per Passenger Various Countries



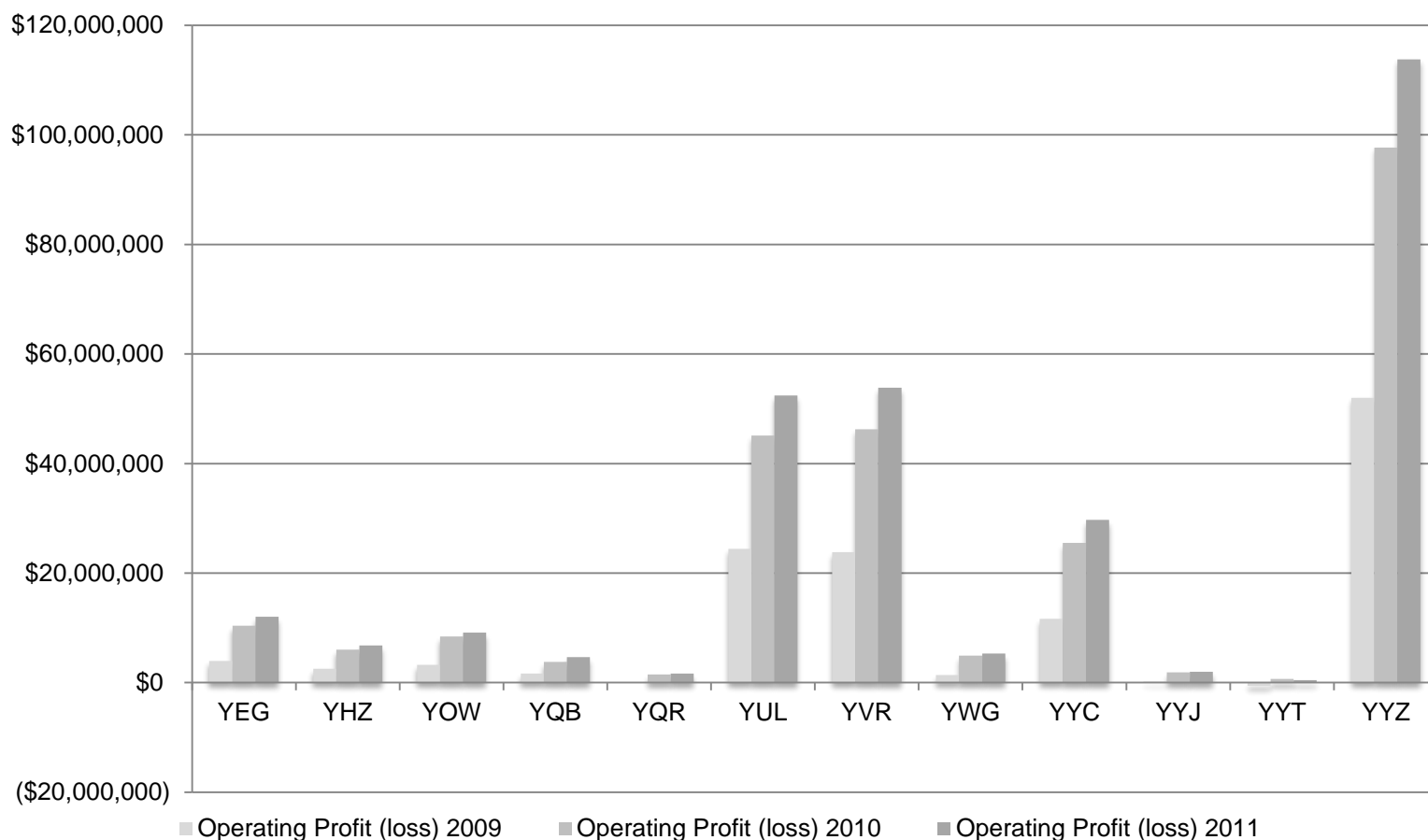
Government Revenue Received from Security Charges Major Airports 2009-2011



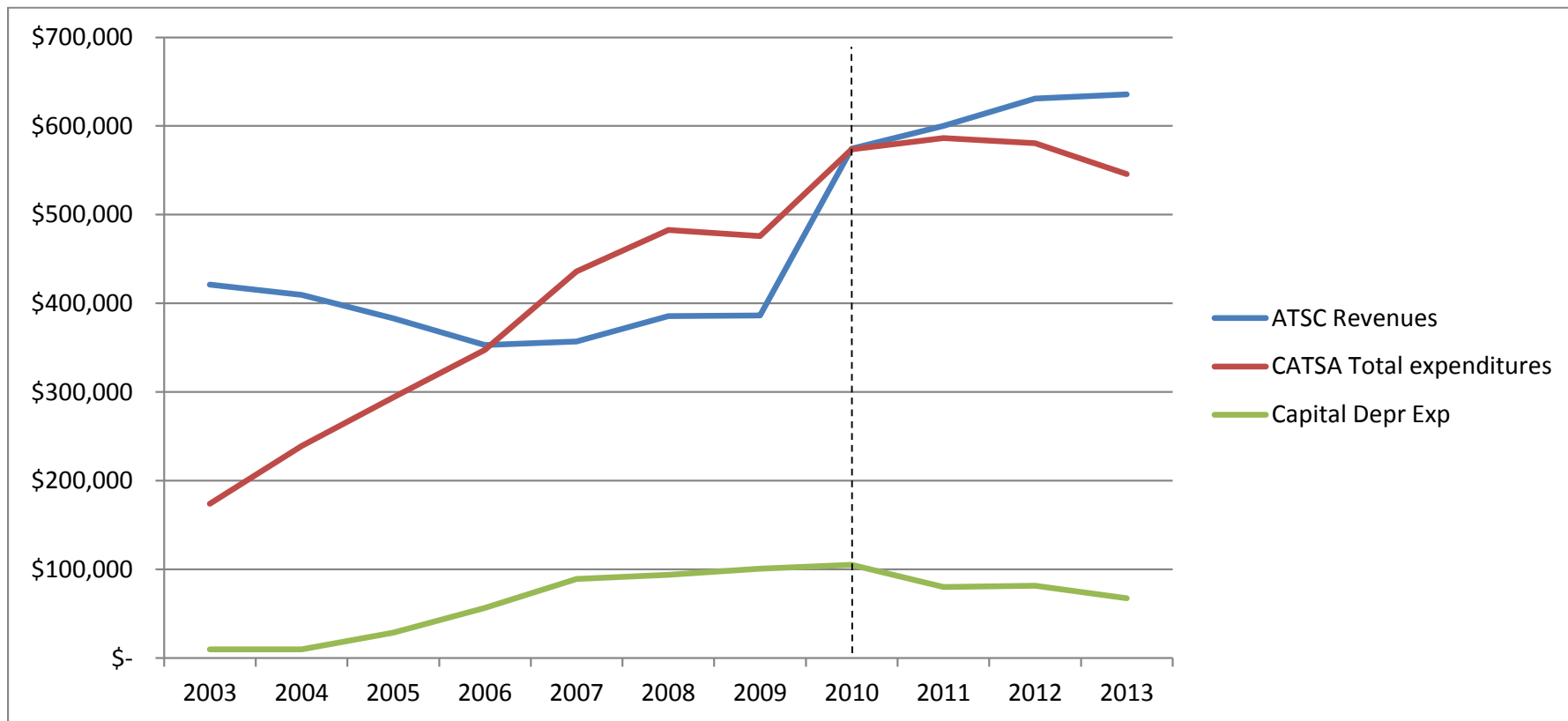
Total Variable Costs 2009-2011 for Major Airports



“Operating Profit” for Government Major Airports for 2011



Capital costs do not explain the growing difference between operating revenues and operating costs

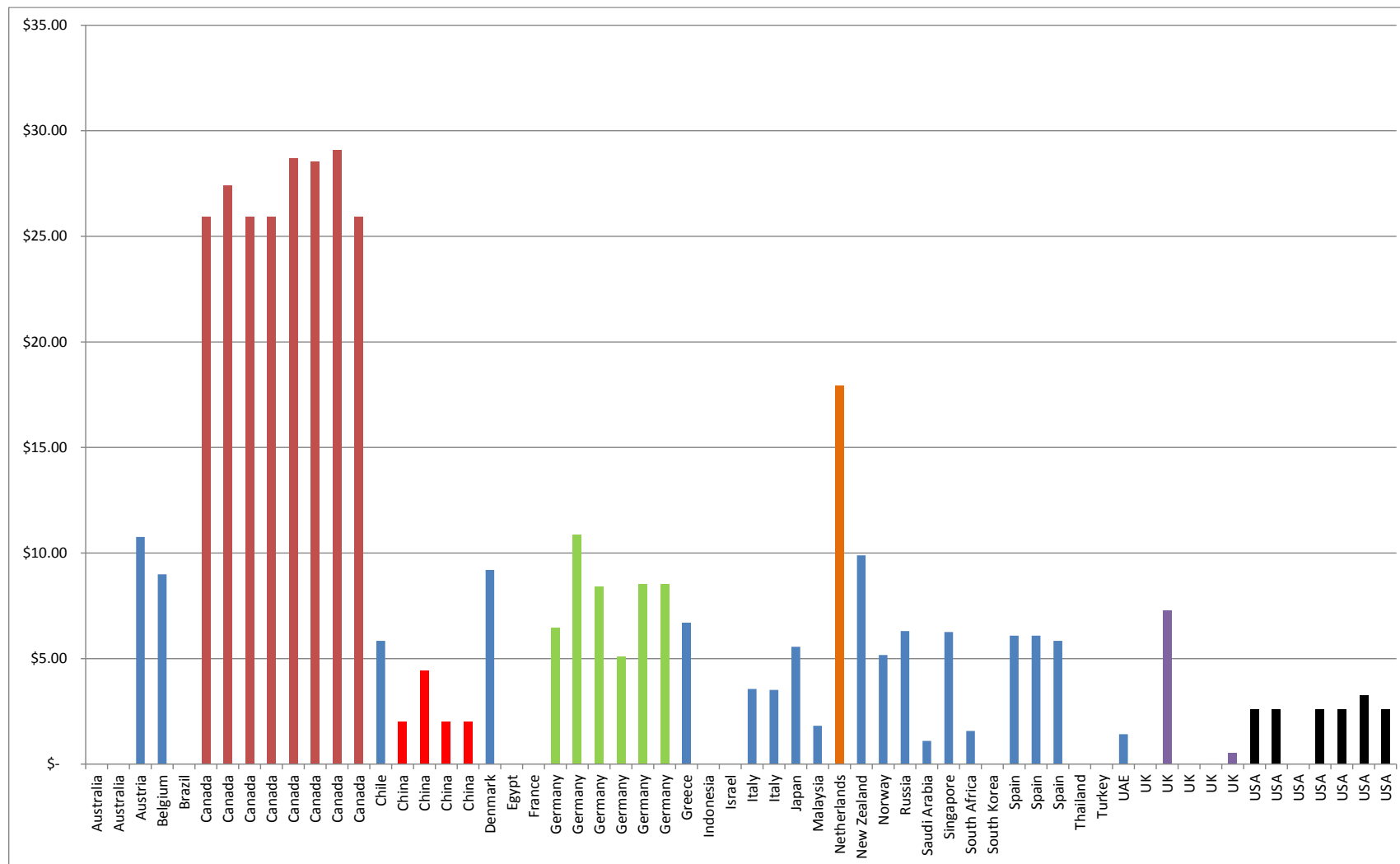


ATSC rates increase

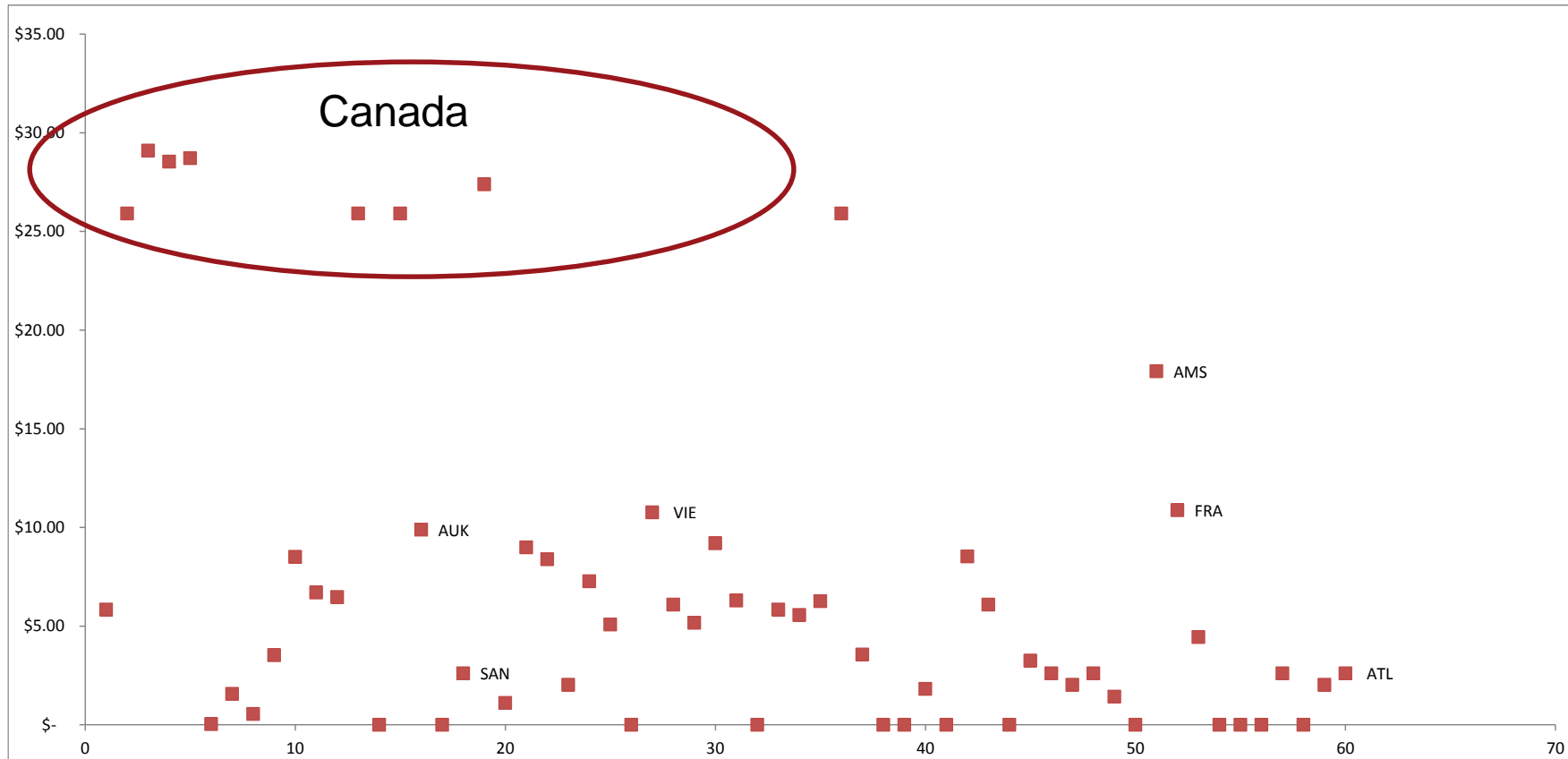
Airport charges exercise

- Comprehensive data on all charges to an airline landing at a given airport
- Sample of 60 airports globally; variation by pax volumes and governance structure
- Where delineated, aviation security charges identified as either airport charges or government charges.
- Controlling for
 - Equipment (same aircraft)
 - Load factor (same number of passengers)
 - Turnaround duration (same time parked at the airport)
 - Date (same day)
 - Exchange rates (all converted into \$US)

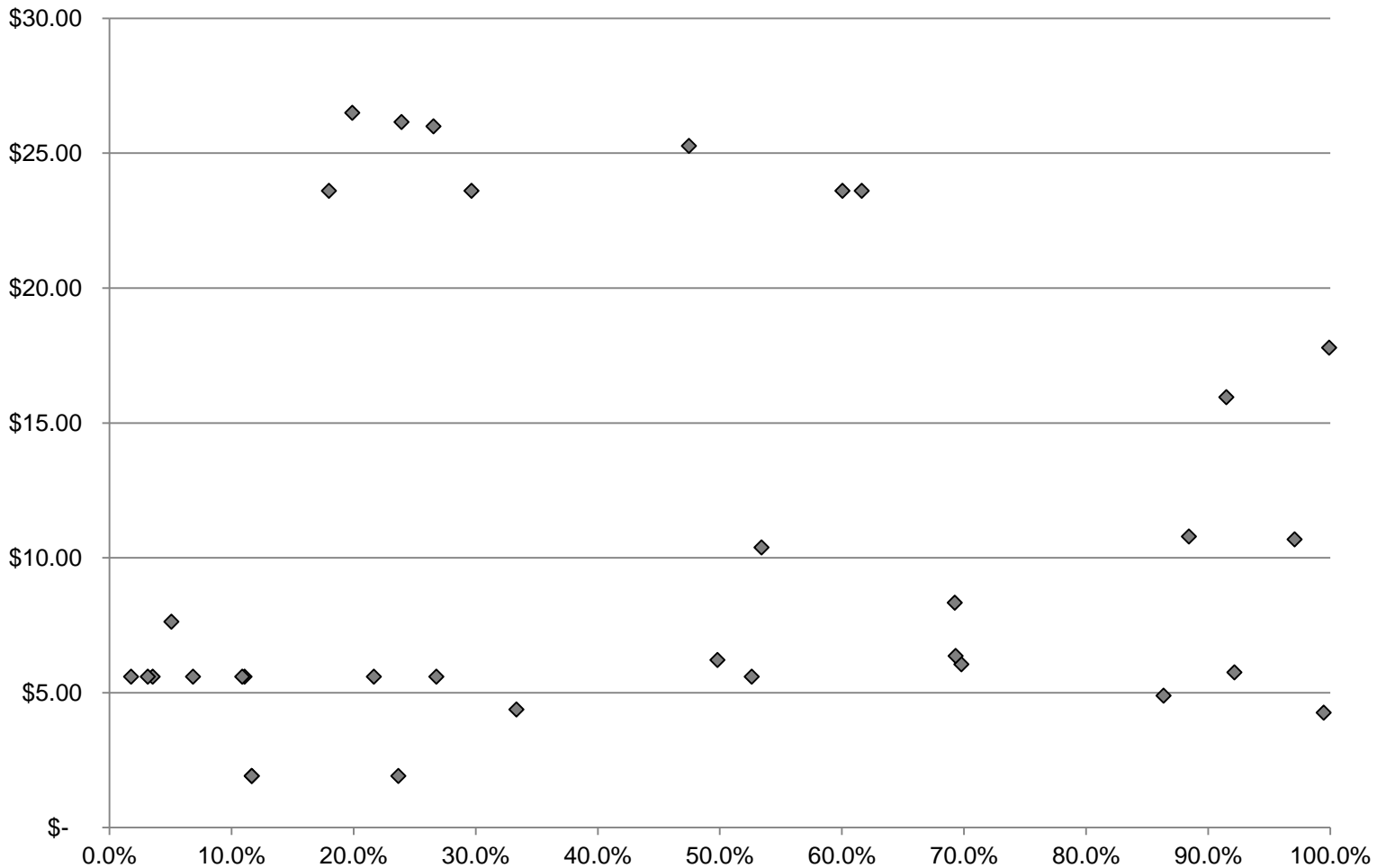
Total Delineated AvSec Charges; 2014 \$US; by country



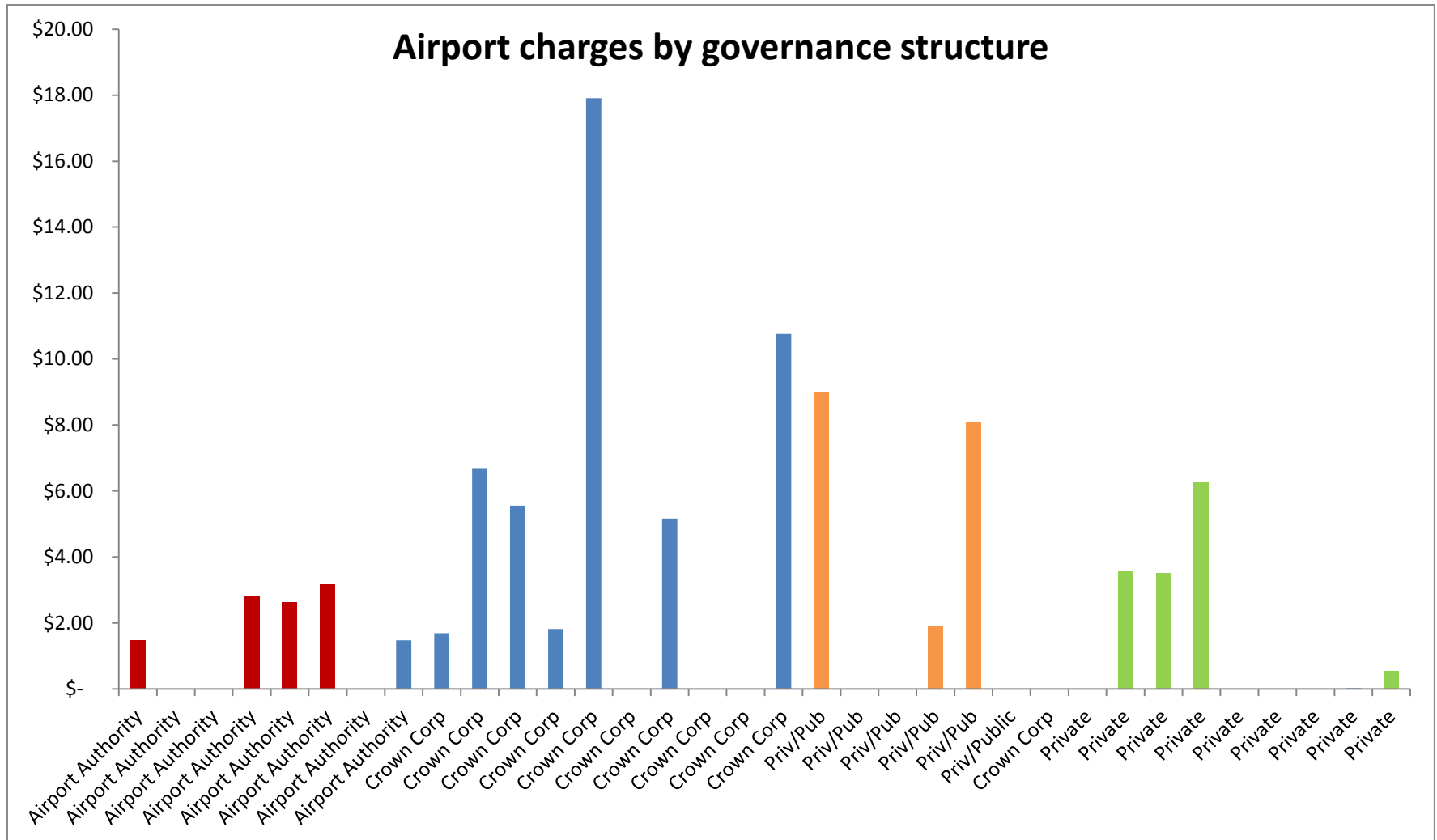
Total Delineated AvSec Charges; 2014 \$US; by pax volume



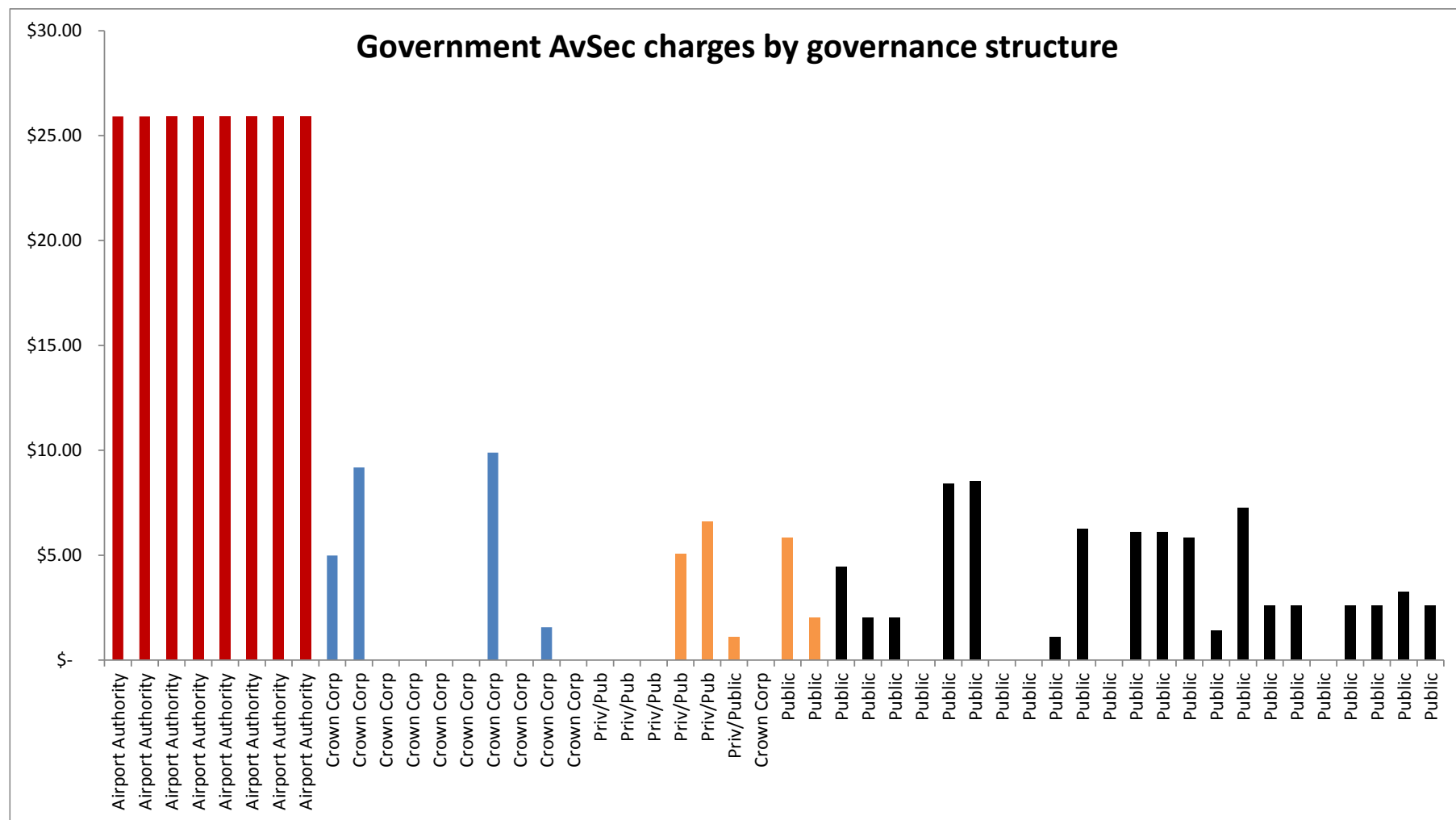
Airport Security Charges (Intl. pax) : % of International Passengers



Airport AvSec Charges; 2014 \$US; by governance structure



Government AvSec Charges; 2014 \$US; by governance structure



Ongoing/ emerging Issues



Transparent and consistent comparative data on aviation security finances

Calculation and decomposition of all costs and revenues related to aviation security

Measuring output in aviation security

- How safe are we? Data required.

Better understanding of revenues and cost relationships

- Economies of scale?
- Role of international passengers?
- Role of governance
- Role of market structure

Calculating the net impact of security charges

- Lost passenger traffic
- Social welfare losses – consumer surplus
- Empirical analysis of indirect costs of aviation security – producer surplus

Benefit-cost analysis of security measures

- Air Marshall programs
- TTP's
- Capital investments (e.g. full body scanners)

Input relationships between difference layers of security

- How do layers of security interact with one another?
- Identifying complements and substitutes

Aviation security as a partial public good

- What share of total expenditures on aviation security should be recovered by air traveller passenger charges

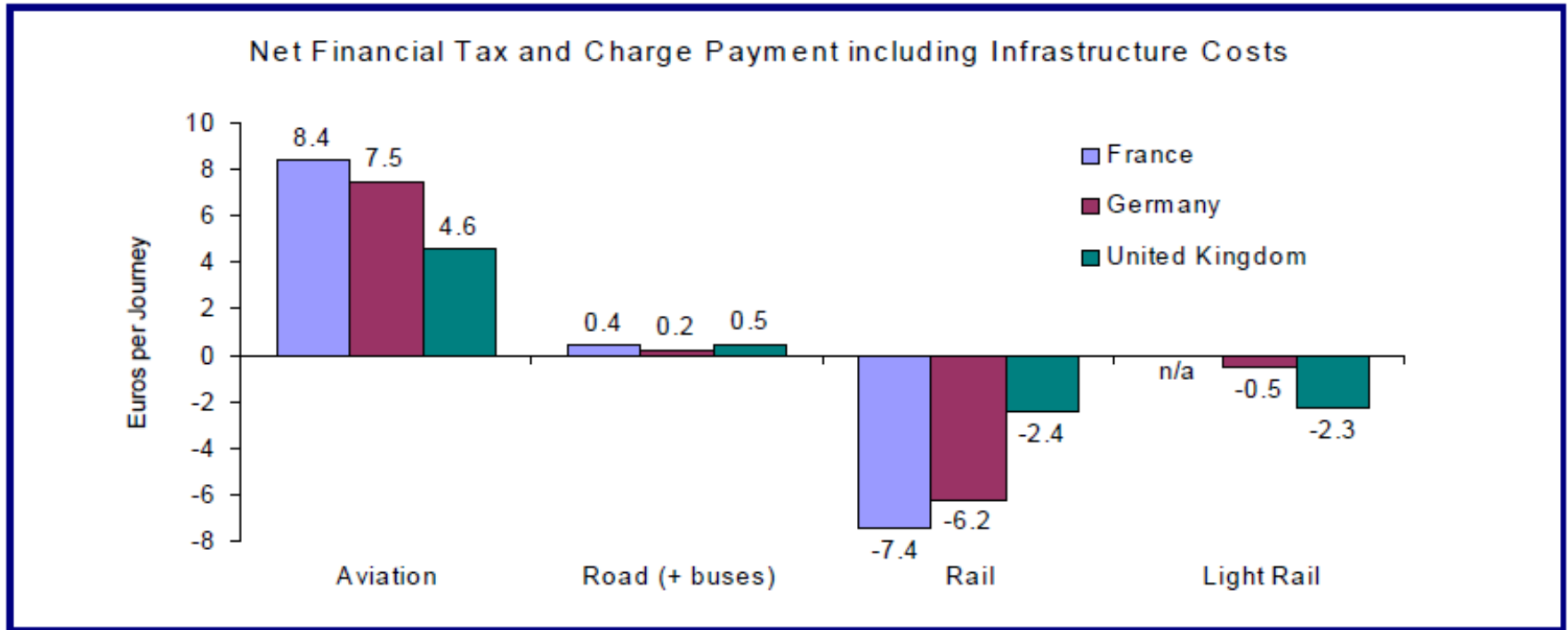
Consistent treatment of aviation relative to other transportation modes

- Trains versus planes

Increasing the role of new technologies and processes

- Risk-based aviation security – TTPs
- Biometrics
- Behavioural screening

The treatment of aviation by governments is not the same as the treatment of other modes of transportation



Risk-based Security and Technology adoption

- Next generation security – the vision
 - Expanded trusted traveler programs (TTPs)
 - Faster security checks for most people (not just trusted travelers)
 - Biometrics, random checks to support identification/increase security in TTPs
 - Real-time security information to checkpoints
 - Behavioural screening
- Challenges
 - Harmonizing visions – IATA, ICAO, ACI, Governments,...
 - Economic efficiency or adding layers?
 - Political economy of aviation security



Thank You!

www.intervistas.com