Can we understand Air Navigation Service Provision performance and impact on ownership form?

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SESAR JOINT UNDERTAKING

Founding Members

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Motivation

Air navigation service provision is a monopoly service by definition

Ownership

- most are government departments
- some are commercialized government owned corporations
- few are purely private with aviation stakeholders:
  - NATS: public private partnership with dividends
  - NavCanada: nonprofit entity
  - Skyguide: government controlled joint stock company

Regulation

- ICAO advises cost based charges
- EU price caps services using Performance Review Board

is there a preferable model?

Literature Search

Elias (Congressional Research Service Report, 2015)

- no conclusive evidence that any institutional set-up is superior with respect to productivity, cost-effectiveness, service quality, safety and security
- Improvements in cost-effectiveness and performance and faster implementation of technologies as a result of access to financial markets are observed

Lewis (IPMJ 2004)

- analyse institutional arrangements for governance of air navigation services of 6 nations
- focus on how boards of public organizations can act as a proxy for market feedback
- conclusions suggest that ATC most effectively provided on not-for-profit basis, with indirect participation by stakeholders including airlines and airport operators.
- no conclusions on impact on efficiency or production

Button & Neiva (JTEP 2014)

- bootstrapped data envelopment analysis with variable returns to scale for 36 European ATC systems for period 2002-2009
- find economics of density or scale as providers with higher number of sectors also more efficient
- state that result on ownership effect is *counterintuitive* as providers closely linked to government are relatively more efficient

Bilotkach et al. (TR part A 2015)

- analyze European ATC providers from 2002–2011 applying data envelopment analysis
- providers' productivity improved due to technical rather than allocative efficiency
- some trend reversals in the post-2008 crisis period are also observed

outline

Stochastic production function

Stochastic cost function

Conclusions

Data

most data from ATM cost-effectiveness benchmarking reports

- assembled by the Performance Review Unit

representative panel dataset of 37 European ATC providers covering 9 years (2006-2014)

Data: Variables in Production Function

En-route

Y total flight hours controlled
X_1 ATCO hours in air control centers
X_2 en-route sectors
Z_1 seasonality
Z_2 complexity

Terminal

Y IFR airport movements
X_1 ATCO hours APP+TWR
X_2 (NBV/ Capital goods price index) * ppp

where ppp= $\frac{\text{Purchasing power parity}}{\text{Exchange rate}}$

Z_1 complexity

Methodology: stochastic production function

$$\ln(IFRkm_{it}) = \beta_0 + \beta_1 \ln(ATCO_{it}) + \beta_2 ln(sectors_{it}) + V_{it} - U_{it}$$

$$where\ U_{it} = \partial_0 + \partial_1 Seasonality_{it} + \partial_2 Complexity_{it} + W_{it}$$

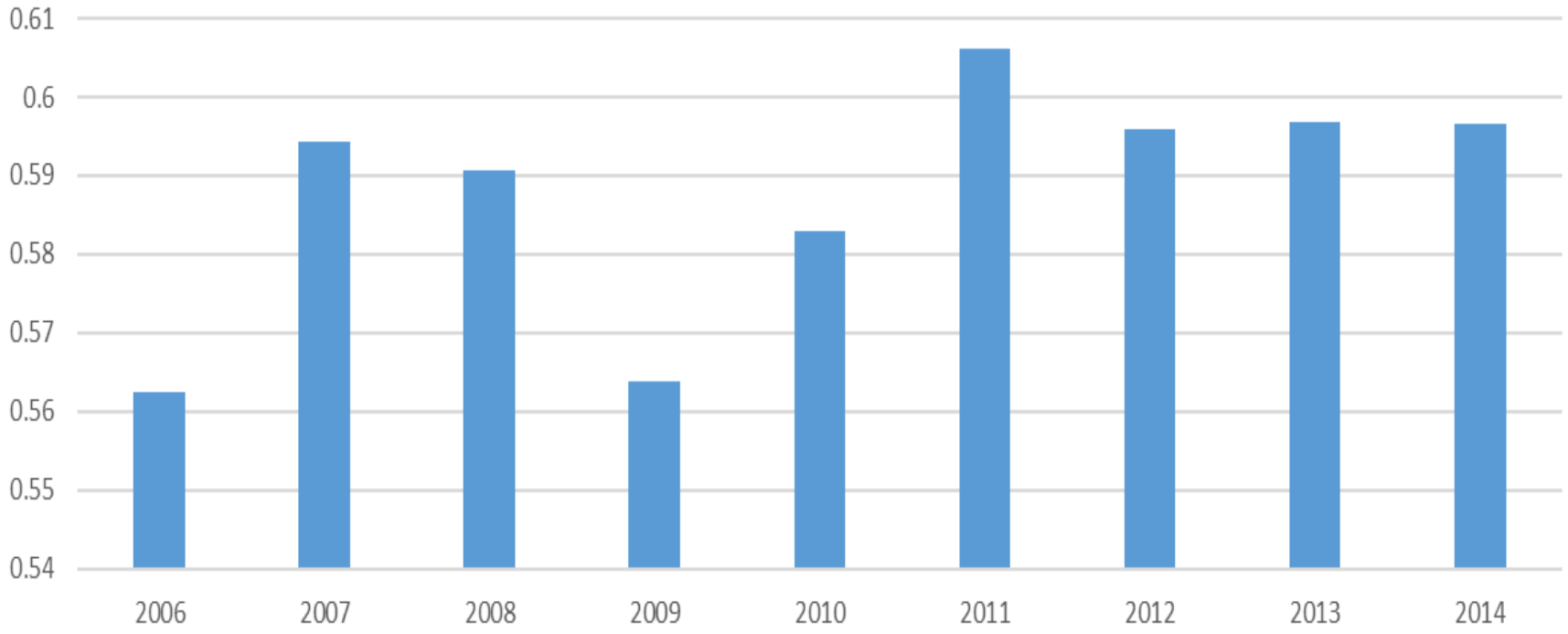
i	i^{th} ATC provider
t	year of the observation
z_{it}	environmental variables
V_{it}	error term
U_{it}	inefficiency term with mean $z_{it}\delta$
w_{it}	random variable

using 1st stage results estimating production function
in 2nd stage estimate the inefficiency of ATC providers

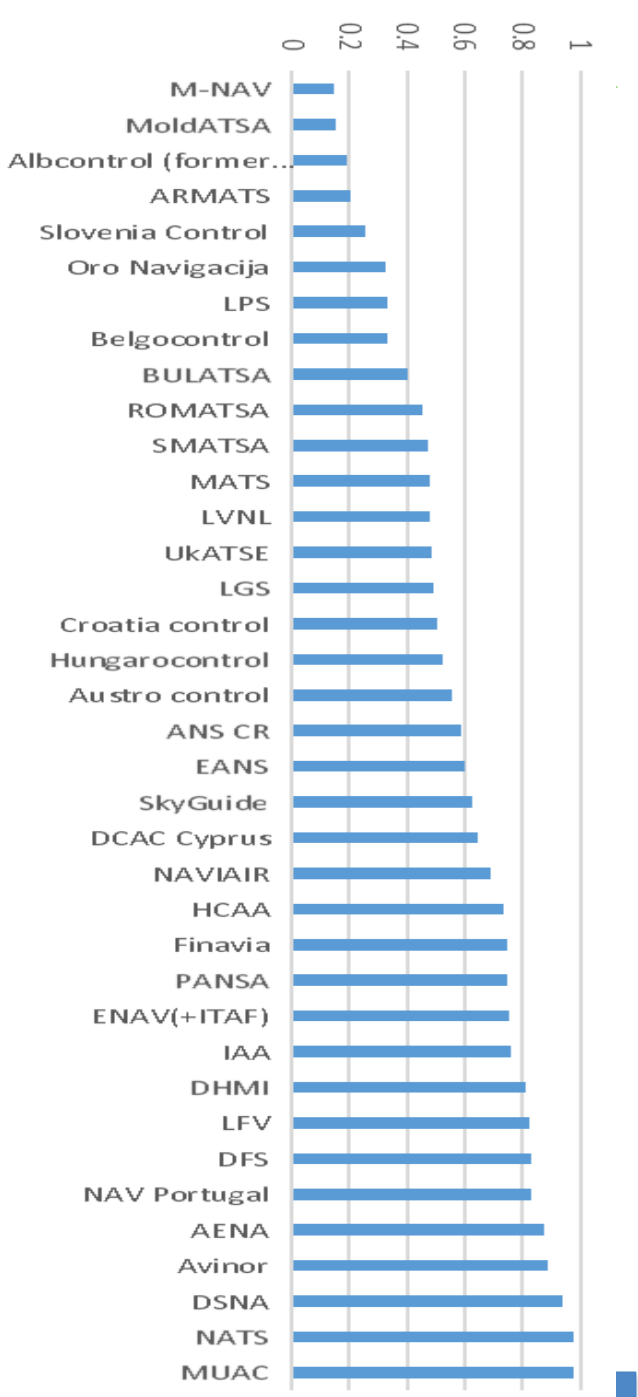
Results of SFA production model with time decay in inefficiency for en-route control (Battese and Coelli 1995)

PRODUCTION FUNCTION	Model 1		Model 2		Model 3	
	En-route					
Input / Output	Total IFR flight hours controlled		Total IFR flight hours controlled		Total IFR flight hours controlled	
	Coef.	P>|Z|	Coef.	P>|Z|	Coef.	P>|Z|
Labor in ACC (hours)	0.497	0.000	0.392	0.000	0.60	0.000
En-route sectors	0.518	0.000	0.661	0.000	0.33	0.000
constant	5.311	0.000	6.432	0.000	4.48	0.000
Z - Variables explaining the mean of the inefficiency (Mu)						
Seasonality			1.74	0.000	4.093	0.000
Complexity					-1.212	0.000
sigma_v	0.235	0.000	0.207	0.000	0.236	0.000
sigma_u	3.380	0.578	0.432	0.000	0.465	0.000
Log Likelihood	-162.773		-151.364		-96.163	
Lambda	14.365	0.018	2.087	0.000	1.970	0.000

Average Production Efficiency Estimates for En-Route ATC (2004-2014)



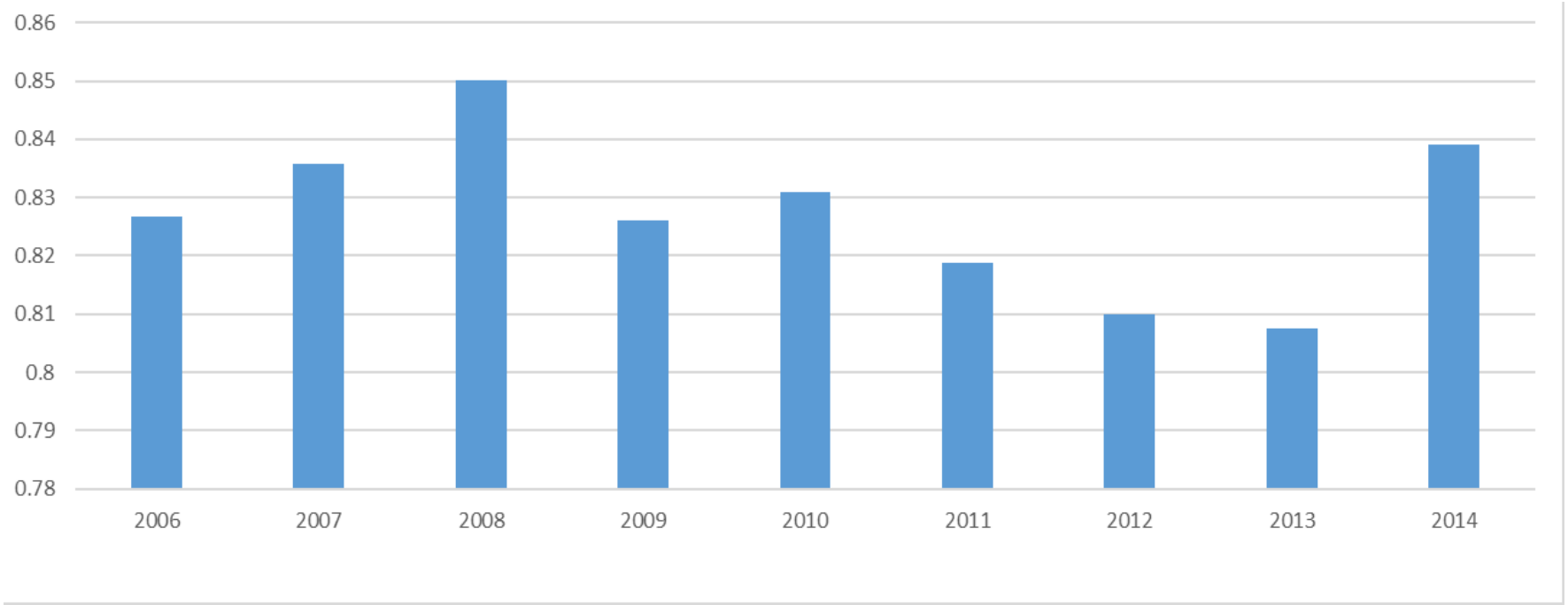
Average Productive Efficiency Estimates per En-route ATC provider



Results of SFA production model with time decay in inefficiency for terminal control (Battese and Coelli 1995)

PRODUCTION FUNCTION	Model 1		Model 2		Model 3	
	Terminal					
Input / *Output*	IFR airport movements		IFR airport movements		IFR airport movements	
	Coef.	P>|Z|	Coef.	P>|Z|	Coef.	P>|Z|
Labor in TWR and APP	0.529	0.000	0.528	0.000	0.575	0.000
Net Book Value of Fixed Assets	0.558	0.000	0.488	0.000	0.428	0.000
Seasonality			-2.818	0.000	-3.094	0.000
constant	2.997	0.000	3.372	0.000	3.267	0.000
Z - Variables explaining the mean of the inefficiency (Mu)						
Complexity					-0.845	0.00
sigma_v	0.095	0.250	0.243	0.000	0.230	0.000
sigma_u	0.422	0.000	2.170	0.671	0.499	0.000
Log Likelihood	-163.974		-64.720		-53.484	
Lambda	4.428	0.018	8.923	0.081	2.174	0.000

Average Productive Efficiency Estimates for Terminal ATC (2004 to 2014)



outline

Stochastic production function

Stochastic cost function

Conclusions

Data: Variables in cost function

where

$$\text{cost of operation index} = \frac{\text{intermediate goods and energy price index}}{\text{ppp}}$$

En-route

$$Y \quad \frac{\text{total cost ACC}}{\text{cost of operation index}}$$

$$X_1 \quad \text{total IFR flight hours controlled}$$

$$X_2 \quad \frac{\text{total staff cost/ATCO hours in ACC}}{\text{cost of operation index}}$$

$$X_3 \quad \frac{\text{(depreciation cost + cost of capital) / (NBV/ capital goods price index)}}{\text{cost of operation index}}$$

Data: Variables in cost function

X_4 seasonality

X_5 complexity

X_7 corporatized (1 if “Gov corp”, 0 otherwise)

X_8 agency (1 if “Agency”, 0 otherwise)

Z_1 complexity

Methodology: stochastic cost function

$$C_{it} = \beta X_{it} + V_{it} - U_{it}$$

$$where\ U_{it} = \partial_0 + \partial_2 Complexity_{it} + W_{it}$$

costs C_i are logged

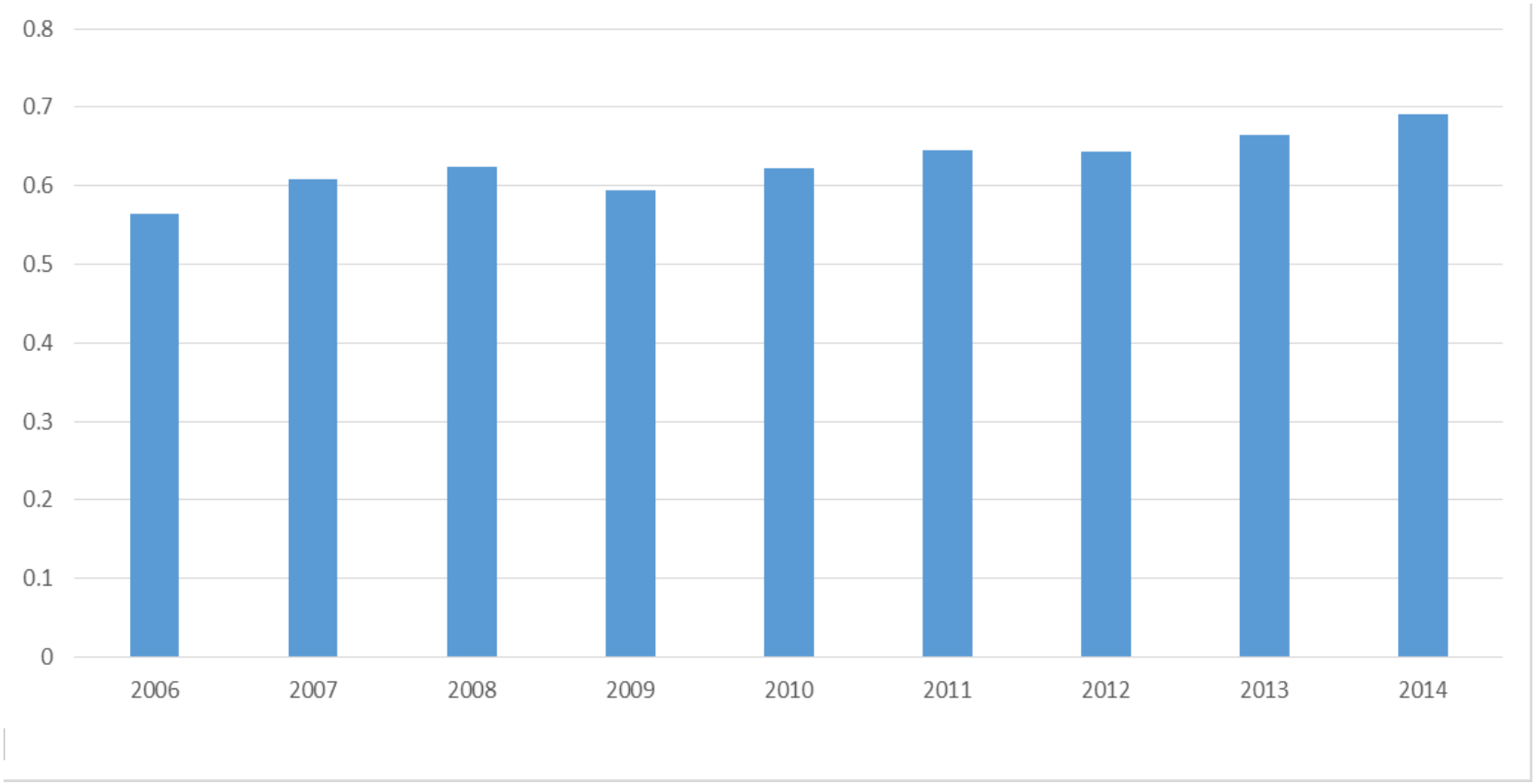
explanatory variables X_i

- normalized and logged
- factor prices w_i
- output level y_i

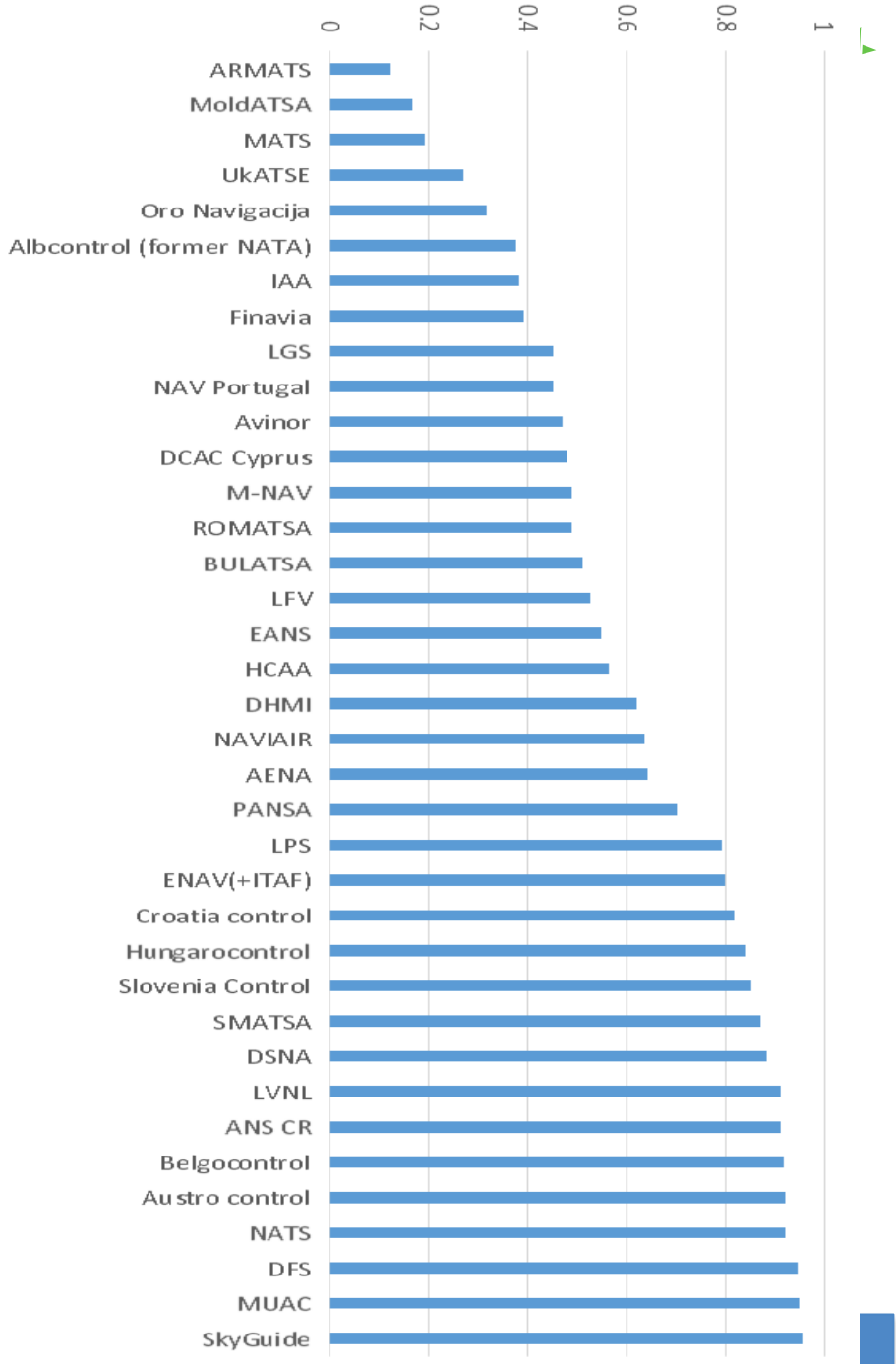
Results of SFA cost model with time decay in inefficiency for en-route control (Battese and Coelli 1995)

COST FUNCTION	Model 1		Model 2		Model 3	
	En-route					
Input / *Output*	$\frac{total\ cost}{op.\ cost\ index}$		$\frac{total\ cost}{op.\ cost\ index}$		$\frac{total\ cost}{op.\ cost\ index}$	
	Coef.	P>|Z|	Coef.	P>|Z|	Coef.	P>|Z|
Total IFR flight hours controlled	0.902	0.000	0.926	0.000	0.969	0.000
$\frac{labor\ cost}{op.\ cost\ index}$	0.308	0.000	0.243	0.000	0.319	0.000
$\frac{capital\ cost}{op.\ cost\ index}$	0.303	0.000	0.319	0.000	0.280	0.000
ownership gov/corp			0.402	0.000	0.556	0.000
ownership agency			0.212	0.000	0.396	0.000
complexity	0.104		0.157	0.000	0.768	0.000
seasonality	1.368		1.344	0.000	1.891	0.000
constant	-2.342		-3.428	0.000	-5.193	0.000
Z - Variables explaining the mean of the inefficiency (Mu)						
complexity					-1.015	0.000
sigma_v	0.333	0.000	0.321	0.000	0.223	0.000
sigma_u	0.098	0.990	0.077	0.983	0.239	0.000
Log Likelihood	-103.400		-91.679		-58.155	
Lambda	0.294	0.970	0.240		1.072	0.000

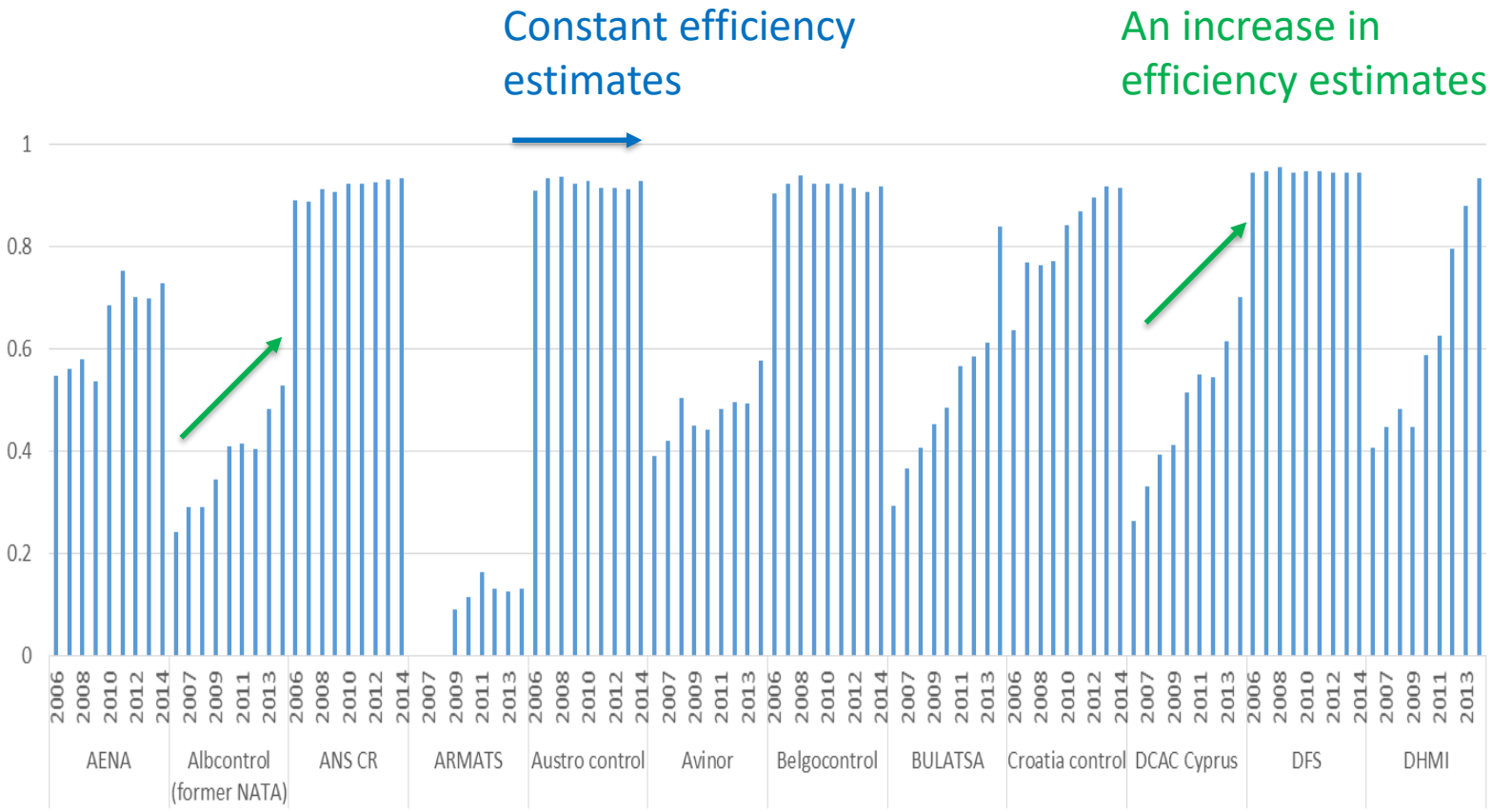
Average Cost Efficiency Estimates for En-route ATC 2006-2014



Average Cost Efficiency Estimates per En-Route ATC Provider



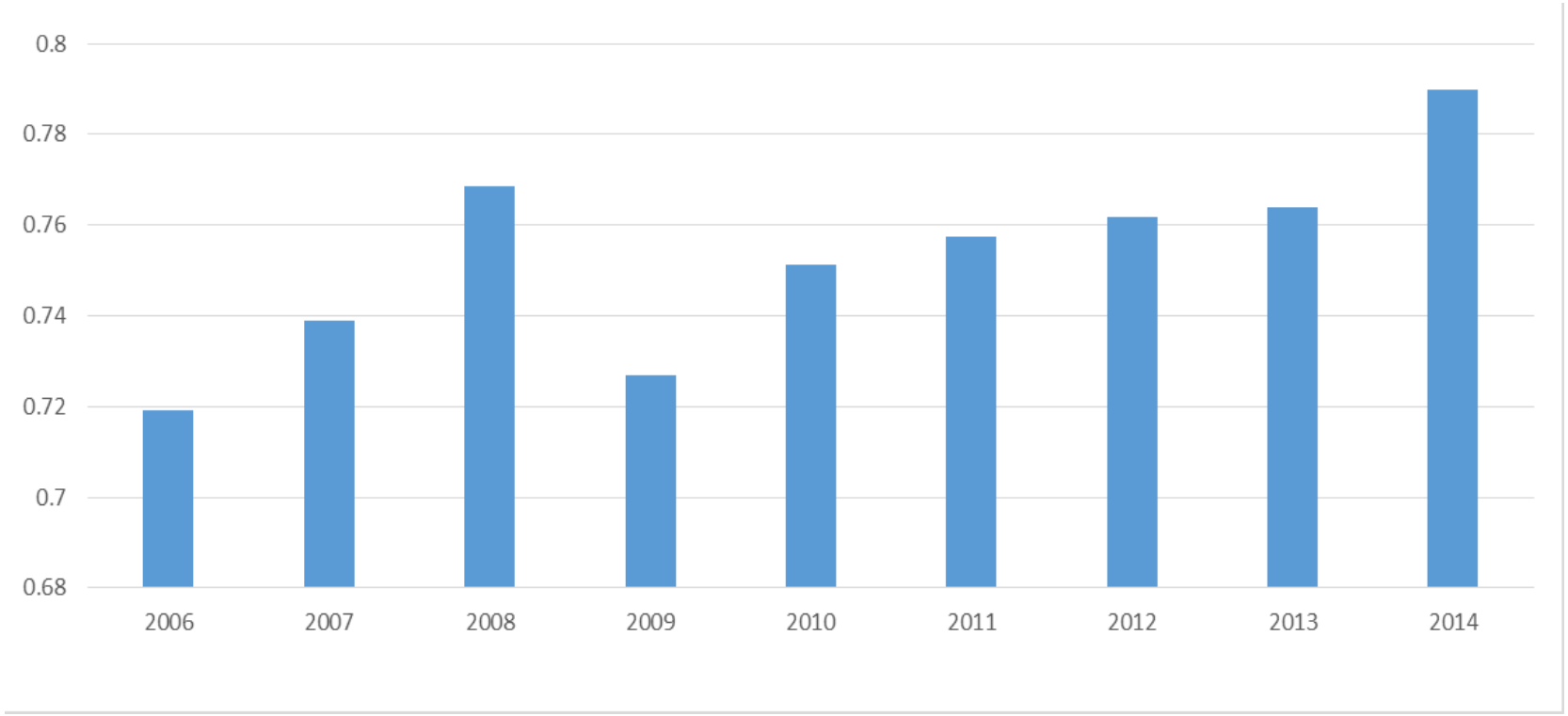
some constant efficiency levels and some improving…



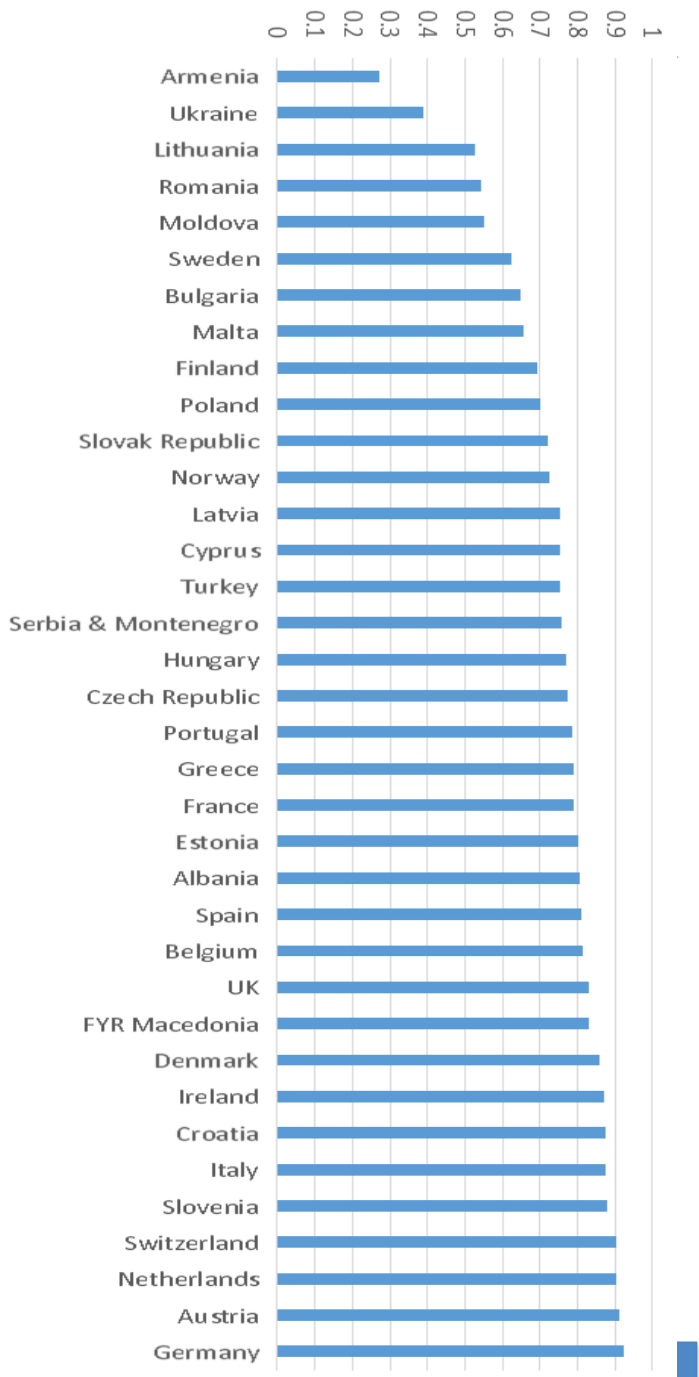
Results of SFA cost model with time decay in inefficiency for terminal control (Battese and Coelli 1995)

COST FUNCTION	Model 1		Model 2		Model 3	
	Terminal					
Input / Output	$\frac{total\ cost}{op.\ cost\ index}$		$\frac{total\ cost}{op.\ cost\ index}$		$\frac{total\ cost}{op.\ cost\ index}$	
	Coef.	P>|Z|	Coef.	P>|Z|	Coef.	P>|Z|
IFR airport movements	0.796	0.000	0.921	0.000	0.931	0.000
$\frac{labor\ cost}{op.\ cost\ index}$	0.362	0.000	0.403	0.000	0.413	0.000
$\frac{capital\ cost}{op.\ cost\ index}$	0.252	0.000	0.327	0.000	0.280	0.000
seasonality			3.115	0.000	3.274	0.000
complexity					0.124	0.036
constant	-3.459	0.000	-5.647	0.000	-6.190	0.000
Z - Variables explaining the mean of the inefficiency (Mu)						
complexity					-0.742	0.01
constant					0.578	0.05
sigma_v	0.436	0.000	0.252	0.000	0.218	0.000
sigma_u	0.088	0.965	1.017	0.525	0.481	0.000
Log Likelihood	-181.422		-99.451		-86.923	
Lambda	0.201	0.920	4.033	0.011	2.201	0.000

Average Cost Efficiency Estimates for Terminal ATC (2006 to 2014)



Average Cost Efficiency Estimates per terminal ATC provider



Conclusions

Could we estimate efficiency levels?

- yes! there is sufficient data (although needs to be cleaned)
- seasonality causes lower production levels and substantially higher production & cost inefficiencies
- complexity causes lower production levels and adds costs
- but… complexity also leads to higher managerial efficiency levels

Would it be possible to create individual price caps?

- yes! there are substantial inefficiencies with price cap reductions of over 10% for every provider potentially
- average cost inefficiencies of 25%

Does ownership matter?

- stochastic cost function identifies the private providers as more efficient than their government owned counterparts