compair
Competition for Air Traffic Management

PRODUCTIVITY MEASUREMENT OF AIR TRAFFIC MANAGEMENT IN EUROPE

Econometric approach using stochastic frontier analysis

BACKGROUND: COMPAIR PROJECT

The COMPAIR project (http://compair-project.eu/) studies new institutional approaches for the ATM sector in Europe. The goal is to increase performance incentives and advance operational improvements. In this context, COMPAIR studies various institutional and market designs, with a focus towards the introduction of (some) competitive incentives. This should give ANSPs the necessary drive to achieve the operational improvements.

The institutional designs which we consider are involve:

- ► Regulatory approaches and ownership forms
- ► Unbundling within the ATM services provided
- ► Public tendering of ATC operating licenses
- ► Institutional approaches under new operational paradigms, such as sector less operations

WHAT DID WE TRY TO DO?

We need a good understanding of the structural performance and cost-efficiency drivers in the ATM industry, to be able to forecast performance changes under the different institutional designs. This is the goal of the current paper. We conduct an econometric study, using ATM performance data mainly drawn from the PRU's ATM cost-effectiveness (ACE) reports. The dataset is enriched with nation-specific data from external sources, such as the national cost of borrowing or the quality of the business environment. The methodological approach is stochastic frontier analysis. This is the standard econometric way to estimate a parametric cost function while allowing for efficiency differences between organization. It represents the relation between costs, output levels, input prices and exogenous factors that have an influence on this relationship.

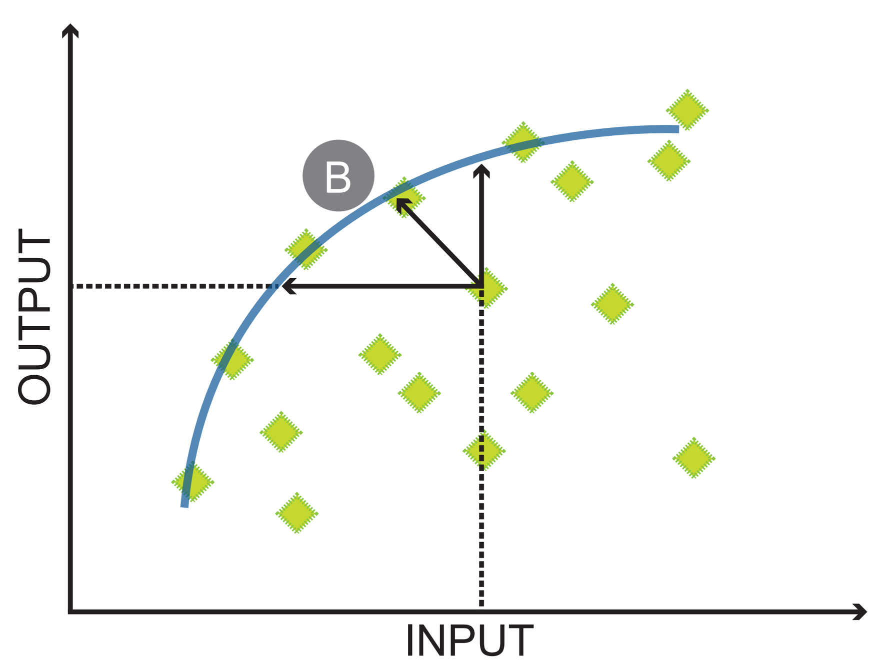
METHODOLOGICAL MODELLING APPROACH

We estimate a Cobb-Douglas cost function which represents a log-linear relationship between costs, outputs, input prices and exogenous drivers. The relationship can be written as follows:

$$C_i = X_i \cdot \beta + \varepsilon_i \quad \text{With:} \quad \varepsilon_i = v_i + u_i$$

Costs C_i are logarithmically transformed. The explanatory variables X_i are the (normalized and logarithmically transformed) factor prices w_i and output level y_i. The explanatory variables should be uncorrelated with the error term; they are determined exogenously to the production relationship. The error term is decomposed in a noise term v_i and an inefficiency term u_i. The noise term is usually assumed to be a random term with zero mean, whereas the inefficiency is strictly positive and assumed to follow a half-normal, truncated-normal or exponential distribution.

DEA efficient frontier



B Projection with the base-oriented model

The most important change we introduce in this paper is the separate estimation of two cost functions, one for costs related to en-route ATM and another one for terminal ATM. The separate estimation entails that we also work with two separate outputs of ATM activities: en-route flight hours and terminal area movements. Most previous econometric productivity benchmarking studies have estimated a single model and used composite flight hours as the relevant output measure. However, the aggregation of en-route flight hours and terminal movements is somewhat artificial and seems to be done in a relatively crude way .

So we choose to estimate two separate cost functions. One advantage of this approach is that it allows us to explore characteristics of the ATM production process for en-route and terminal control separately. For instance, we are able to estimate the economies of scale in both types of activities. We also investigate the existence of economies of scope in the combination of en-route and terminal control. This is particularly interesting given the focus of the current study on identification of productivity relationships and performance drivers in the ATM sector .

The current study also differs from previous econometric productivity benchmarking studies in the sense that we modify the measurement and the construction of a few variables.

[1] The PRU reports on the computation of composite flight-hours in Appendix of its ATM cost-effectiveness benchmarking reports. Weights for en-route flight hours and terminal movements are computed based on aggregates at European level: "total cost en-route" divided by "total en-route kms" or "total cost terminal" divided by "total terminal movements".

[2] Notice that previous econometric productivity measurement studies were oriented towards cost-benchmarking among ANSPs, rather than the identification of characteristics of the production/cost function.

WHAT DATA DID WE USE?

We derive most of the data from the ATM cost-effectiveness benchmarking reports, which come out yearly and are assembled by the PRU. These reports contain information on ATM costs and revenues each year, reported separately for en-route and terminal control. They also report ATM output measures. They further provide additional detail on separate cost components and provide information on airspace characteristics per ANSP. We also included two indicators related to institutional setting and some economic indicators linked to prices and exchange rates.

We complemented this dataset with other data. We assemble a cost of borrowing indicator which we will use to reflect the ANSP capital cost in the econometric analysis.

Finally, we added an indicator that represents business environment quality from the transparency international database.

After performing checks on data quality and missing data, we obtain a representative panel dataset of 37 ANSPs covering 11 years (2004-2014), with no drastic jumps or structural breaks over the years. The panel is close to being balanced. There are just a few missing: PANSA (Poland) in 2004-2005, ARMATS (Armenia) for 2004-2008, MUAC is missing for all terminal control activities as it does not perform any terminal control.

From this dataset, we constructed a number of indicators that will be used in the econometric analysis in which we corrected all monetary indicators through a division by the purchasing power parity price index. Next, we apply a logarithmic transformation to all of the continuous variables because of the log-linear characteristic of the Cobb-Douglas cost model.

... AND WHAT WAS THE OUTCOME?

We implement the estimation in STATA. We have tried out a number of alternative specifications, which are:

- ► Stochastic frontier model with time decay in the inefficiency term ("Battese and Coelli 1992" [12]).
- ► Stochastic frontier model with exogenous drivers that affect the distribution of the inefficiency term, ("Battese and Coelli 1995" [13]).
- ► Stochastic frontier model with time-variation in the inefficiency term and unit-specific intercepts ([14]). This "true fixed effects" approach allows one to disentangle time-varying inefficiency from unit specific time invariant unobserved heterogeneity.

We estimate all models with robust standard errors to account for possible heterogeneity in the noise error term. This robustness comes at a cost as it increases the estimated standard errors and reduces the statistical significance of the results that we obtain. We only report on the first model here.

With respect to economies of scale for en-route, we find a difference in whether we control for airspace size or not. A 10% increase in traffic corresponds, on average, to a cost increase of around 6% in costs, if traffic levels rise keeping the current airspace structure. If we let airspace size also increase with 10% we find that costs rise by around 8%, indicating lower economies of scale. For terminal control activities, this effect seems to be even stronger: a 10% traffic increase is associated with a 5% increase in costs if we control for the number of TMA/APP areas (showing strong economies of scale). But if we let TMA/APP areas also increase proportionally (10%), then the expected cost increase also equals 10%. In this case, the economies of scale disappear entirely. Both results seem to indicate that simply joining airspaces or TMA/APP zones under a single ANSP is not likely to lead to significant cost reductions in itself. It is on the other hand the consolidation of centers (possibly enabled by virtualization technologies) that enables stronger economies of scale to kick in.

With respect to economies of scope, we find indicative results suggesting the presence of diseconomies of scope. ANSPs that have a proportional repartition of activities over en-route and terminal control do not seem to have a cost advantage over ANSPs that rather focus on one type of activity. This result suggests that unbundling both activities may lead to cost reductions. However, we want to stress that further research into this issue is needed.

Further, we have observed the following tendencies in the econometric analysis:

- ► Input prices for labor costs (wages) seems to carry a higher importance in comparison to input prices for capital costs. This is particularly the case for en-route, but it is to a certain extent also true for terminal control.This observation may be explained by the higher share of labor costs in the ANSP total cost level.
- ► Structural differences in air traffic characteristics between ANSPs are important to explain productivity and efficiency performance differences in en-route. Traffic variability and traffic complexity seem to be particularly relevant.
- ► Quality of business environment has a slight negative effect on costs, both for en-route and for terminal control
- ► Institutional elements, such as ownership form, turns out to be less relevant than expected. Coefficients are mostly non-significant in almost all econometric models. Also, we have found less variation in ownership form than we anticipated. Most of the ANSPs are 100% state-owned corporations. There is a wider variation in names given to this institutional setting, than in the bottom line.
- ► We find, consistently, a negative time trend in inefficiency. So inefficiency has, on average, been decreasing over time in our dataset.

Results of SFA model with time decay in inefficiency "Battese and Coelli 1992", for en-route control

VARIABLE	COEFFICIENT	STD. ERR.	P-VALUE
W_ATCO	0.443	0.073	0.00
W_support	0.326	0.072	0.00
Kcost	-0.001	0.004	0.61
Y_enroute	0.202	0.256	0.43
VAR	0.105	0.321	0.74
BUS	-0.047	0.193	0.81
DENS	0.100	0.129	0.44
COMPLEX	0.247	0.222	0.27
SIZE	0.341	0.257	0.19
Eta	0.126	0.008	0.094

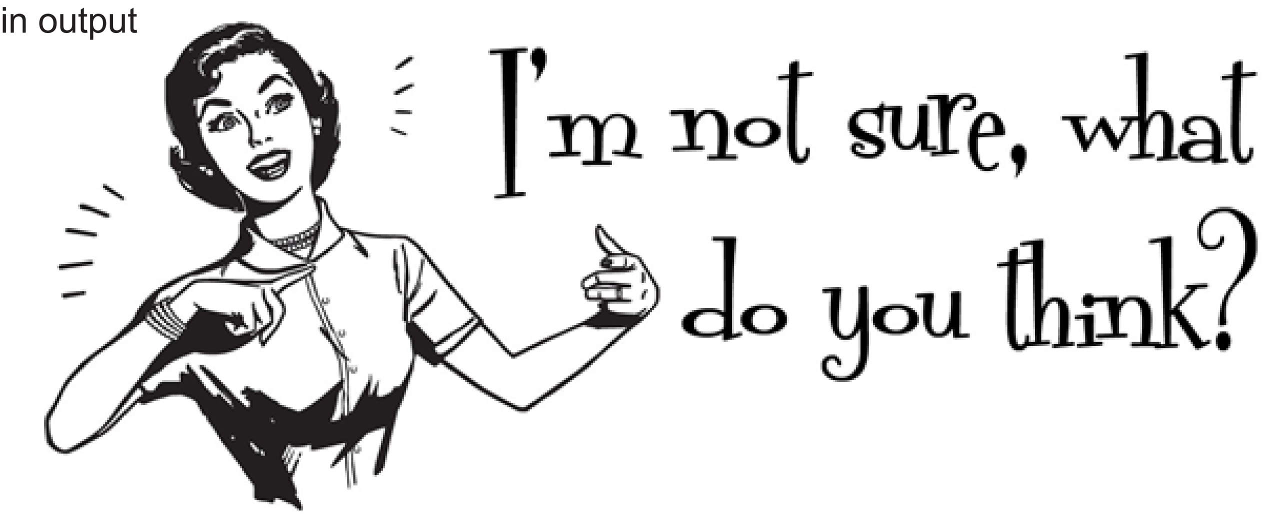
Results of SFA model with time decay in inefficiency "Battese and Coelli 1992", for terminal control

VARIABLE	COEFFICIENT	STD. ERR.	P-VALUE
W_ATCO	0.651	0.118	0.00
W_support	0.398	0.079	0.00
Kcost	0.011	0.006	0.09
Y_enroute	0.488	0.133	0.00
VAR	-0.316	0.287	0.27
BUS	0.505	0.216	0.02
DENS	0.154	0.121	0.20
COMPLEX	0.222	0.353	0.53
SIZE	1.14	0.385	0.00
Eta	0.032	0.009	0.00

BUT MANY VARIABLES PROVED TO BE INSIGNIFICANT! A BIT DISAPPOINTING – NO?

Possible causes:

- ► Was it a good idea to split the composite flight hours? There is still a substantial degree of arbitrariness and methodological inconsistencies in cost allocation between the terminal and enroute control across European ANSPs. Therefore, it is quite likely that the results obtained and conclusions consequently drawn are considerably affected by this issue and as such not sufficiently reliable.
- ► Toomanyvariables,toolittleobservations?
- ► Introduce quality element in output



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