# Potential gains from ANSP mergers in Europe (Working Paper)

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## Abstract

This research identifies potential gains of different merger scenarios between air navigation service providers (ANSPs) in Europe, as well as how these potential gains might be captured, in order to offer ANSPs and policymakers support for the Single European Sky (SES) II+ package implementation. While existing research has mainly looked into the existence of economies of scale or into efficiency of functional airspace blocks (FABs), there is a need for a research shift towards other potential consolidation scenarios. The potential gains of such merger scenarios has not yet been analysed thoroughly, which is the main contribution of this paper. The results suggest that the potential merger gains of the analysed scenarios are mainly due to improvements in technical efficiency which could possibly also be achieved by improving the current ANSP performance scheme.

***Keywords***— air navigation service providers, cost functions, merger analysis, consolidation, stochastic frontier analysis

## 1 Introduction

With instrumental flight rules (IFR) movements in the European Civil Aviation Conference predicted to grow by 15% in the next seven years (EUROCONTROL, 2019), the European air navigation services (ANS) sector is under pressure to reform in order to be able to handle the increase in traffic. At the same time EUROCONTROL (2016) notes that the US airspace system is 10% smaller in size than the European system, but in 2015 controlled 57% more IFR flights with 24% fewer air traffic controllers (ATCOs). Back in 2004, the European Commission launched the SES and Single European Sky ATM Research (SESAR) initiatives with the aim to increase capacity to be able to match future demand and to make the European ANS sector more efficient.

As part of the SES initiative, FABs were established in an attempt to optimise ANS provision over state boundaries by enhancing cooperation between air navigation service providers (ANSPs). The ultimate aim as mentioned in the SES framework regulation is to, where appropriate, have one integrated ANSP for a FAB (European Commission, 2004).

An early paper looking at efficiency of FABs is one by Button and Neiva (2013), however they were not able to take conclusions on the improvement in efficiency due to the FABs. Their results instead suggest the existence of an optimal airspace size that would maximize efficiency. Later work by Standfuss et al. (2017) comes to similar conclusions, they stress that especially smaller ANSPs could potentially benefit from consolidation.

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To date, the FABs seem to be somewhat rigid constructions (European Commission, 2018). However, the consolidation question remains very present in today's policy discussion. Research should hence also look beyond the current proposed FAB structures.

This research identifies potential gains of different merger scenarios between ANSPs in Europe, other than the traditional FABs, as well as how these potential gains might be captured, in order to offer ANSPs and policy-makers support for the SES II+ package implementation.

The paper presents the estimates of a multi-product translog cost frontier, which are used to simulate the potential gains of different merger scenarios under a set of assumptions. These merger gains are decomposed in technical efficiency, size and harmony gains using the methodology proposed by Bogetoft and Wang (2005) adapted to Stochastic Frontier Analysis (SFA).

The remainder of the paper is structured as follows: section 2 elaborates in detail on the methodology, while section 3 introduces the dataset used. The estimation and simulation results are presented and discussed in section 4, followed by the conclusions and policy recommendations in section 5.

# 2 Methodology

## 2.1 Estimation of cost frontier

In a first step, a multi-product translog cost frontier is estimated according to the Battese and Coelli (1995) specification:

$$TC_{it} = f(Q_{it}; W_{it}, Z_{it}; \beta) \exp{(v_{it} + u_{it})}$$

$$u_{it} = A_{it}\xi + r_{it}$$

in which $Q_{it}$ is the vector of output quantities for firm $i$ at time period $t$, $W_{it}$ the vector of input prices, $Z_{it}$ and $A_{it}$ vectors of exogenous variables, $\beta$ and $\xi$ vectors of parameters to be estimated.

In a SFA framework, the total *observed* cost is composed out of three parts: (1) the *minimum cost frontier* $f$, which is a function of the output level, input level as well as other exogenous variables, and reflects the minimal cost at which the output level can be produced; (2) a deviation from the cost frontier $u_{it}$ due to *inefficiency*; and (3) a deviation from the cost frontier $v_{it}$ due to *random variability* not explained by the model.

The $v_{it}$'s are assumed to be independent and identically distributed (i.i.d.) and to follow a $N(0, \sigma_v^2)$ distribution, while the $r_{it}$'s are assumed to be a random variable taken from a truncation of the $N(0, \sigma_u^2)$ distribution such that the $u_{it}$'s are i.i.d. and follow a non-negative truncation of the $N(A_{it}\xi, \sigma_u^2)$ distribution.

The vector $Z$ is composed of the logarithm of the airspace size controlled by the ANSP as a measure of its geographical span; and an index reflecting the complexity of the airspace. Both variables are assumed to be under control of the firm and to determine the shape of the frontier.

The vector $A$ contains a time index and a traffic variability index for each observation. Both are considered to determine efficiency but not the shape of the frontier as they are less controllable by the ANSP. Note that $A$ itself can vary between firms and over time, but its impact $\xi$ is considered to be constant.

The likelihood function used to estimate the parameters of the frontier is the one defined by Battese and Corra (1977) which uses a parameter $\gamma$ defined as

$$\gamma = \frac{\sigma_u^2}{\sigma_u^2 + \sigma_v^2}$$

and takes values between 0 and 1.

In the estimation, the translog multi-product cost frontier is specified such that the coefficients of the inproducts comply with the symmetry restriction. All monetary variables are divided by one of the input prices to implement linear homogeneity in input prices (Schmidt and Knox Lovell, 1979, eq. 5). The severity of violations against the monotonicity in input prices and outputs is assessed after the estimation.

## 2.2 Individual firm efficiencies

After estimating the multi-product translog cost frontier on the original (pre-merger) dataset, cost-efficiency measures for each firm can be calculated by dividing the minimum achievable cost (given by the frontier) by the observed cost.

$$E_{it} = \frac{f(Q_{it}; W_{it}; Z_{it}; \beta)}{W_{it}^T X_{it}} = \exp u_{it}$$

in which $X_{it}$ are the quantities of the inputs used, and $W_{it}^T X_{it}$ equals to $TC_{it}$ which in turn is given by the SFA model. The model assumes that $\exp v_{it} \approx 1$ and hence the random error can be neglected.

## 2.3 Potential merger gains

In a third step possible interesting mergers between firms in the panel can be identified. The goal is then to assess the effect on efficiency of each proposed merger. To do this, the methodology developed by Bogetoft and Wang (2005) is used. This methodology was initially developed for production efficiency in a Data Envelopment Analysis (DEA) context. However, for the purpose of this paper the concepts are adapted for cost efficiency in a SFA context.

Let $J \subset I$ denote the subset of firms in the panel that form the potential merger which is being analysed. In order to be able to calculate the effects of this merger on cost-efficiency, some assumptions on the merger need to be made.

### 2.3.1 Assumptions

The merger of the firms in $J$ is assumed to result in the direct pooling of the individual inputs and outputs. The output of the new entity is hence assumed to equal the sum of the individual outputs:

$$Q_J = \sum_{j \in J} Q_j$$

For each input factor the factor price of the new entity is assumed to correspond with the weighted average of the individual prices:

$$\forall w'_i \in W_J : w'_i = \frac{\sum_{j \in J} w_{ij} x_{ij}}{\sum_{j \in J} x_{ij}}$$

Separate assumptions need to be taken with regard to the exogenous variables in vector $Z$, depending on the definition of the variables taken into account. In this paper the variables in $Z$ are the logarithm of airspace size and the airspace complexity index. For airspace size it is reasonable to assume that the merged entity has its airspace composed out of the sum of the individual firms as their airspaces are non overlapping. For airspace complexity the average complexity within $J$ is considered.

### 2.3.2 Potential overall merger gain

The potential overall cost-efficiency gain from the merger is calculated in line with Bogetoft and Wang (2005) and Bogetoft et al. (2010, eq. 2) as the minimum cost of producing the pooled output divided by the sum of the observed costs:

$$E_J = \frac{f(Q_J; W_J; Z_J; \beta)}{\sum_{j \in J}(W_j^T X_j)}$$

This measure reflects the maximal reduction in costs that allows the production of the aggregated output profile (Bogetoft et al., 2010). If $E_J$ is smaller than one, the merger can save $(1 - E_J)\%$ on costs, while if $E_J$ is larger than one, the merger leads at least to a cost increase of $(E_J - 1)\%$.

### 2.3.3 Merger effect decomposition

The cost-efficiency gains of a merger can originate from different sources. The main contribution of the methodology proposed by Bogetoft and Wang (2005) is that it provides a way to decompose the overall cost-efficiency gain from the merger, which is easily interpretable towards policy advice.

The first step in the decomposition starts from the idea that some or all firms in the merged subset $J$ might have been technically inefficient before the merger. The merger might, hence, reduce (or completely eliminate) these technical inefficiencies due to new management or the adoption of best practices within $J$. This is what Bogetoft and Wang (2005) call the *technical efficiency effect*.

The technical efficiency effect is separated from the other possible effects of the merger by calculating an *adjusted overall gain* which is calculated according to (Bogetoft et al., 2010, eq. 4-2):

$$E_J^* = \frac{f(Q_J; W_J; Z_J; \beta)}{\sum_{j \in J} f(Q_j; W_j; Z_j; \beta)}$$

The adjusted overall merger gain $E_J^*$ measures the efficiency gain from the merger as if all firms in $J$ initially would have produced at their efficient level. Hence, $E_J^*$ is adjusted for improvements in technical efficiency from adopting best practices.

As the decomposition is multiplicative

$$E_J = TE_J \cdot E_J^*$$

the *technical efficiency gain* can be derived as

$$TE_J = \frac{E_J}{E_J^*} = \frac{\sum_{j \in J} f(Q_j; W_j; Z_j; \beta)}{\sum_{j \in J}(W_j^T X_j)}$$

which is in line with (Bogetoft et al., 2010, eq. 4-1). It reflects the reduction in costs if each firm in the merger learns the best practice, but remains an independent identity. Bogetoft and Wang (2005) note that in case of a low technical efficiency measure (hence, large potential cost savings), depending on the situation different advice can be given. In the case the sector is faced with a lack of motivation to produce efficiently, the regulator could better improve incentives via regulation rather than stimulating full scale mergers. In case of a lack of managerial talent, full scale mergers are advisable in an attempt to stimulate improvement in managerial processes.

The adjusted overall merger gain can be further decomposed into a *scale effect* and a *harmony effect*. A scale or size effect is present when the merged firm is able to produce the pooled output at lower costs than the separate individual firms due to its larger operational size. It is defined as the minimum cost of operating at full (integrated) scale divided by the minimal cost of operating at average scale (Bogetoft et al., 2010, eq. 4-4):

$$S_J = \frac{f(Q_J; W_J; Z_J; \beta_J)}{|J| \cdot f(\frac{\sum_{j \in J} Q_j}{|J|}; \frac{\sum_{j \in J} W_j}{|J|}; \frac{\sum_{j \in J} Z_j}{|J|}; \beta)}$$

in which $|J|$ represents the number of firms in subset $J$. As Bogetoft and Wang (2005) note, a full-scale merger might be the only option to capture size gains.

A merger typically leads to different input and output mixes. These new combinations might take the merged entity to more productive areas of the product space (Bogetoft and Wang, 2005). This effect is what Bogetoft and Wang (2005) call the *harmony effect* and it can be calculated by taking the minimum cost when producing the average output at the average input prices and dividing it by the average minimum cost of the individual firms in the merger:

$$H_J = \frac{f(\frac{\sum_{j \in J} Q_j}{|J|}; \frac{\sum_{j \in J} W_j}{|J|}; \frac{\sum_{j \in J} Z_j}{|J|}; \beta)}{\frac{\sum_{j \in J} f(Q_j; W_j; Z_j; \beta)}{|J|}}$$

The total decomposition of the potential merger gain is hence

$$E_J = TE_J \cdot S_J \cdot H_J$$

# 3 Data

All estimations are based on panel data from the EUROCONTROL ACE Benchmarking reports. The panel extends from 2006 until 2016 and contains data on 36 European ANSPs. The year of the financial crisis (2008) is excluded as this contributed to the improvement of the model. The panel is slightly unbalanced with data for ARMATS (Armenia) and HCAA (Greece) only being fully available starting from 2009.

As the ANS sector is a multi-product environment, two outputs are taken into consideration in the cost frontier: the annual number of IFR en-route movements (EN-ROUTE) and the annual number of IFR terminal movements handled (TERMINAL) by the ANSP.

Two contextual variables influence the shape of the frontier via vector $Z$: the logarithm of airspace size and airspace complexity. A traffic variability and

Table 1: Descriptive statistics of data after PPP adjustment (2016)

| **Variable** | **Mean** | **SD** | **Minimum** | **Maximum** |
|---|---|---|---|---|
| TC | 246,093 | 303,752 | 16,535 | 1,139,966 |
| EN-ROUTE | 774,221 | 739,939 | 38,968 | 3,015,153 |
| TERMINAL | 427,744 | 552,267 | 16,511 | 2,017,084 |
| CAPITAL | 0.13 | 0.11 | 0.01 | 0.56 |
| WAGE | 102 | 37 | 22 | 174 |
| GDPDEF | 115 | 25 | 94 | 242 |

Total costs and wages expressed in thousands.

Source: own composition

time index are considered to have an effect on efficiency via the vector $A$ and are considered to not be under direct control of the ANSP. The variability index is calculated by EUROCONTROL and reflects the percentage of traffic in the peak week of the year compared with an average week.

Three factor prices are included in the cost frontier: the capital user cost (CAPITAL), the average wage (WAGE) and the unit price of non-staff operational costs which is approximated by the GDP deflator (GDPDEF) sourced from the World Bank. The total ATM/CNS gate-to-gate costs are used as the dependent total cost variable.

The total user cost of capital is calculated by EUROCONTROL in the ACE Benchmarking reports as the sum of the cost of equity and interest costs through the weighted average cost of capital. This total user cost of capital is divided by the net book value of assets in operation adjusted by the national capital goods price index from Eurostat to get the unit price of the capital stock. The same method is used in previous studies. Missing values in the capital goods price index from Eurostat are imputed via a predictive mean matching method.

The average wage is the price paid by the ANSP for one full-time equivalent (FTE) of labour and is calculated by dividing the total gate-to-gate staff costs by the number of FTEs employed.

All monetary variables are adjusted by Purchase Power Parities (PPP) and divided by the country GDP deflator to implement homogeneity in factor prices. All explanatory variables are also normalised by dividing the observations by the sample means to be able to interpret the estimated coefficients as cost elasticities in the sample means (Gillen et al., 1990).

Table 1 provides an overview of the descriptive statistics of the dataset used for 2016.

# 4 Results and discussion

Table 2 presents the maximum likelihood estimates for the multi-product translog cost frontier. The estimated value for the parameter gamma supports the choice for an SFA approach, as a relevant part of the deviation between the frontier and the observations can be attributed to inefficiency.

## 4.1 Output and price elasticities

All output and price elasticities are significant when evaluated in the sample means and have the expected sign. Around 25% of total costs are due to labour

Table 2: Maximum likelihood estimates translog cost frontier

| | **Estimate** | **Std. Error** | **t value** | **Pr(> \|t\|)** | |
|---|---|---|---|---|---|
| (Intercept) | 7.03 | 0.07 | 107.39 | $< 0.01$ | *** |
| EN-ROUTE | 0.79 | 0.08 | 10.32 | $< 0.01$ | *** |
| TERMINAL | 0.29 | 0.06 | 5.17 | $< 0.01$ | *** |
| WAGE | 0.25 | 0.05 | 4.59 | $< 0.01$ | *** |
| CAPITAL | 0.37 | 0.04 | 9.00 | $< 0.01$ | *** |
| (EN-ROUTE)^2 | 0.27 | 0.10 | 2.66 | 0.01 | ** |
| (TERMINAL)^2 | 0.05 | 0.03 | 1.48 | 0.14 | |
| (WAGE)^2 | 0.39 | 0.05 | 7.43 | $< 0.01$ | *** |
| (CAPITAL)^2 | 0.09 | 0.01 | 7.42 | $< 0.01$ | *** |
| AIRSPACE SIZE | 0.15 | 0.03 | 4.52 | $< 0.01$ | *** |
| COMPLEXITY | 0.04 | 0.01 | 3.17 | $< 0.01$ | ** |
| EN-ROUTE*TERMINAL | -0.23 | 0.10 | -2.28 | 0.02 | * |
| WAGE*CAPITAL | -0.23 | 0.05 | -4.57 | $< 0.01$ | *** |
| EN-ROUTE*WAGE | -0.37 | 0.14 | -2.62 | 0.01 | ** |
| EN-ROUTE*CAPITAL | 0.09 | 0.05 | 1.79 | 0.07 | ° |
| TERMINAL*WAGE | 0.15 | 0.08 | 1.78 | 0.08 | ° |
| TERMINAL*CAPITAL | 0.06 | 0.04 | 1.41 | 0.16 | |
| A_(Intercept) | -1.83 | 0.29 | -6.37 | $< 0.01$ | *** |
| A_VARIABILITY | 2.03 | 0.22 | 9.45 | $< 0.01$ | *** |
| A_TIME | -0.04 | 0.01 | -4.94 | $< 0.01$ | *** |
| sigmaSq | 0.09 | 0.01 | 7.07 | $< 0.01$ | *** |
| gamma | 0.93 | 0.04 | 21.48 | $< 0.01$ | *** |

Signif. codes: 0 *** 0.001 ** 0.01 * 0.05 ° 0.1 1

Source: own composition

costs and 37% is due to capital user costs. In the sample means, an increase of 10% in the annual en-route movements would lead to a total cost increase of 7.9%, while a similar increase in terminal movements would lead to a cost increase of only 2.9%.

As discussed before, the cost frontier should fulfil the monotonicity requirement in input prices and outputs. This regularity condition equals to the requirement that all output and price elasticities should be positive for all observations in the panel, which reflects that total costs should increase whenever the production level or input prices increase.

The regularity condition is fulfilled for the output elasticities, however for certain ANSPs the wage elasticity (Albcontrol, BULATSA, DCAC Cyprus, DHMI, LGS, LPS, Oro navigacija, SMATSA and UkSATSE), the capital price elasticity (M-NAV) or both price elasticities (ARMATS, EANS and MoldATSA) are negative in certain years. These negative elasticities are caused by the relative high user cost of capital in combination with relatively low wages for these ANSPs.

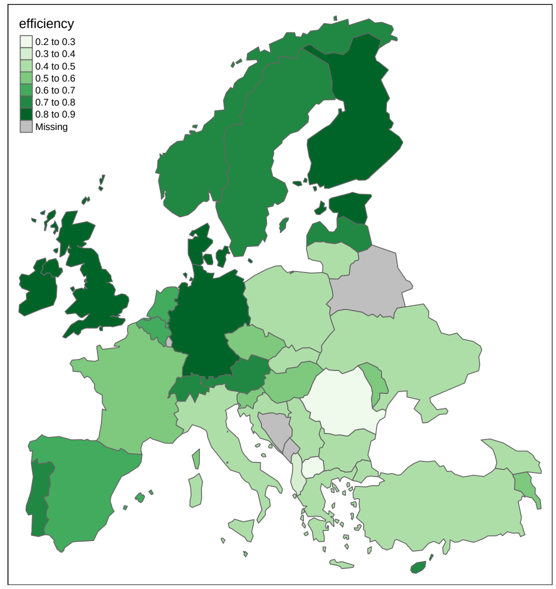
## 4.2 Potential mergers

In order to identify potential interesting mergers, the mean efficiency and the economy of scale measure are calculated for each ANSP in the panel over time. Figure 1 shows a map with the mean efficiency scores. The greener on the map, the more efficient the national ANSP.

The most efficient ANSPs are NATS (UK), IAA (Ireland), NAVIAIR (Denmark), EANS (Estonia), ANS Finland (Finland) and DFS (Germany). All have a mean efficiency above 0.80. As the map shows, the less efficient ANSPs are mainly located in Eastern and Southern Europe.

Figure 2 shows the average economies of scale measure over the period 2006 - 2016 for each of the national ANSPs. The darker the red on the map, the lower the estimated average economies will be. The ANSPs with the largest economies of scale measures are ANS Finland (Finland), LVNL (the Netherlands), Skeyes (Belgium), AustroControl (Austria), NAV Portugal (Portugal), LFV (Sweden), Avinor (Norway), Skyguide (Switzerland) and MATS (Malta).

Figure 1: Mean efficiencies 2006 - 2016




These ANSPs have measures higher than 1.2.

One set of mergers that would make organisational sense, are those mergers between neighbouring ANSPs which have high economies of scale measures, and could benefit from efficiency improvement. A good example would be a merger between Skeyes (Belgium) and LVNL (the Netherlands), or between LFV (Sweden) and NAVIAIR (Denmark). The latter two already work closely together.

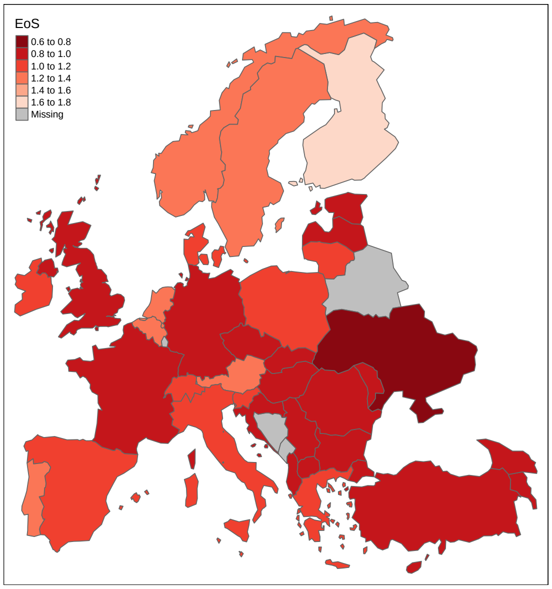
## 4.3 Potential merger gains

Table 3: Merger gains

| **Merger** | $E_J$ | $TE_J$ | $S_J$ | $H_J$ |
|---|---|---|---|---|
| BE+NL | 0.63 | 0.67 | 0.95 | 0.98 |
| SE+DK | 0.91 | 0.86 | 1.04 | 1.02 |

Table 3 presents the estimated potential merger gains for the mergers between Skeyes (Belgium) and LVNL (the Netherlands) and between LFV (Sweden)

Figure 2: Mean economies of scale 2006 - 2016




and NAVIAIR (Denmark). The first one could potentially save 37% on costs, mainly from improvements in technical efficiency. Despite that both Skeyes and LVNL have high average economies of scale measures, the potential gains from the scale increase is rather low compared with the gains from efficiency improvements. Even for the merger between LFV and NAVIAIR, there are potential gains to be achieved due to technical efficiency improvements, despite the fact that both ANSPs are already amongst the most efficient.

Since the results suggest that the main gains from a merger are coming from gains in technical efficiency, the question should be asked whether there is currently a lack in incentives or a lack in managerial talent. From discussions with academic experts in the field one can learn that there is some debate about whether the current performance scheme provides the right incentives. It is likely that the identified potential technical efficiency gains could be reached by improving the current performance scheme, rather than stimulating full scale mergers between ANSPs.

# 5 Conclusions

In this paper, a multi-product translog cost frontier was estimated for the European ANS industry from the yearly EUROCONTROL ACE Benchmarking reports. The estimated frontier was afterwards used to assess the potential merger gains from a set of mergers that would make organisational sense. While previous research looked into efficiency of FABs, this paper is the first that looks into the potential effects of a merger compared to individual ANSPs, beyond the scope of the institutionally driven FABs. To estimate these potential gains, the paper made use of a methodology proposed by Bogetoft and Wang (2005) which was originally developed in a DEA framework and here adapted to an SFA context.

The results suggest that the potential gains of the proposed mergers are mainly due to improvements in technical efficiency. It can be argued that these improvements could also be achieved via a more strict performance regulation, making it unnecessary to stimulate full scale mergers between European national ANSPs.

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