Standard Inputs for EUROCONTROL Cost-Benefit Analyses

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12/25/22

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The EUROCONTROL Business Case Team has made every effort to ensure that the information and analysis contained in this document are as accurate as possible. Only information from quoted sources has been used and information relating to named parties has been checked with the parties concerned. Despite these precautions, should you find any errors or inconsistencies we would be grateful if you could please bring them to the EUROCONTROL Business Case Team's attention. Our email address is:

Economics.Business-Cases@eurocontrol.int

This document is published by the EUROCONTROL Business Case Team in the interest of the exchange of information

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Foreword

Although we cannot foresee when, or even if, the world will return to what it was prior to the COVID-19 pandemic, we have decided to publish this new edition of the standard inputs as a valuable source of inputs for economic and cost-benefit analyses in aviation. The recommended values are often based on 2019 statistics and data which do not yet take account of the impact of the pandemic.

For this edition, the focus is on environmental values, a new value for airports, turn-around time, and the introduction of two values related to drones. Drones represent a highly complex and fast-moving market, which makes forecasting more difficult than legacy aviation sectors. Suggestions for improvement and collaboration are welcome. Please send them to aviation.intelligence@eurocontrol.int.

We would like to make a special mention of the launch of the EUROCONTROL Aviation Intelligence Portal, which provides valuable and up-to-date information for economic analyses (https://ansperformance.eu/). The Portal will soon include the standard inputs (2021) and more information of use for cost-benefit analyses.

Introduction

This document provides a set of standard inputs for data commonly used in economic and financial ATM-related analyses and appraisals. The standard inputs will save time in the development, for example, of cost-benefit analyses (CBAs) and economic impact assessments and will also help achieve greater consistency and comparability between different CBAs.

We are using whatever.

In this, the 10.0.1th edition:

- the title has been changed to "EUROCONTROL standard inputs for economic analyses", a more accurate description of its use;
- the values have been regrouped by stakeholder and key topic of interest;
- all prices have been updated to 2019 euro values unless otherwise specified. The costs can be easily adjusted using the table of indices contained in the section Conversions, Inflation, Cost of Fuel, Exchange Rate;
- some values have been reviewed and replaced, namely turn-around time, all causes of delay, and statistics;
- comparable historical data have been added;
- two new values have been introduced, namely drone fleet and U-space related investments;
- the value "cost of an ATFM slot swap" was removed because the UDPP concept has evolved and makes reference to "measures" (which involves multiple swaps). The value of a measure has a big range and is still being worked on;
- a link to the EUROCONTROL Aviation Intelligence Portal providing latest information was added when and where appropriate;
- whenever single values are contentious, a range of low, base and high values is given, allowing users of the data to conduct sensitivity analyses.

The standard inputs have been compiled from EUROCONTROL data and intelligence, from values provided by airspace users, ANSPs, airports, IATA,

EASA and other organisations, and from other relevant documents which are publicly available.

They are average values and may not be appropriate in all circumstances. The document also gives details of the sources of information, and discusses the applicability and use of the values.

This document will remain a living document, and so comments and suggestions are very welcome. Readers are invited to send these to aviation.intelligence@eurocontrol.int.

Details per data item

For each standard input, the following information is provided, where relevant.

Section	Description
Definition	A statement which describes the concept.
EUROCONTROL recommended value or source	One or a set of recommended values or sources put forward by EUROCONTROL for the specific indicator.
Source and date	The source documents and their publication dates.
Description	Any relevant information or details regarding the standard input. Information can be found here on how the value is computed, the specific use of the indicator, etc. Information regarding the limitations on using the values may also be included.
Other possible values	Other values found in different sources, which are included for the purpose of information or discussion.
Related standard inputs	A link to other related standard inputs included in the document in order to increase its consistency.
Further reading	References to other interesting sources.

Section	Description
Comments	Any questions or further comments regarding the source or derivation of the value, for example the degree of confidence in the values and sources cited.

General parameters

Below are presented some key values used in the Standard Inputs and that can serve as a reference for other uses.

For any questions relating to this document, please contact EUROCONTROL using the e-mail aviation.intelligence@eurocontrol.int[1], naming the Standard Inputs in the subject line.

Inflation

The inflation levels have been calculated based on the Harmonised Index of Consumer Prices (HICP), as the yearly difference in the HICP. The HICP data was extracted from Eurostat[2] HICP - annual data (average index and rate of change) database (prc_hicp_aind).

The annual change in the index is shown below. The values of the index are available from Eurostat[3] (table Table 2.)

```
Attaching package: 'dplyr'

The following objects are masked from 'package:stats':

    filter, lag

The following objects are masked from 'package:base':

    intersect, setdiff, setequal, union

Warning: Since gt v0.3.0, `columns = vars(...)` has been deprecated.
* Please use `columns = c(...)` instead.
Since gt v0.3.0, `columns = vars(...)` has been deprecated.
* Please use `columns = c(...)` instead.
```

[1] mailto:aviation.intelligence@eurocontrol.int?subject=Standard%20inputs
[2] http://ec.europa.eu/eurostat
[3] http://ec.europa.eu/eurostat

```
Since gt v0.3.0, `columns = vars(...)` has been deprecated.
* Please use `columns = c(...)` instead.
Since gt v0.3.0, `columns = vars(...)` has been deprecated.
* Please use `columns = c(...)` instead.
```

Table 2: Annual average inflation values

Year	Index	Rate of change
2021	NA	NA
2020	NA	NA
2019	105.42	1.47%
2018	103.89	1.89%
2017	101.96	1.71%
2016	100.25	0.25%
2015	100.00	0.10%
2014	99.90	0.55%
2013	99.35	1.50%
2012	97.88	2.64%
2011	95.36	3.10%
2010	92.49	2.09%
2009	90.60	0.98%
2008	89.72	3.54%
2007	86.65	2.34%
2006	84.67	2.20%
2005	82.85	2.17%
2004	81.09	2.01%
2003	79.49	1.96%
2002	77.96	2.08%
2001	76.37	2.19%
2000	74.73	1.90%

Source: Eurostat[a]

[a] http://ec.europa.eu/eurostat

Exchange Rate Conversion

The currency exchange rates provided below are based on the European Central Bank (ECB) rates as are published daily. The rates exposed in the table below correspond to the average rate for the year 2021 as published by ECB.

```
Rows: 2 Columns: 3
-- Column specification --------------------------------------------------------
```

```
Delimiter: ","
chr (1): currency
dbl (2): to_eur, from_eur

i Use `spec()` to retrieve the full column specification for this data.
i Specify the column types or set `show_col_types = FALSE` to quiet this message.
```

Table 3: Average euro foreign exchange rate (2021)

Currency	Currency-€	€-Currency
USD	0.89	1.12
GBP	1.22	0.82

Source: European Central Bank[a]

[a] https://www.ecb.europa.eu/stats/policy_and_exchange_rates/euro_reference_exchange_rates/html/index.en.html

Cost of fuel

The cost of fuel used in this document is based on the 2021 average jet fuel price handled by IATA[4], unless otherwise specified. All conversions are done using the values specified on this page.

Table 4: Average jet fuel price

Currency	Price per barrel	Price per gallon	Price per kg
USD	141.7	3.80	1.1
EUR	138.9	3.31	1.1

Source: IATA[a]

[a] https://www.iata.org/en/publications/economics/fuel-monitor/

Conversion values

Table 5: Units conversion values.

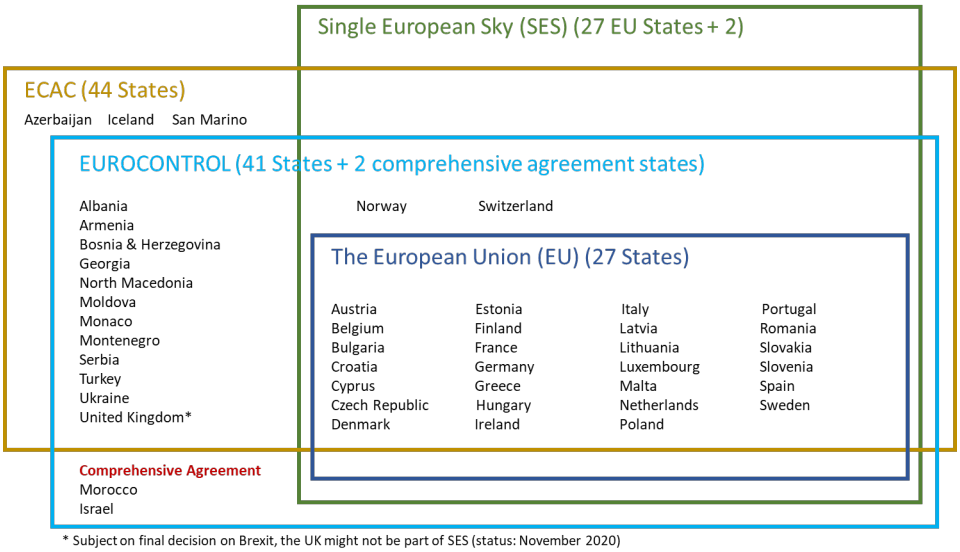
From	To
1 nautical mile (NM)	1.852 km
1 kilometre (km)	0.53996 NM

[4] https://www.iata.org/en/publications/economics/fuel-monitor/

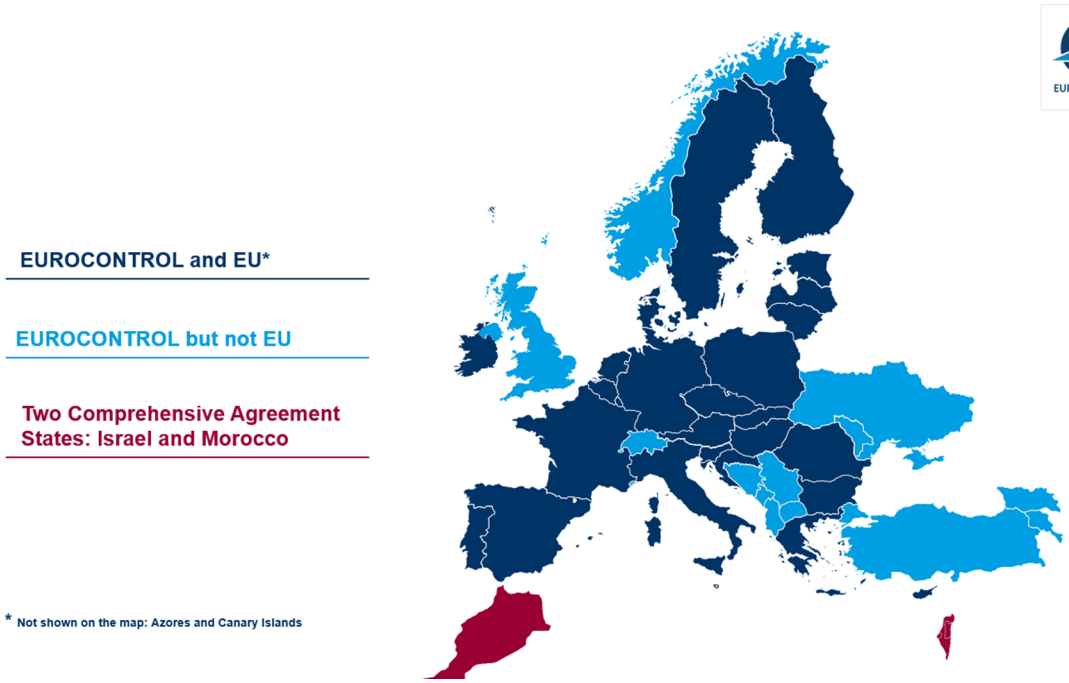
1 tonne (metric = 1 000 kg) of jet fuel	325.33 US gallons
	1 235 litres
	7.8 barrels
1 barrel (bbl) of jet fuel	42 US gallons
	158.99 litres
	0.1291 ton = 129.10 kg
1 US gallon of jet fuel (US gal)	3.7854 litres
	3.073 kg
	6.7764 lb
Density of kerosene	0.812 kg/litre
1 litre of fuel (l)	0.26417 US gallons
1 kilogramme of fuel (kg)	2.2046 lb
1 pound of fuel (lb)	0.45359 kg

Geographical Areas

Member States and geographical areas covered



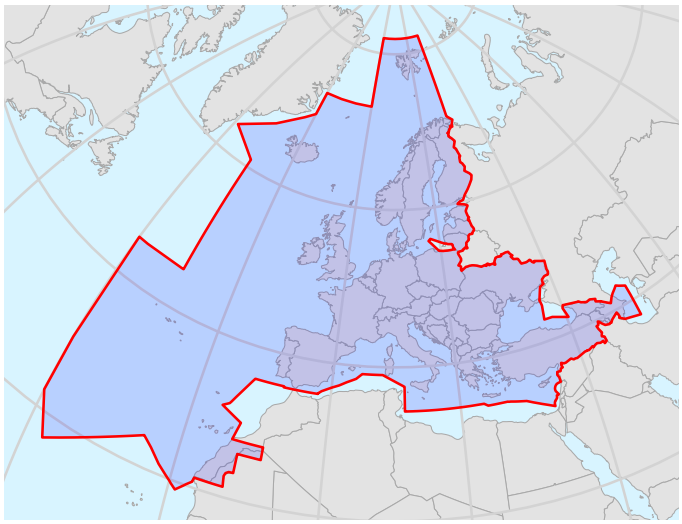
EUROCONTROL Member States (status: November 2020)



Airspace of the ECAC Member States

```
Attaching package: 'dplyr'

The following objects are masked from 'package:stats':

    filter, lag

The following objects are masked from 'package:base':

    intersect, setdiff, setequal, union
```

Country FIR for ECAC
at altitude FL000



Comment

ECAC is an intergovernmental organisation which was established by ICAO and the Council of Europe. ECAC now has 44 Member States, including all 27 EU Member States, 31 of the 32 European Aviation Safety Agency Member States, and all 41 EUROCONTROL Member States. Further information on traffic region definitions is available in the EUROCONTROL STATFOR 7-year IFR Flight Movements and Service Units Forecast, Annex 1. https://ansperformance.eu/traffic/statfor/

Part I

Traffic and capacity

Chapter 1

Air traffic statistics and forecasts

1.1 Definition

Actual and forecast numbers of flights and service units.

1.2 EUROCONTROL recommended source

Source EUROCONTROL Statistics and Forecasts Service (STATFOR)
https://www.eurocontrol.int/forecasting

1.3 Description

The objective of the Statistics and Forecast (STATFOR) service is to provide statistics and forecasts on air traffic in Europe and to monitor and analyse the evolution of the air transport Industry.

It produces the following:

- Seven-year forecasts The 7-year forecasts give a comprehensive picture of anticipated air traffic development in Europe for the next seven years. They combine flight statistics with economic growth and models of other industry drivers, including costs, airport capacity, passenger numbers, load factors and aircraft size. Using high- and low-growth scenarios, they present a likely range for growth, to help planners manage risks. We publish them biannually, in spring and autumn, covering flights, and en route and terminal service units every year.
- Twenty-year forecasts The 20-year forecasts look at a range of distinct possible scenarios for how the air traffic industry might look in 20

years' time. This allows a range of 'what if?' questions to be explored, for factors inside the industry (e.g. the growth of small business jets, or of point-to-point traffic) or outside the industry (e.g. the price of oil or environmental constraints). Twenty-year forecasts are usually published every two to three years.

- Ad-hoc publications, such as the Challenges to Growth reports, trends in air traffic studies and other analyses can be found in the EUROCONTROL library: https://www.eurocontrol.int/library

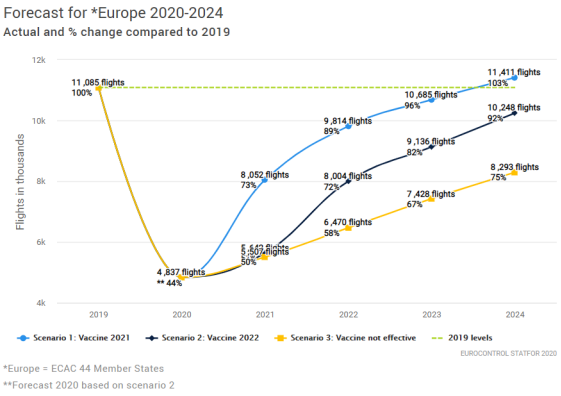
Traffic statistics and forecasts can be obtained directly from the **STATFOR Interactive Dashboard (SID)**: https://www.eurocontrol.int/dashboard/statfor-interactive-dashboard.

1.4 Related standard inputs

[Medium-term capacity planning], air traffic delay, [flow management delay] and [cost of delay].

1.5 Comments

The following chart (status: November 2020) shows the traffic forecast taking account of the impact of COVID.



*Europe = ECAC 44 Member States
**Forecast 2020 based on scenario 2

Source: EUROCONTROL STATFOR 2020, https://www.eurocontrol.int/covid19

Chapter 2

Number of IFR flights

2.1 Definition

The number of IFR flights in Europe.

2.2 EUROCONTROL recommended sources

Value 1 Monthly and yearly number of flights by flow category, ECAC, year 2019

```
Rows: 13 Columns: 6
-- Column specification --------------------------------------------------------
Delimiter: ","
chr (1): Month
dbl (5): Arrivals, Departures, Internal, Overflights, Total

i Use `spec()` to retrieve the full column specification for this data.
i Specify the column types or set `show_col_types = FALSE` to quiet this message.
```

Month	Arrivals	Departures	Internal	Overflights	Total
January	85052	84909	601427	16115	787503
February	75500	75447	573216	13600	737763
March	87907	87966	653641	16928	846442
April	91421	91354	706721	17043	906539
May	94944	94649	780080	16189	985862
June	105522	105571	810253	16782	1038128
July	113863	114128	846783	17788	1092562
August	115290	115399	831933	17932	1080554
September	104350	104260	809520	16192	1034322

October	99236	99824	764457	16532	980049
November	85442	85748	615031	15740	801961
December	87339	87539	602431	16308	793617
Total	1145866	1146794	8595493	197149	11085302

Source 1 EUROCONTROL (2020) – STATFOR statistics Traffic statistics and forecasts can be obtained from the STATFOR Interactive Dashboard (SID). http://www.eurocontrol.int/statfor

Value 2 Flights by market segment[1] of operator, ECAC, year 2019

```
Rows: 8 Columns: 4
-- Column specification --------------------------------------------------------
Delimiter: ","
chr (3): Operator, Proportion, Evolution 2019 vs. 2018
dbl (1): Number of flights

i Use `spec()` to retrieve the full column specification for this data.
i Specify the column types or set `show_col_types = FALSE` to quiet this me
```

Operator	Number of flights	Proportion	Evolution 2019 vs. 2018
Traditional scheduled	5858759	52.9%	1.4%
Low-cost	3352186	30.2%	0.7%
Business aviation	704308	6.4%	-3.0%
Charter	441924	4.0%	2.7%
All-cargo	323395	2.9%	-2.7%
Other types	294766	2.7%	0.7%
Military	109964	1.0%	-4.7%
Grand total	11085302	100%	0.8%

Source 2 EUROCONTROL (2020) – STATFOR statistics Traffic statistics and forecasts can be obtained from the STATFOR Interactive Dashboard (SID). http://www.eurocontrol.int/statfor

Value 3 Top 20 number of flights by civil aircraft operating in airspace in Europe controlled by the EUROCONTROL Network Manager, year 2019.

```
Warning: One or more parsing issues, call `problems()` on your data frame f
e.g.:
  dat <- vroom(...)
  problems(dat)

Rows: 22 Columns: 4
```

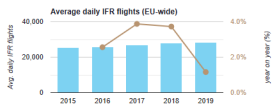
[1]Rules for EUROCONTROL classification of low-cost, all-cargo and business aviation types of flights: https://www.eurocontrol.int/publication/market-segment-rules]

```
-- Column specification --------------------------------------------------------
Delimiter: ","
chr (3): FPL aircraft type, Proportion, Cumulative
dbl (1): Flights

i Use `spec()` to retrieve the full column specification for this data.
i Specify the column types or set `show_col_types = FALSE` to quiet this message.
```

FPL aircraft type	Flights	Proportion	Cumulative
B738	2165864	19.54%	19.54%
A320	1896439	17.11%	36.65%
A319	870521	7.85%	44.50%
A321	664047	5.99%	50.49%
DH8D	311352	2.81%	53.30%
E190	278773	2.51%	55.81%
A20N	259032	2.34%	58.15%
B77W	189882	1.71%	59.86%
CRJ9	181291	1.64%	61.50%
A332	166619	1.50%	63.00%
AT76	162415	1.47%	64.47%
B737	161821	1.46%	65.93%
AT75	158337	1.43%	67.35%
A333	158229	1.43%	68.78%
E195	154665	1.40%	70.18%
B789	116394	1.05%	71.23%
B763	103803	0.94%	72.16%
B772	101232	0.91%	73.08%
B752	99583	0.90%	73.97%
CRJX	92270	0.83%	74.81%
Other types	2792733	25%	100%
Total	11107046	100%	,

Source 3 EUROCONTROL (2019) — Network Manager flight plans and PRISME fleet data (ECAC region)

Value 4 Daily average of IFR flights, 2015 to 2019, EU-wide area.



year	2015	2016	2017	2018	2019
Average daily IFR flights	25321	25972	26980	27987	28313

Source 4 Performance Review Board (PRB) – ANS performance monitoring (EU-wide) https://www.eurocontrol.int/prudata/dashboard/vis/2019/

2.3 Description

Value 1 shows the typical fluctuation in traffic during the year, peaking in July and August. The lowest level usually occurs in February.

Value 2 indicates an overall increase in flights of 0.8% in 2019 compared with 2018. Traditional scheduled traffic increased by 1.4% and charter traffic by 2.7%, whilst business aviation decreased by 3% and cargo by 2.7%. Military traffic covering only those flights operating as general air traffic (GAT) and excluding operational air traffic (OAT) decreased by 4.7%.

Value 3 Of those aircraft which flew IFR in 2019, four hundred and thirty-six (436) different civil aircraft types operated in Europe in 2019. Some 75% of the flights were carried out by the 20 aircraft types displayed.

2.4 Related standard inputs

IFR flight information per operator segment, [fleet age], [fleet size] and [fleet CNS capability].

2.5 Further reading

EUROCONTROL Performance Review Commission The Performance Review Commission publishes traffic analyses in the annual Performance Review reports (https://www.eurocontrol.int/prc/publications).

2.6 Comment

These traffic figures are from 2019 and do not yet reflect the impact of COVID. Estimated traffic figures for 2020 and beyond can be found in the EUROCONTROL five year forecast https://www.eurocontrol.int/publication/eurocontrol-five-year-forecast-2020-2024.

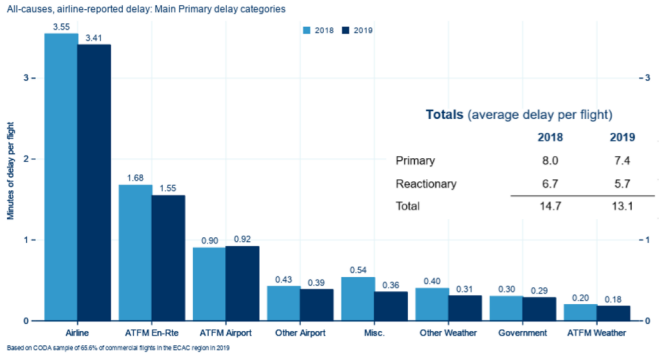
Chapter 3

Air traffic delay

3.1 Definition

Statistical reports on all causes of delay.

3.2 EUROCONTROL recommended sources



Value

Source EUROCONTROL CODA (2019) All-Causes Delay to Air Transport in Europe https://www.eurocontrol.int/sites/default/files/2020-04/eurocontrol-coda-digest-annual-report-2019.pdf

3.3 Description

The report identified in the source value gives an overview of the delay situation in the European Civil Aviation Conference area. It has been prepared by the Central Office for Delay Analysis (CODA), a EUROCONTROL service. It is based on delay data provided directly by airlines. This data on all

causes of delay is derived by airlines, comparing actual timings with their published schedules.

Statistics on all causes of delay can be obtained directly from the CODA Interactive Dashboard (CID) (a request for access is required). This dashboard aims to provide the user with an enhanced understanding of the causes of delay to flights, both that relating to air traffic flow management (ATFM) and non-ATFM-related delay. ATFM delay constitutes only a fraction of primary delays from all causes, and around half of all delay is reactionary rather than primary. Analyses within the dashboard are based on flight-by-flight data provided by airspace users as well as the Network Manager.

More information about CODA can be found at https://www.eurocontrol.int/network-performance (go to CID).

3.4 Related standard inputs

Air traffic statistics and forecast, [flow management delay] and [cost of delay].

Part II

Environment

Chapter 4

Cost of emissions

4.1 Definition

Estimate of the cost of CO2 and other aircraft emissions released by the combustion of aviation fuel.

4.2 EUROCONTROL recommended sources and values

Value 1 `Warning: Since gt v0.3.0, `columns = vars(...)` has been deprecated.`
`* Please use `columns = c(...)` instead.`
`Since gt v0.3.0, `columns = vars(...)` has been deprecated.`
`* Please use `columns = c(...)` instead.`

Price of CO2

Climate change avoidance costs in € per tonne of CO2 equivalent

Forecast	Low[1,2]	Medium[1]	High[1]
Short and medium run (up to 2030)	63	105	199
Long run (from 2040 to 2060)	164	283	524

[1]adjusted from € 2016 to € 2019 prices

[2]These values were derived by calculating the average of the low, central and high estimates for the relevant time periods of the values from the literature, but excluding the lowest and highest values in order to eliminate outliers.

Value 2 `Warning: Since gt v0.3.0, `columns = vars(...)` has been deprecated.`
`* Please use `columns = c(...)` instead.`

```
Warning: Since gt v0.3.0, `columns = TRUE` has been deprecated.
* Please use `columns = everything()` instead.
```

Well-to-tank air pollution costs: damage cost estimates in €/kg emission
(emissions in the year 2016, EU-27+UK values)

Costs in € per kg	NOx[1]	NMVOC[1]	SO2[1]	High[1]
EU-27+UK	11.5	1.3	11.5	20.4

[1]adjusted from € 2016 to € 2019 prices

Value 3 `Warning: Since gt v0.3.0, `columns = vars(...)` has been deprecated.`
`* Please use `columns = c(...)` instead.`

```
Warning: HTML tags found, and they will be removed.
* Set `options(gt.html_tag_check = FALSE)` to disable this check.
```

Total and average air pollution costs for aviation for 33 selected EU airports[1]

Distance group	Range	M€/year[2]	€-cent/km[2]	€-cent/ pax(complete flight)[2]
Short-haul	< 1 500 km	284	0.32	171
Medium-haul	< 1 500-5 000 km	400	0.14	243
Long-haul	> 5 000 km	379	0.06	467

[1]The largest airports in each EU country (including the UK)
[2]adjusted from € 2016 to € 2019 prices

Value 4 `Attaching package: 'dplyr'`

```
The following objects are masked from 'package:stats':

    filter, lag

The following objects are masked from 'package:base':

    intersect, setdiff, setequal, union
```

Marginal air pollution costs of aviation for selected cases[1,2]

Distance [km]	Emission class	Example of aircraft type	€ per LTO[3]	€-cent per pax km[3]
Short-haul				
500	Low	Bombardier CRJ900	106.00	0.29

500	High	Embraer 170	144.00	0.32	1
Medium- haul					
1500	Low	Airbus 320	174.00	0.07	1
1500	High	Boeing 737	195.00	0.12	1
3000	Low	Airbus 320	230.00	0.05	1
3000	High	Boeing 737	258.00	0.07	2
Long-haul					
5000	Low	Airbus 340	528.00	0.03	1
5000	High	Boeing 777	876.00	0.04	2
15000	Low	Airbus 340	748.00	0.02	2
15000	High	Boeing 777	1.24	0.02	2

[1]For the following emissions: NH_3, NMVOC, SO2, NOx, PM2.5 and PM10

[2]For the cost factors for air pollution costs, the emissions during the LTO cycle are mainly relevant, as the cruise emissions lead to almost no damage costs.

[3]adjusted from € 2016 to € 2019 prices

Sources 1 to 4 "Handbook on the external costs of transport", CE Delft, January 2019 (commissioned by European Union DG Move), tables 24, 49, 17 and 23 https://www.cedelft.eu/en/publications/2311/handbook-on-the-external-costs-of-transport-version-2019 Also available from the Publications Office of the EU.

4.3 Description

The CO2 price used to calculate the external costs of climate change in **Value 1** is based on the cost avoidance approach. Extract from the "Handbook on the external costs of transport": *It determines external cost valuation factors (i.e. shadow prices) by determining the cost to achieve a particular policy target (e.g. EU CO2 reduction targets). This is done by estimating an avoidance cost function, which provides a proxy for the supply of environmental quality. It determines how much it would cost to supply an additional level of environmental quality (e.g. reduction of one additional tonne of CO2). Based on this cost curve, the minimal cost required to meet the policy target is estimated. The assumption is that this policy target reflects collective preferences with respect to the externality concerned and hence, that the minimum cost to reach this target is a good proxy of the (collective) willingness-to-pay (WTP) to avoid the damage caused by the externality.*

The calculations for **Value 2 and 3** have been made on the basis of the cost factor of €100 per tonne of CO_2 equivalent, the central value for short- and medium-run estimates given in value 1. As was the case in the 2008 Handbook, it is further assumed that the aviation emissions relevant for air quality are restricted to the emissions in the landing and take-off (LTO) phases. The total emissions have been cross-checked with the total emission database from the European Monitoring and Evaluation Programme under the auspices of the European Environmental Agency (EMEP/EEA). The values are for passenger flights.

4.4 Further reading

4.4.1 EASA/EEA/EUROCONTROL

- European Environmental Report, 2019 https://www.eurocontrol.int/publication/european aviation-environmental-report-2019 The document provides an updated assessment of the environmental performance of the aviation sector published in the first report of 2016. The continued growth of the sector has produced economic benefits and connectivity within Europe and is stimulating investment in novel technology. This draws on a wider pool of expertise and innovative approaches from other sectors, thereby creating potential new opportunities to address the environmental impacts of aviation. However, it is recognised that the contribution of aviation activities to climate change, noise and air quality impacts is increasing, thereby affecting the health and quality of life of European citizens.

  Para. 5.3 touches on environmental charges levied by some airports.

- European Commission https://ec.europa.eu/clima/policies/ets/auctioning_en https://www.eex.com/en/

  Extracted from the EC website: "*Twenty-eight countries (25 EU Member States and 3 EEA/EFTA countries) auction their allowances on the common auction platform. The common auction platform is nominated for up to five years by a joint procurement between the Commission and the participating countries, in accordance to the rules laid down by the joint procurement agreement. Currently, the European Energy Exchange (EEX) in Leipzig is the common auction platform. Some countries participating in the EU ETS have opted out of the common auctioning platform: Germany has nominated EEX as its opt-out platform. Poland is making use of the common auction platform to auction its share of allowances until the appointment of its opt-out platform. ICE Futures Europe (ICE) in London acts as the United Kingdom's platform. The Withdrawal Agreement between the*

EU and the United Kingdom ensures that UK operators remain subject to compliance obligations for the years 2019 and 2020."

- ECAC (2011) NOx emission classification scheme, ECAC recommendation ECAC27/4, 11 September 2011 https://www.ecac-ceac.org/documents/
- UK Department for Environment, Food and Rural Affairs (DEFRA) Air quality damage cost update 2019, prepared by Ricardo Energy & Environment (Ricardo-AEA Ltd) https://uk-air.defra.gov.uk/assets/documents/reports/cat09/1902271109_Damage_cost_update_2018_FINA

```
Warning: Since gt v0.3.0, `columns = vars(...)` has been deprecated.
* Please use `columns = c(...)` instead.
Since gt v0.3.0, `columns = vars(...)` has been deprecated.
* Please use `columns = c(...)` instead.

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* Set `options(gt.html_tag_check = FALSE)` to disable this check.
```

Revised sector PM and NOx damage cost estimates and sensitivity boundaries
(2017 prices, impacts discounted to 2017, average exchange rate 2017)

		damage cost sensitivity range	
Emission emitted by aircraft[1]	Central damage cost£(€)/kg	Low£(€)/kg	High£(€)/kg
PM2.5	194 (222)	41 (46)	560 (639)
NOx	12 (13)	1.1 (1.2)	45 (51)

[1]PM2.5 is the preferred metric for the change in PM emissions.
Extract from tables 20-21 of the 'Air quality damage cost update 2019'

4.5 Related standard inputs

[Amount of emissions released by fuel burn] and [rate of fuel burn].

4.6 Comments

With regard to NOx charges, a LTO NOx charge is currently applied at several European airports. The level of the charge per kg of NOx is set

according to the cost of damage caused by NOx to local air quality (LAQ), at or near airports. The charge is levied in several countries, namely Sweden, the UK, Germany, Demark and Switzerland. Two examples are provided below.

4.6.1 London Heathrow

At London Heathrow, a NOx emission charge is payable on each movement (per LTO cycle) by a fixed-wing aircraft over 8 618 kg. The charge per kg of NOx is calculated on the aircraft's ascertained NOx emission[^An aircraft's ascertained NOx emission means the product of the engine NOx emission as set out in the ICAO Emission Database and based on the number of engines on the aircraft.]. https://www.heathrow.com/content/dam/heathrow/web/common/documents/company/doing
business-with-heathrow/flights-condition-of-use/structure-of-charges-decision/Airport_Charges_Decision-5-August-2015.pdf

The Emissions Airport Charges for 2020 **per kg of NOx is £16.84** (€20.5 at the 2019 exchange rate) "Decision – 2020 Airport Charges" https://www.heathrow.com/content/dam/heathrow/web/common/documents/company/doing
business-with-heathrow/flights-condition-of-use/conditions-of-use-documents/Heathrow_Airpo

4.6.2 Copenhagen Airports

Copenhagen Airports support, through financial incentives, the use of engine types which emit the lowest emissions. The model used for calculating emissions and charges is based on the models currently found in Sweden and Switzerland. The model works with absolute NOx emissions of a specific aircraft engine during a standardised landing and take-off cycle (LTO). NOx emissions per aircraft engine are based on the ICAO specifications and guidelines. The published emissions charge (November 2020) is **kr.16.50 per kg NOx** (€2.2 at the 2019 exchange rate). https://www.cph.dk/en/cph-business/aviation/charges-and-slot/calculation-of-emission-charges

Part III

Airspace Users

Chapter 5

Average number of passengers per movement

5.1 Definition

Average[1] number of passengers per movement (take-off or landing) in Europe.

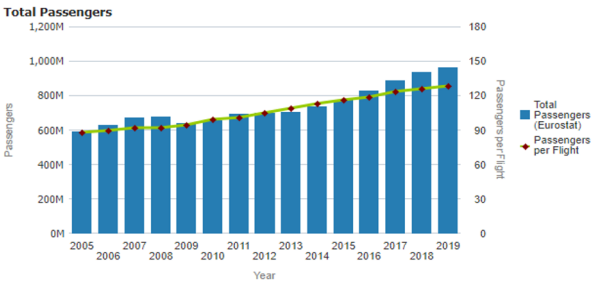
5.2 EUROCONTROL recommended sources

Average number of passengers per departing flight
EU-27+UK and EFTA[1]

2013	2014	2015	2016	2017	2018	2019
109	113	117	119	124	126	129

[1]European Free Trade Association: Iceland, Liechtenstein, Norway and Switzerland

Value



[1]In this context, the (arithmetic) mean value

Source Eurostat: air passenger transport by reporting country (extract: avia_paoc)
http://ec.europa.eu/eurostat/web/transport/data/database
EUROCONTROL STATFOR Interactive Dashboard (SID)19 (goto PAX+)
https://www.eurocontrol.int/dashboard/statfor-interactive-dashboard

Description The average number of passengers per movement[2] for a given year is obtained by dividing the number of 'departing passengers on board' by the number of 'departing flights for that year'.

5.3 Description

The Eurostat air transport domain contains national and international intra- and extra-EU data. This provides air transport data for passengers (in numbers of passengers) and for freight and mail (in thousands of tonnes) as well as air traffic data for airports, airlines and aircraft. Data are transmitted to Eurostat by the Member States of the European Union as well as the candidate countries Iceland, Norway and Switzerland. The air transport data have been calculated using data collected at airports.

5.4 Other possible value

Passengers per IFR movement
Values for the main 34 European airports (all operations)

2008	2010	2012	2013	2015	2017
96	102	108	111	118	125

Value

Source PRC and FAA, "2017 Comparison of ATM-related operational performance: US – Europe", March 2019 (page 25):
https://www.eurocontrol.int/publication/useurope-comparison-air-traffic-management-related-operational-performance-2017
Reports from previous years are available in the EUROCONTROL library:
https://www.eurocontrol.int/library.

Description The table below provides high-level indicators for the main 34 airports21 in Europe using data reported by the airports.
The number of passengers per IFR movement is calculated by dividing the 'average number of annual passengers per airport'

[2]A movement is either a take-off or a landing at an airport.

Average number of annual passengers per airport (million)

2008	2010	2012	2013	2015	2017
25	24	25	25	28	31

by the 'average number of annual IFR movements per airport'.

Average number of annual IFR movements per airport ('000)

2008	2010	2012	2013	2015	2017
260	237	233	228	223	248

5.5 Related standard inputs

5.6 Comment

Chapter 6

Turnaround time

6.1 Definition

6.2 EUROCONTROL recommended sources

6.3 Description

6.4 Related standard inputs

6.5 Comment

Part IV

ATM

Part V

Airports

Part VI

Drones

Part VII

Passengers

Part VIII

Safety

Part IX

Financial values

(PART) Financial values

Chapter 7

Discount rate

7.1 Definition

7.2 EUROCONTROL recommended sources

7.3 Description

7.4 Related standard inputs

7.5 Comment

Chapter 8

Exchange rate

8.1 Definition

8.2 EUROCONTROL recommended sources

8.3 Description

8.4 Related standard inputs

8.5 Comment

Part X

General information

References

(APPENDIX) Annexes

Chapter 9

Data

```
Attaching package: 'dplyr'
```

```
The following objects are masked from 'package:stats':

    filter, lag
```

```
The following objects are masked from 'package:base':

    intersect, setdiff, setequal, union
```

The various data sets introduced are available as CSV files as follows:

(ref:csv-files-table) Data sets (at 2016 EUR price level).

filename	description	url
inflation.csv	Inflation	https://example.com
exchange_rate.csv	Exchange rate	https://example.com

(ref:csv-files-table)

All released versions of this website/document are available at GITHUB repo.