Lufthansa Consulting

Final Report

Review of Standard Passenger Weights

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ACRONYMS

ACI	Airports Council International
AFM	Aircraft Flight Manual
AIS	Aeronautical Information System
ANS	Air Navigation Service
ANSP	Air Navigation Service Provider
AOC	Air Operator Certificate
ARCM	AIG Regional Cooperation Mechanism
ASC	Airline Safety Committee
ATH	Athens Airport
ATM	Air Traffic Management
BRU	Brussels Airport
CAA	Civil Aviation Authority
CAP	Corrective Action Plan
CAT	Commercial Air Transport (operations)
CG	Center of Gravity
CPH	Copenhagen Airport
DFS	Deutsche Flugsicherung
DG	Director General
EASA	European Union Aviation Safety Agency
ECAC	European Civil Aviation Conference
EU	European Union
FAA	Federal Aviation Administration
FRA	Frankfurt Airport
FSC	Full Service Carrier
GAM	General Airport Management
ICAO	International Civil Aviation Organization
LCC	Low Cost Carrier
MTOW	Maximum Takeoff Weight
MXP	Milan Malpensa Airport
MUC	Munich Airport
NAA	National Aviation Authority

NCASP	National Civil Aviation Security Program
NOTAM	Notices to Airmen
RfS	Requests for Service
RSOO	Regional Safety Oversight Organization
SAFA	European Community Safety Assessment of Foreign Aircraft
SEAC	SESAR European Airports Consortium
SESAR	Single European Sky ATM Research Program
SOF	Sofia Airport

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Executive Summary

The study presented in this report continues the regular survey conducted on behalf of EASA to obtain actual data on the average weight of passengers and luggage on domestic, international and intercontinental flights with a focus on validating or updating the current regulations. The overall objective is to conduct a survey of the current weights of passengers and luggage to update the set of standard masses for the purpose of aircraft mass and balance. The update will also help assessing if a review of the applicable EU legislation is needed.

The study conducted a field survey to obtain the average weight of passengers, the weight of hand luggage and the weight of checked luggage at six airports, representing different regions in Europe: ATH (Athens Eleftherios Venizelos, Greece), BRU (Brussels, Belgium), CPH (Copenhagen-Kastrup, Denmark), MXP (Milan Malpensa, Italy), MUC (Munich Franz Josef Strauß, Germany), SOF (Sofia, Bulgaria). Due to operational constraints, MUC Airport participated only in the winter season.

In total 4,164 passengers were surveyed with their hand luggage and 1,998,070 checked luggage data sets were analyzed.

The results were subject to a statistical analysis and led to generally satisfactory results. Similar to the previous study from 2008-9, children have lower observations than most other age categories. Since the survey aims at a random draw of the overall sampling population to achieve statistically valid outcomes, no over-sampling of children was performed. The mean weights and statistical procedures should therefore be unbiased with respect to the “true” population mean. Comparison with and enriching the data with data collected in 2008-9 further allowed us to verify our results and procedure.

Despite the expectation when launching the survey, mean masses of passengers did not significantly change from the previous study from 2008-9, both for male and female passengers.

The measured mean masses are 90 kg for male passengers and 75 kg for female, the resulting mean for all adults being 84 kg, thus slightly above the previous study which indicated 83.8 kg.

The average weight of checked luggage, which is always limited by the luggage policies of the airlines, averaged 16 kg. This value is about 1kg below the value observed in the previous EASA study from 2008-9.

1 Introduction

1.1 Project overview

The purpose of this project is to provide EASA (the Agency) with current figures of passenger and luggage weights. This will help to confirm whether the weights of passengers, hand luggage and checked luggage are still adequately reflected in the AIR OPS Regulation to meet the aircraft mass and balance requirements.

The EASA tender issued as “EASA.2021.MVP.03: Review of Standard Passenger Weights” clearly states the importance of the current study and highlights the background of the request.

This study is proposed in support of EASA rulemaking task RMT.0392, amending the Air Operations Regulation.

In 2008, EASA conducted a survey on standard weights of passengers and luggage, reference EASA 2008.C.06. The conduct of this Pan-European study originated in the Joint Aviation Authorities (JAA) and its aim was to review the weights of passengers, hand luggage and checked luggage be used for aircraft mass and balance purposes. In this report the previous survey is referred to as “2008-9”.

The JAA stated that a number of factors had changed since the standard mass values were determined. The study has, indeed, confirmed that the standard masses of male and female passengers and of the checked luggage were higher than the figures reflected in the applicable rules during winter survey. The study recommended to conduct a new survey in 10 years’ time as the average mass of the European population is expected to increase.

Figure 1 demonstrates the figures of passengers and luggage masses in the AIR OPS Regulation and the figures recommended by the EASA 2008.C.06 Study.

Standard masses for passengers - aircraft with a total number of passenger seats of 20 or more

Passenger seats	20 and more		30 and more
	Male	Female	All adult
AIR OPS Regulation			
All flights except holiday charters	88	70	84
Holiday charters	83	69	76
Children	35	35	35
EASA 2008.C.06 Study			
Scheduled	92	73	86
Non-scheduled	88	71	80
Children	40	40	40
Recommended standard masses by EASA 2008.C.06 Study			
All flights	94	75	88
Checked luggage			
All flights	17	17	17

Standard masses for luggage - aircraft with a total number of passenger seats of 20 or more

Type of flight	Baggage standard mass	
	AIR OPS Regulation	EASA 2008.C.06 Study
Domestic	11	15
Within the European region	13	16
Intercontinental	15	18
Mean mass (recommended by the Study)	.....	17

Figure 1 - Standard mass from regulation and previous 2009 study

Air OPS Regulation requires that an aircraft shall not takeoff, if its takeoff mass exceeds the certified Maximum Takeoff Mass (MTOM) permitted by the manufacturer, after taking into account a number of the circumstances of the proposed flight such as the ambient temperature and the pressure altitude at the aerodrome of departure/arrival.

In commercial operations, it would be practically and economically challenging to weigh all passengers and crew with their luggage. Therefore, standard masses are commonly used for crew, adults, children, infants, and hand luggage, especially for aircraft above certain passenger capacity (10 for airplanes and 6 for helicopters).

Holders of an Air Operators Certificate (AOC) must establish a method for determining weights for luggage, passengers and crew members including hand luggage. The use of the standard masses will, in most cases, ensure that the takeoff mass of the aircraft does not exceed the maximum certified takeoff mass of the aircraft.

Without obtaining updated data on standard masses, as recommended by the previous study, there is a risk that the current figures may lead to incorrect weight and balance calculations.

Therefore, the current study aimed to obtain updated figures of passenger, hand luggage and checked bag weights as recommended in the previous study.

1.1.1 Trend analysis on weight development

Herein study importance relies not only on the previous study recommendation, but also in the fact that World Health Organization (WHO) and Eurostat articles published in recent years, all indicating overweight trends during last decades.

Eurostat is the statistical office of the European Union, responsible for publishing high-quality Europe-wide statistics and indicators that enable comparisons between countries and regions. Figure 2 shows the results of the “European Overweight and Obesity 2019” study[1].

[1] https://ec.europa.eu/eurostat/statistics-explained/index.php?title=Overweight_and_obesity_-_BMI_statistics

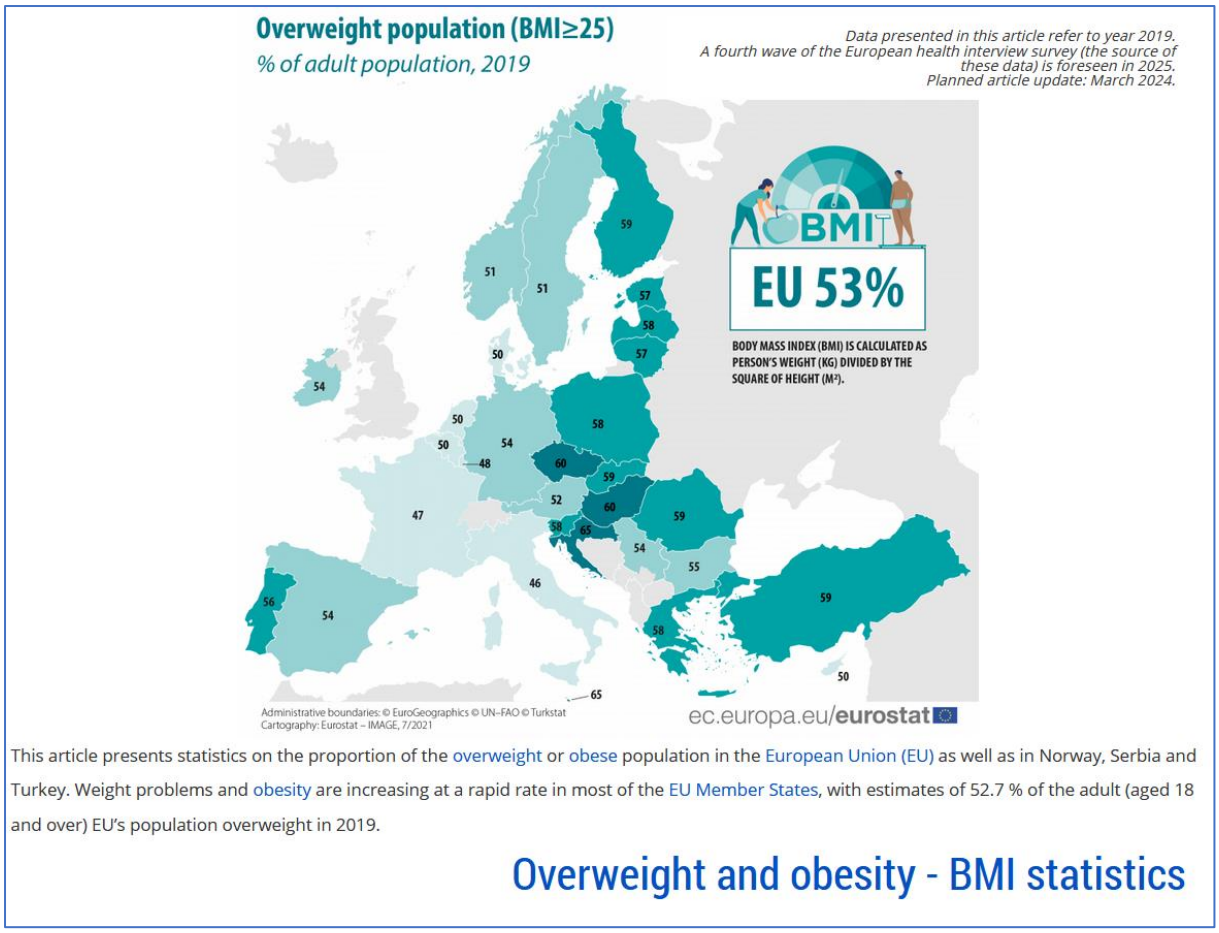


Figure 2 - Overweight and Obesity European 2019 study results

In accordance with World Health Organization (WHO) study, childhood obesity is significantly increasing since 1975, leading to adults' overweight condition.

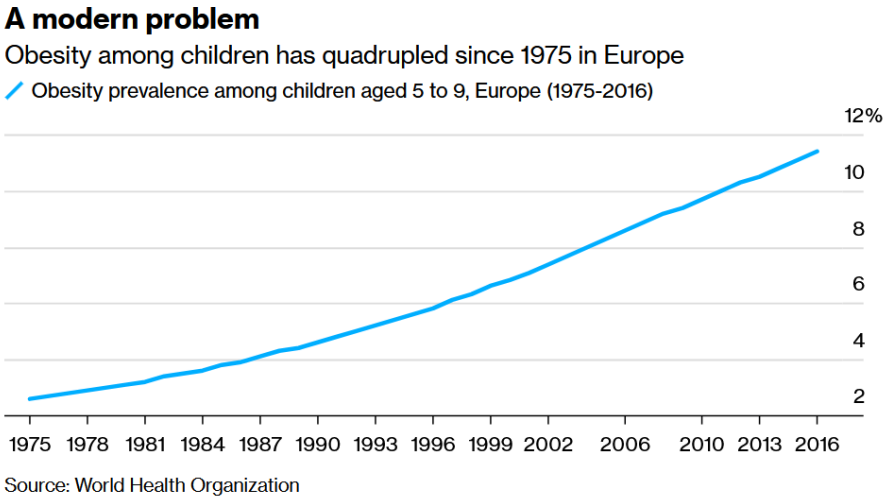


Figure 3 - World Health Organization (WHO) study, children obesity is significantly increasing since 1975[2]

[2] https://www.bloomberg.com/news/articles/2022-05-03/obesity-rates-have-increased-in-europe-led-by-turkey-u-k

Therefore, weight increase is clearly a trend in European countries, thus, monitoring passengers' weight and its luggage weight is highly important to keep regulations reflecting real numbers.

The same situation is observed in the United States of America, whose Centers for Disease Control and Prevention (CDC) shows data of obesity consistently increasing throughout the years.

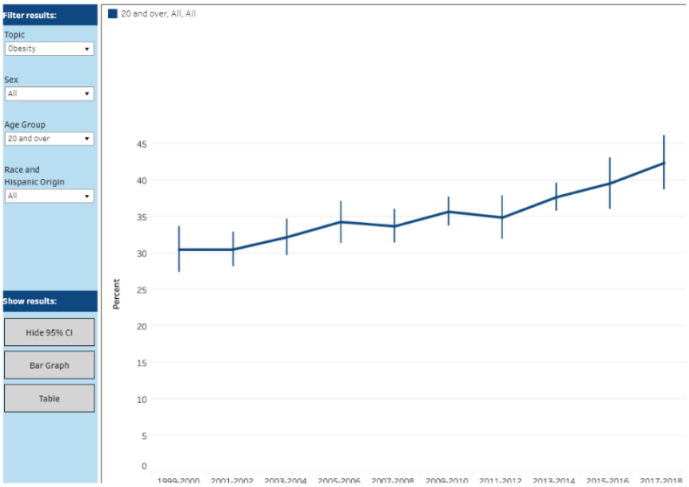


Figure 4 - Centers for Disease Control and Prevention, CDC, data indicating obesity increasing over past decades[3]

In accordance with WHO, overweight and obesity are defined as abnormal or excessive fat accumulation that may impair health. Body Mass Index (BMI) is a simple index of weight-for-height that is commonly used to classify overweight and obesity among adults. It is defined as a person's weight in kilograms divided by the square of his height in meters (kg/m2).

Around 59 percent of adults in Europe are overweight or obese, according to the 2022 European regional obesity report presented by the World Health Organization (WHO).

Data obtained in the WHO European region said the problem affects more men than women, with around 63 percent of men being overweight and 54 percent of women.

[3] https://www.cdc.gov/nchs/nhanes/visualization/

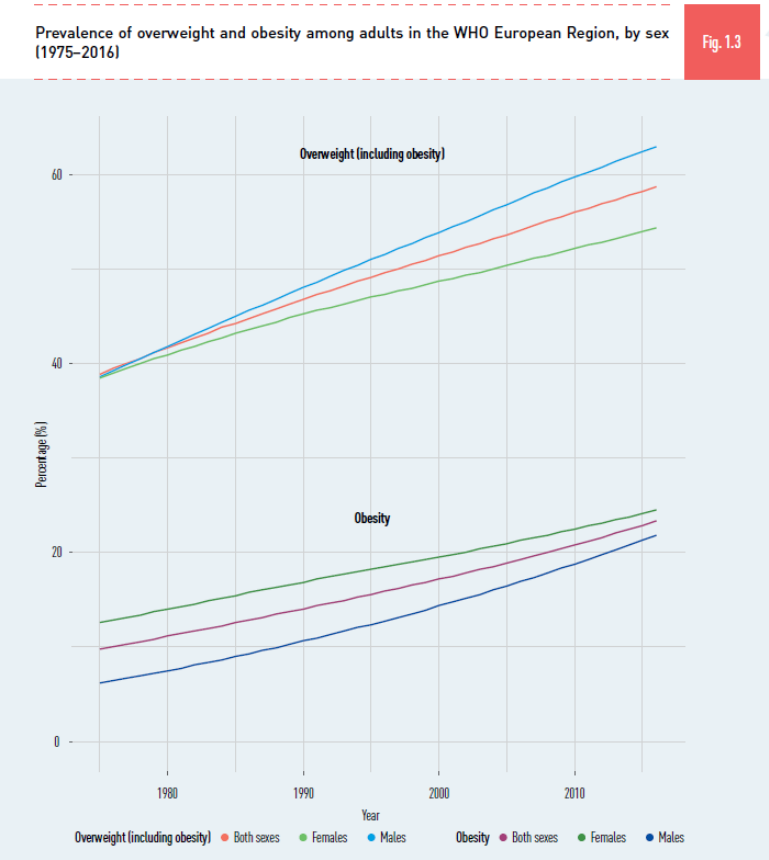


Figure 5 - 2022 European regional obesity report issued by WHO data[4]

Although BMI measurements are not an absolute definition of weight gain, because it is a ratio of a person's weight to height, it is a solid indication that the population may be getting heavier.

Therefore, continuously checking the actual weight of passengers is a key factor in keeping regulations updated, thus making weight surveys important to conduct on a systematic basis for contributing to flight safety.

1.1.2 Luggage weight trends

Considering air transportation luggage, it is necessary to observe the weights of the checked bags and the weight of the cabin bags.

Checked bags, usually, have a more accurate control, since they are dispatched at check-in desk, after weighing and usually the passenger does not have access to put more weight on it afterwards.

Therefore, despite the possibility of luggage weight increase, as reported in a study of 2018, published by USJetcost that 21% of U.S. travelers have exceeded their luggage allowance, the weight is noted prior to takeoff, and so, it is considered into weight and balance calculations.

[4] WHO European Regional Obesity Report 2022, p. 9

On the other hand, the biggest concern lies with carry-on luggage, which is sometimes weighed at check-in, but is not subject to significant control before takeoff, thus allowing passengers to carry significantly more weight than allowed.

Additionally, airline policies that charge a fee for any piece of checked luggage act as an incentive for passengers to "overweight" carry-on luggage and/or carry too many items into the aircraft cabin, which when added together exceed the defined limit.

It is a challenge for airline operators to establish procedures during boarding to ensure that only weighed carry-on luggage will be boarded in the passenger cabin.

Even airlines that are requiring air travelers at the gate to have their carry-on luggage weighed before boarding, especially common for low cost airlines, will often experience passengers removing jackets or heavy items from their bags and carry them instead, leading to heavy weights to be carried anyway on their flights.

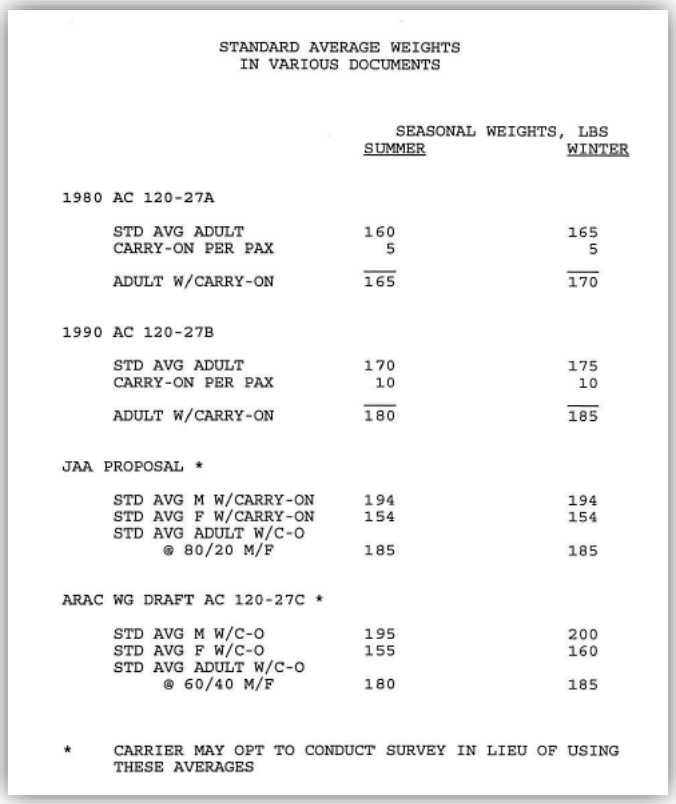
Therefore, understanding real trends in passengers' total weight, which includes passenger weight, carry-on items weight and checked luggage weight is key to ensure that weight and balance numbers are in line with standards weights in aviation regulations.

1.1.3 Forecast and future trends

With some airlines changing their luggage policies to charge for checked items or even reduce the luggage allowance, the number of items and weight carried by each passenger in the passenger cabin is expected to increase.

Statistics of the 1980´s and 1990´s decades depicted an increasing body weight observed by the World Health Organization (WHO) and others, were also considered by regulatory aviation agencies and supported by own studies.

An FAA analysis from 1994, supported by a working group to discuss "Substantiation of Weight Values for Proposed AC 120-27C, Aircraft Weight and Balance", provided the table below, which indicates values adopted over the last decades for the average weight of passengers. It demonstrates the increased values in the regulations over the last decades.



STANDARD AVERAGE WEIGHTS
IN VARIOUS DOCUMENTS

	SEASONAL WEIGHTS, LBS SUMMER	WINTER
1980 AC 120-27A		
STD AVG ADULT	160	165
CARRY-ON PER PAX	5	5
ADULT W/CARRY-ON	165	170
1990 AC 120-27B		
STD AVG ADULT	170	175
CARRY-ON PER PAX	10	10
ADULT W/CARRY-ON	180	185
JAA PROPOSAL *		
STD AVG M W/CARRY-ON	194	194
STD AVG F W/CARRY-ON	154	154
STD AVG ADULT W/C-O @ 80/20 M/F	185	185
ARAC WG DRAFT AC 120-27C *		
STD AVG M W/C-O	195	200
STD AVG F W/C-O	155	160
STD AVG ADULT W/C-O @ 60/40 M/F	180	185

* CARRIER MAY OPT TO CONDUCT SURVEY IN LIEU OF USING THESE AVERAGES

Figure 6 - FAA and JAA regulations indicating passenger weight increase over decades[5]

Comparing those results with the outcome of the current study, clearly indicates the use case for regular respective surveys in order to define evidence-based regulatory standard weights.

1.1.4 Impact of weight on air transport operations

The consideration of a higher passenger weight when the airline operator adopts standardized values, if this value is higher than the one defined in the current regulation, will lead to a possible reduction of transported cargo in more critical operations, such as short runways and higher temperatures when the aircraft has less operational capacity.

This impact is higher in general aviation and less for commercial fixed wing aviation, however, the systematic review of current standard weights defined in regulations is necessary to reflect the air operations conditions of weight of bags and passengers, to keep the safety margins.

[5] https://www.faa.gov/regulations_policies/rulemaking/committees/documents/media/AGAMwabT1-08271991.pdf

2 Methodology

2.1 Introduction

The primary objective of the survey is to obtain passenger weight data from a representative mix of passengers in order to provide the best possibility to obtain updated mass data within statistically acceptable accuracies.

Not only the weight of the passengers is important, but also the weight of the bags, whether hand luggage or checked bags, is needed to assess the adherence of the travelers with the regulations in place.

For the geographic spread, the participating countries under Article 129 of the Basic Regulation (Regulation 2018/1139), so the member states of the European Union (EU) and the members of the European Free Trade Association, i.e. Liechtenstein, Norway, Switzerland and Iceland were divided into regions and the most favorable airports in each region were initially sought to represent travelers and airlines with the required various profiles for the survey.

2.2 Definition of the representative mix for the survey

The survey was conducted in person at the selected airports and the local fieldworker teams worked together with local representatives of each airport to find the best conditions and best places to obtain data.

To get the weight of passengers, the fieldworkers tried to be as close as possible to the boarding points, but always at locations with a constant flow of passengers to ensure the highest possible data collection amount for the period stipulated at the airport.

It should be noted that the surveys were exclusively voluntary and therefore a cordial and encouraging approach was necessary to achieve defined rate of weight records per airport.

The required data can be divided into three categories.

Category A: Passenger mass:

- Adult male, adult female, child, infant passenger

Category B: Hand luggage:

- Carried by all passengers of Category A above

Category C: Checked luggage:

- Mean mass of checked luggage

Data surveyed and recorded:

a. Route (domestic, EU, non-EU),
b. Type of flight (scheduled, non-scheduled),
c. Passenger (as per the above) weight to nearest 0,1 kg,
d. Hand luggage weight to nearest 0,1 kg,
e. Mean mass of checked luggage.

2.3 Methodology for airport selection

Running a structured and methodological selection of airports, in order for all contractual requirements to be met, the team has concentrated on the following criteria:

A) Regional Representativeness

As a first criteria, the EASA countries were divided in different regions. In order to ease comparability, the team adopted the same regions as in the previous study, which itself was based on the Standard Weights Working Group (SWWG) of the Joint Aviation Authorities (JAA).

B) Traffic representativeness

Furthermore, the traffic at the selected airports shall include a diverse set of passenger profiles, including gender, age, leisure and business passengers. Second, the airports would also have to accommodate a diversified set of flight types, including international, domestic and EU flights, which should be operated by a mix of aircraft categories including narrow body, wide body, regional jets and turbo prop aircraft. Finally, a diversified set of airline types should be included, such as Low-Cost Carriers (LCC), Full Service Carriers (FSC), Charter Carriers and others.

C) Terminals dispositions for survey execution

Ideally, airports would contain the most diversified set of traffic mentioned on criteria A in one or two terminals. Lufthansa Consulting aimed to avoid airports with several terminals or with big distances and transportation time between the terminals of an airport. In case a single carrier had a disproportionate market share (e.g. LH in MUC due to its hub setup), sampling was ideally also done at a secondary location outside the hub carrier's terminal(s)/concourse(s).

The selected airports across the European Union were chosen as the ones combining two factors: the traffic variety and geographical representativeness. Further details to the methodology applied to the selection of airports according to these three criteria are listed in the upcoming sub-chapters.

2.3.1 Selection of airports according to regional representativeness

As mentioned before, the selected airports were chosen according to the different EU regions as defined in the previous study. The regions are depicted below:

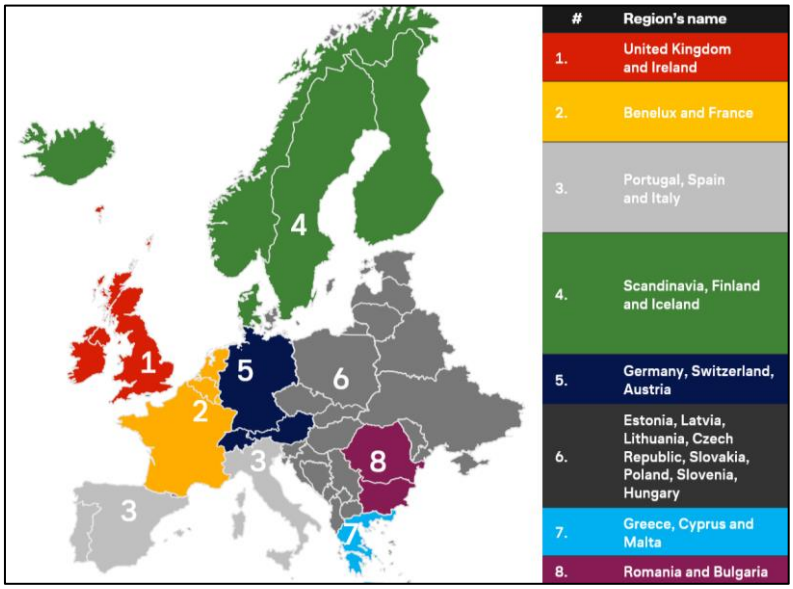


Figure 7 - EU regions according to previous study[6]

At least one airport for each region was short-listed as an initial step to fulfill the regional criteria. As an initial exercise, this first short-listing of airports per region was done based on Lufthansa Consulting's estimation and experience on the level of difficulty to access airport facilities, contact key airport personnel, receive airport data and potential cooperation. As a result of this first approach, the following airports were short-listed for each region:

Table 1 - European regions and airports

Region code	Region	Short-listed airports
1	UK & Ireland	MAN (Manchester) LGW (London Gatwick)
2	Benelux & France	AMS (Amsterdam Schiphol) TLS (Toulouse Blagnac) BRU (Brussels National)
3	Portugal, Spain & Italy	MAD (Madrid Barajas) BCN (Barcelona El Prat) BGY (Bergamo) LIS (Lisbon Portela) MXP (Milan Malpensa)

[6] Based on NEA: Survey on standard weights of passengers and baggage - Final report (R20090095.doc), p. 24

4	Scandinavia, Finland & Iceland	ARN (Stockholm Arlanda) CPH (Copenhagen-Kastrup) HEL (Helsinki Vantaa) OSL (Oslo Gardermoen)
5	Germany, Switzerland and Austria	FRA (Frankfurt Rhein-Main) MUC (Munich) KLU (Klagenfurt) FMM (Memmingen) SCN (Saarbrücken) VIE (Vienna Schwechat)
6	Estonia, Latvia, Lithuania, Czechia, Slovakia, Poland, Slovenia, Hungary	PRG (Prague Václav Havel) TLL (Tallinn) BUD (Budapest) WAW (Warsaw Chopin)
7	Greece, Cyprus & Malta	ATH (Athens Venizelos)
8	Romania and Bulgaria	SOF (Sofia Intl)

According to the contract requirements, a minimum of five airports needed to be selected for the surveys to take place. Ideally, six airports could be selected.

This resulted in the exclusion of two EU regions of the list shown above. Yet, the geographical coverage is considered wide and varied enough, as it stretches through a series of airports in several countries and regions of the European Union.

2.3.2 Traffic representativeness

Perhaps the most important aspect that was taken into account during the selection process of the airports is the representativeness of the traffic. The representativeness aspect was evaluated based on two different factors:

1) Traffic size: How large is the airport in terms of passenger traffic?
2) Traffic variety: What is the traffic profile at the airport?

For the traffic size analysis, the base annual passenger traffic handled at the airport in the year 2019 was used as a reference. Given that 2020 was not a normal year with the impact of the COVID-19 pandemic especially for the aviation industry, the traffic for that year could not be considered representative and was therefore not used. Other than that, prior to the start of the survey during winter 2022, the traffic statistics in the required level of detail was not yet available in the two industry data sources used by Lufthansa Consulting: IATA AirportIS and Albatross Airport Information. Therefore, the figures of the year 2019 were evaluated.

The following approval criteria list was developed and used in the airport selection process:

Table 2 - Criteria for airport selection

Indicator	Criteria for approval of airport as candidate	Remarks / Rationale

Yearly traffic size 2019 base	Minimum of 2 Million passengers / year	-
Traffic size February 2019 (low season sample)	Minimum of 500 thousand passengers / month	-
Traffic size July 2019 (high season sample)	Minimum of 500 thousand passengers / month	-
Average monthly traffic size in 2019	Minimum of 500 thousand passengers / month	-
Domestic traffic	Minimum of 1 Million passengers / year	Traffic to same-country destinations
EU traffic	Minimum of 1 Million passengers / year	Traffic to EU destinations
Non-EU traffic	Minimum of 1 Million passengers / year	Traffic to non-EU destinations
% of Low-Cost-Carrier traffic	Minimum of 30% and maximum of 70% of total	Mix of low-cost and full-service should be well balanced, avoiding concentration
% of Business class passengers	Minimum of 2% of total traffic	-
Scheduled operation of turbo prop aircraft	“Yes” for approval	-
Scheduled operation of narrow body jet	“Yes” for approval	-
Scheduled operation of wide body jet	“Yes” for approval	-
Scheduled operation of regional jets	“Yes” for approval	-
Operation of low-cost and full-service carriers from the same terminal	“Yes” for approval	-
At least 10 published “holiday” destinations	“Yes” for approval	Holiday destinations were considered the ones with significant tourist flows in and outside of the European Union, such as PMI, BCN, PUJ, FAO, AGP, RAK
Lufthansa Group operation	“Yes” for approval	Presence of Lufthansa Group airlines was considered as a facilitator for the survey
Positive response after Lufthansa Consulting’s initial contact	“Yes” for approval	Initial feedback after first attempt from Lufthansa Consulting to contact the airport on the survey topic

One point would be awarded to each of the above-shown “pass or fail” criteria. As a result, each airport could receive a total score of seventeen points, based on the seventeen indicators listed above. The detailed results of the analysis for each of the criteria above for all short-listed airports can be found in the table provided in Appendix A to this report.

The table below shows the summarized version of the results of the airport traffic analysis.

Table 3 - Airport selection final score

Area #	Area coverage	Potential airports	Score
1	UK & Ireland	LGW (London Gatwick)	16
		MAN (Manchester)	15
2	Benelux & France	AMS (Amsterdam Schiphol)	15
		TLS (Toulouse Blagnac)	11
		BRU (Brussels National)	15
3	Portugal, Spain & Italy	LIS (Lisbon Portela)	17
		MAD (Madrid Barajas)	15
		BCN (Barcelona El Prat)	15
		BGY (Bergamo)	12
		MXP (Milan Malpensa)	15
4	Scandinavia, Finland & Iceland	CPH (Kopenhagen Kastrup)	16
		ARN (Stockholm Arlanda)	15
		HEL (Helsinki Vantaa)	15
		OSL (Oslo Gardermoen)	15
5	Germany, Switzerland and Austria	MUC (Munich Strauss)	15
		FRA (Frankfurt Rhein-Main)	15
		KLU (Klagenfurt)	9
		FMM (Memmingen)	7
		SCN (Saabrücken)	7
		VIE (Vienna Schwechat)	14
6	Estonia, Latvia, Lithiania, Czechia, Slovakia, Poland, Slovenia, Hungary	PRG (Prague Václav Havel)	15
		TLL (Tallin)	10
		BUD (Budapest)	14
		WAW (Warsaw Chopin)	15
7	Greece, Cyprus & Malta	ATH (Athens Venizelos)	15
8	Romania and Bulgaria	SOF (Sofia Intl)	13

As a next step, up to two airports with the highest score per region were contacted by Lufthansa Consulting. Further important steps were executed in order to ensure that surveys could eventually be executed at the airports. During this phase, Lufthansa Consulting also requested and executed all formalities and processes to obtain airport batches, access the terminals, receive the approval of airlines at the stations and start surveys within the winter period.

The selected airports for the survey were:

- ATH (Athens, Greece)
- BRU (Brussels, Belgium)
- CPH (Copenhagen, Denmark)
- MUC (Munich, Germany)

- MXP (Milan Malpensa, Italy)
- SOF (Sofia, Bulgaria)

It is important to bear in mind that just before the winter survey starts, a new pandemic wave of COVID-19 spread throughout the world, especially as an effect of a new virus variant which emerged during the winter season in the northern hemisphere. On top, the war in Ukraine started end of February 2022. Those unforeseen force majeure events have resulted in several flight cancellations, operational disruptions and termination of travel plans of passengers in Europe and beyond. This did not entirely compromise Lufthansa Consulting's airport analysis, but did impact the conduction of the surveys, e.g. with fewer passengers traveling, passengers being more stressed at airports and less willing to participate in the survey, with airlines and airports reducing resources and withdrawing their support for the survey activities.

2.3.3 Terminals disposition for survey execution

Once the traffic analysis was conducted and the airports were finally selected, a high-level analysis of the terminals dispositions was carried out. This included an overall analysis of check-in facilities, gate area, shops and other airport facilities, which was done with airport terminal maps and via virtual meetings with the airports' contact persons, airline representatives and other stakeholders. All terminals of the selected airports were considered to have facilities that would enable the surveys to be conducted.

2.3.4 Overview of selected airports and survey dates

Table 4 - Final list of airports and dates for the survey

AIRPORT	IATA CODE	REGION	WINTER DATES	SUMMER DATES
Athens	ATH	Greece, Cyprus, Malta	16-17FEB, 11-12MAR	14-16JUL
Brussels	BRU	Benelux, France	21-23FEB, 21-22MAR	25JUN
Copenhagen	CPH	Scandinavia, Iceland, Finland	21-23FEB, 18-19MAR	17-18JUN
Milan Malpensa	MXP	Spain, Portugal, Italy	25-27MAR	7-9JUL
Munich	MUC	Germany, Austria, Switzerland	21-23FEB, 17-19MAR	n/a
Sofia	SOF	Romania, Bulgaria	25FEB, 11-12MAR	4-6JUL

2.4 Methodology applied during surveys

The fieldwork was done by two fieldworkers per airport. At almost every airport, a security escort was necessary to get access to the security area (where the passenger weighing took place).

The fieldworkers were briefed with a detailed document with information on the respective airport (e.g. maps, schedules, contacts). They arrived the day before the first working day at the respective airport to get in touch with an airport manager in order to collect the visitor badges, and identify the best survey spots.

The fieldwork consisted of two different surveys: one for checked luggage and one for passengers (plus carry-on luggage)[7]. The first survey took place in front of – or near – the check-in counters of the airport. The second survey took place between the duty-free shops and the gates. The following definitions of these terms were used:

- Checked luggage: any piece of luggage that has to be checked-in for travel
- Carry-on luggage: all bags (including duty-free bags), cases (including photo equipment), purses, a pillow, etc. carried by a passenger into the aircraft cabin
- Passenger weight: the weight of a passenger including all clothing carried by that passenger

To ensure representativeness, fieldworkers were instructed to recruit a representative sample of passengers, by approaching every fifth passenger and making sure that all groups that are present at the airport were sufficiently represented in the survey (without discriminating on appearance or characteristics).

The importance of a good mix of passengers (gender / age / business / leisure), routes (intercontinental / international / domestic) and airline types (legacy / low cost) was clearly stressed to the fieldworkers.

[7] The questionnaire of the passenger survey can be found in appendix H

During the survey, fieldworkers introduced themselves and asked the approached passengers if they were willing to participate in an air safety related survey. This was presented as a study for the European Union Aviation Safety Agency (EASA), regarding passenger and luggage weights. It was also communicated that participation was strictly voluntary and that the survey is anonymous. Larger groups were also welcome to participate. Children under the age of 16 years were only surveyed with parental supervision/consent. Infants (0-2 years) were included in the weight of the passenger.

The fieldworkers received a weighing scale (SECA Robusta 813, max. load 200 kg, graduation: 100g) and an official letter from EASA to confirm the project. They used an iPad to conduct the survey and had a roll-up banner as visual support next to them.

To obtain the sufficient number of observations for checked luggage data, it was started during the winter measurements with physical weighings of checked luggage at the check-in area of the airports.

Due to the various external constraints (e.g. COVID-19 pandemic, Ukraine war) during the survey period, a second approach was tested. Airlines and airports were asked to provide electronic data of checked luggage.

There is no common Baggage Handling System (BHS) at the participating airports and no common data format at the airlines IT. In order to analyze and compare the extracted data, all data were cleaned and reordered into a consistent manner to match one format.

The project team asked for a longer period for both seasons, winter and summer, in order to cover missing or incorrect data in the datasets. This also allows to reduce the number of datasets per airport/airline to a representative level.

Although some electronic data was already available in summer 2022, the team decided to collect again some data onsite at some airports directly at the check-in counter of some airlines.

2.5 Required sample size

The sample sizes for passengers and checked luggage per airport was defined in the tender document: *At least 750 passengers and 1500 pieces of checked luggage are to be weighed at each airport.*

It is worth mentioning that, given that the current project to obtain passenger weight data was developed during cycles of COVID-19 outbreaks worldwide, passengers and airports were asked/ordered to implement measures to prevent the spread of COVID-19, e.g. social distancing and wearing masks. This certainly caused significant difficulties in getting the attention of passengers to participate in the campaign.

Additionally, the number of flights and passengers was still significantly lower than before the onset of the pandemic.

2.6 Data surveyed and recorded

In order to keep the same basis as the previous EASA study from 2008-9, the following definitions were respected:

2.6.1 Operational definition of dependent variables

Mass

Values in kilograms measured by calibrated scales.

Mass of passenger

The value in kilograms of a single passenger including clothing carried by a passenger (jacket, sweater, scarf) and carry-on luggage, measured by calibrated scales with one decimal digit. In case the passenger is travelling with an infant younger than two years the mass of the infant is included in the passenger mass.

Mass of passenger without carry-on luggage

The value in kilograms of a single passenger including clothing carried by a passenger (jacket, sweater, scarf) and without carry-on luggage, measured by calibrated scales with one decimal digit.

Mass of carry-on luggage

The value in kilograms of all belongings carried by a single passenger to be taken into the aircraft, e.g. purse, duty-free bags, electronic equipment, excluding clothing carried by a passenger (jacket, sweater, scarf). This is calculated as the difference between the mass of a passenger without carry-on luggage from the mass of the same passenger with carry-on luggage.

Mass of checked luggage

The value in kilograms per piece of luggage that the passenger was going to check-in before boarding.

2.6.2 Independent factors recorded

- Passenger characteristics: age, gender;
- Passenger behavioral characteristics: carrying an infant, carrying carry-on luggage, travelling by purpose (business or leisure);
- Place and time of the measurements: airport selected and season (Summer or Winter);
- Trip characteristics: direction (outbound or inbound), route type (domestic, European and non-European), region of departure or arrival, flight length

categories (short-haul, medium-haul and long-haul) and class of travel (economy, premium economy, business, first class);

- Flight characteristics: airline and flight number, flight type (scheduled or non-scheduled), airline type (regular scheduled or charter) and airline policies concerning maximum of luggage mass.
- Additionally, LCC vs. FSC – Two airline types are distinguished: 'low cost carriers' (LCC's) and 'full service carriers' (FSC's).

2.7 Data cleaning

To avoid outliers, which is an observation that resides at an abnormal distance from other values in a random sample of a population, all data were consistently reviewed by an independent researcher to ensure their identification and subsequent action, which could be removal of the value and therefore the entire entry or, where possible, correction using additional data sources (e.g. OAG Analyser data[8]). Correction was used only for additional information, such as flight characteristics for example flight numbers. For abnormal weights (in checked luggage), trip type or age entries, the entries were deleted as a whole (see next section) or amended (in two instances).

The following error types were considered:

(1) Missing data in records,

(2) Data entry errors – Inconsistent values

Only reliable data entries were kept in the final report without prejudice of the required sample size.

For checked luggage data consisting of survey data and electronic data, the following procedure is executed:

1. Extract checked luggage from survey date
2. Convert electronic checked luggage information from airports and airlines to standard format
    a. Match and transform variables to standard unit size
    b. Rename variables
    c. Drop unused variables
3. Merge OAG analytics data with flight numbers or origin/destination to obtain flight characteristics

[8] OAG Analyser. (n.d.). Retrieved 21 september 2022, from http://analytics.oag.com/analyser-client/home

3 Data and descriptive statistics

3.1 Data

We collected data on passenger weights, hand luggage weights and checked luggage in 2022 and enriched these data by adding data from the precursor EASA study in 2008-9, EASA 2008.C.06, for comparison and reference. In 2022, the passenger and hand luggage data includes 4,164 observations. This can be further divided into observations during the winter months between 16 February and 29 March, during which 2,303 observations were collected. For the observations in summer, 1,861 observations have been collected between 17 June and 16 July. For comparison, the more extensive study by EASA in 2008-9 has 22,901 observations of which 11,495 were collected in the summer and 11,406 in the winter.

Observations with missing observations for key variables (i.e. age and gender) have been deleted. This is the case for 0.69 percent of the 2022 observations because of missing gender (and 0.11 percent of the entire 2022 and 2008-9 dataset) and 0.17 percent because of missing age (and 0.03 percent of the entire 2022 and 2008-9 dataset). All the deleted observations has either missing age or missing gender — none of them had both categories missing simultaneously. Hence, it does not matter which is deleted first.

We merge the cross-sectional data from the 2008-9 survey with the newly collected cross-sectional data of 2022. This allows us to make a comparison in terms of descriptive statistics and use the full information within both datasets for econometric analyses. The sum of all observations of both studies is 27,065 observations.

3.2 Descriptive Statistics

Based on the data explained above, we provide general descriptive statistics including extensive one- and two-way descriptive statistics for the main variable of interest. Descriptive statistics here include means, standard deviations, distributions and two-way figures. We also provide a direct comparison with the EASA 2008-9 study.

In order to update the EU safety regulations, we specifically show the following standard masses:

- Mean weight passenger and hand luggage
- Mean weight passenger and hand luggage by age
- Mean weight passenger and hand luggage by gender
- Mean weight passenger and hand luggage by airport
- Mean weight passenger and hand luggage by carrier type
- Mean weight passenger and hand luggage by flight distance
- Mean weight passenger and hand luggage by size
- Mean weight checked luggage
- Mean weight checked luggage by gender
- Mean weight checked luggage by class
- Mean weight checked luggage by aircraft type

- Mean weight checked luggage by flight distance
- Mean weight checked luggage by airport

4 Results

The purpose of this research is to understand the weights that are taken on airplanes by its passengers and if these weights changed over time and if so, by which passenger characteristics. The weights considered here can be divided into three categories: passenger weights, carry-on luggage and checked luggage. The outcomes of the descriptive statistics and the econometrics analyses are presented in this chapter. The section 4.1.1 presents the actual average weights for passenger, carry-on and checked luggage weights of both 2022 and 2008-9 for both seasons. Section 4.1.2 describes the traveler's weight and age distributions. This is followed by average weights per gender categories. Afterwards, we zoom in on the ratios of passengers per airport for different factors, including gender, purpose and class. The last subparagraph of section 4.1 contains the descriptive statistics of the final weight category: checked luggage. This finalizes the descriptive statistics of the three weight categories. After the descriptive statistics, section 4.2 on the econometric analyses provides the linear regression (OLS) results on the different weight categories.

4.1 Descriptive statistics

The main findings of the statistical analyses are that passenger and carry-on luggage weights and passenger characteristics have similar means and distributions in 2022 as they did in 2008-9. The mean value of all passengers in 2022 is 75.6 kg and for carry-on luggage, it is 7.6 kg. Male passengers have a mean weight of 82.2 kg, which is 14.7 kg more than the average female passenger (67.5 kg). Mean passenger weight increased by 1.1 kg while hand luggage weight increased by 1.5 kg with respect to 2008-9. In terms of the checked luggage, the average passenger takes 16.7 kg in 2022, which is 0.8 kg less than in 2008-9 (15.9 kg).

4.1.1 Mean masses: Passenger, carry-on and checked luggage weights

The mean weight of passengers in 2022 is 75.6 kg and for carry-on luggage it is 7.6 kg. Table 6 below presents the mean values for all passenger weight and carry-on luggage divided in winter, summer and total sample. Children are included in the mean weights. The average passenger weight in 2022 (75.6 kg) is 1.1 kg more than in 2008-9 (74.5 kg), implying that the average passenger became heavier since 2008-9. Not only passengers, but also the carry-on luggage got heavier since 2008-9. The average passenger took 1.5 kg more hand luggage with them in 2022 compared with the average of 6.1 kg in 2008-9. The mean weight of checked luggage in 2022 is 15.9 kg. The average checked luggage weight in 2022 is 0.8 kg less than in 2008-9, implying that the average checked luggage got lighter since 2008.

Table 5 - Passenger, carry-on and checked luggage weights per season and year incl. children

	Weight in kg	Winter	Summer	Total
2009	Passenger	78.0	70.9	74.5
	Carry-on luggage	6.9	5.3	6.1
	Checked luggage	16.6	16.9	16.7
2022	Passengers	76.8	74.0	75.6
	Carry-on luggage	7.9	7.3	7.6
	Checked luggage	15.9	16.0	15.9

An important factor to consider for passenger weights and carry-on luggage is the season. Both these weights are on average heavier in the winter than they are in the summer. The average passenger weighs 74.0 kg in the summer of 2022; this is 2.8 kg more in the winter (76.8 kg). The difference between seasons for carry-on luggage is 0.6 kg. While the average passenger takes 7.3 kg carry-on luggage in the summer, this is 7.9 kg in winter. A possible explanation for the difference in passenger weights, is that passengers wear more and heavier clothing in the winter than in the summer. The difference between winter and summer passenger weights in 2008-9 was considerably larger than that in 2022. This difference can be explained by the fact that in summer 2008-9, 49 percent of the passengers is male and almost 10 percent are children. While in the winter of 2008-9, 61 percent is male and 3 percent is a child. The share of females stayed fairly constant: 37 percent in the summer and 36 percent in the winter. In 2022, this difference is not as big with males representing around 58 percent in the summer and 55 percent in the winter. Children represent 1.5 percent in both summer and winter.

In order to be consistent with the 2008-9 study, the mean weights are also provided excluding children. In this instance, only adult observations are taken into account. These means for passenger weights, carry-on luggage and checked weights are resented in Table 6.

Table 6 - Passenger, carry-on and checked luggage weights per season and year excl. children

All adults	Weight in kg	Winter	Summer	Total
2009	Passenger	79.5	75.1	77.4
	Carry-on luggage	7.0	5.7	6.4
	Checked luggage	16.6	17.0	16.8
2022	Passengers	77.6	74.7	76.3
	Carry-on luggage	8.0	7.4	7.7
	Checked luggage	15.9	16.0	16.0

Note: This table included results of adult weights only. Children masses are not included.

4.1.2 Passenger characteristics

The average passenger in 2022 is 36.8 years of age. This can be split into the summer of 2022, were the average age is 35.7, while in the winter the average age is 2 years older (37.7 years). A plausible explanation is that in the winter less children, teenagers and students fly, due to schooling or that COVID-19 reduced travel for these age categories. Of the passengers flying within our sample, 1.5 percent are children. However, in the summer and winter of 2022, the percentage of children flying is 2.3 and 1.5 percent, respectively. The average age of passengers in the decade between 2008-9 and 2022 barely changed. In 2008-9, the average age was 36.7 years old, that is, 0.1 years younger than 2022 (36.8 years).

Passenger age distribution

Figure 8 - Summer 2022

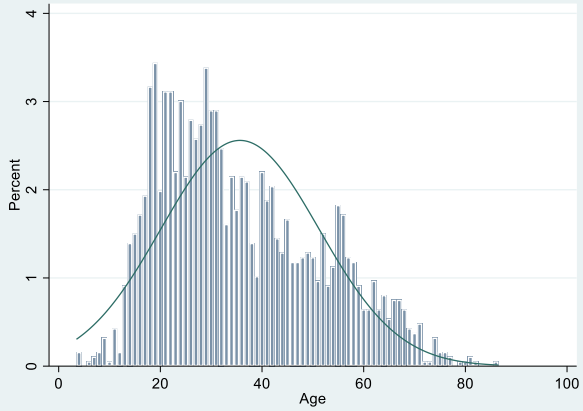


Figure 9 - Winter 2022

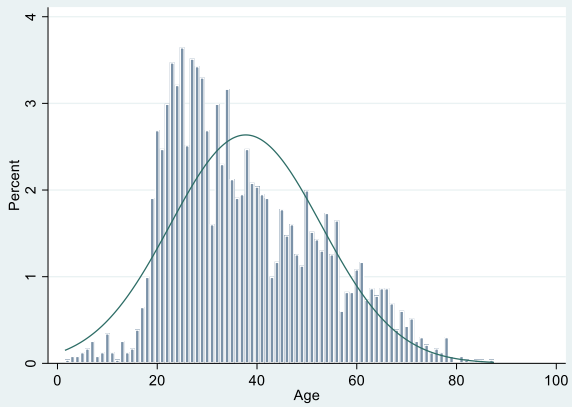


Figure 10 - Summer 2009

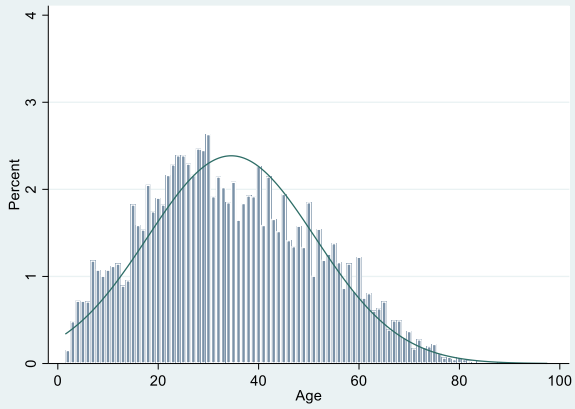
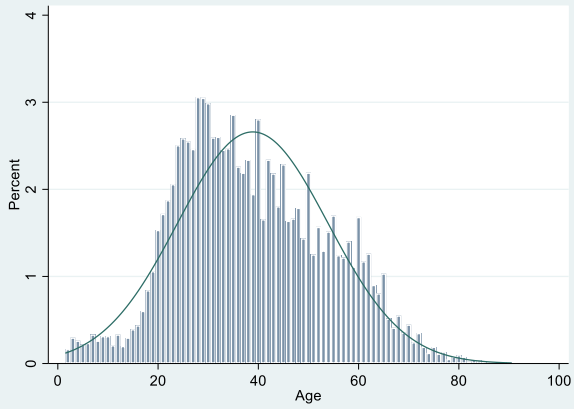


Figure 11 - Winter 2009



While the average age difference between 2008-9 and 2022 is minimal, the distribution of passenger ages highlights substantial variation between the observed years and seasons. Figure 8 and Figure 9 show the age distributions of both seasons in 2022, while Figure 10 and Figure 11 do the same but for 2008-9. The age distributions in all observed periods show a higher number of adults between 18 and 35 as compared to other age groups. We can speculate on the possible explanations, such as the global COVID-19 pandemic having the least

impact on the travel behavior of these adults. Accordingly, and in the absence of any contradicting information, we consider the 2022 sampling as valid. On top of that, the econometric techniques applied at a later stage account for a change in the passenger composition in terms of age and gender.

The mean passenger weight follows a clear pattern over age, see Figure 12 and Figure 13. The strongest increase in passenger weights takes place from birth until around 20 years of age. In both the 2022 (Figure 12) and the 2008-9 (Figure 13) data, this pattern is visible. After age 20, weight increase slows down. Between 20 and 40 year, the average weight increases by 8.6 kg. Between 40 and 50 year, this increase has slowed down to 0.6 kg. The average passenger weight is still increasing, until around 60 years, where it flattens out or only slightly decreases. For children below 15 and adults above the age of 80, the confidence interval widens due to the lower number of observations.

Passenger weight distributions over age

Figure 12 - Age with confidence interval in 2022

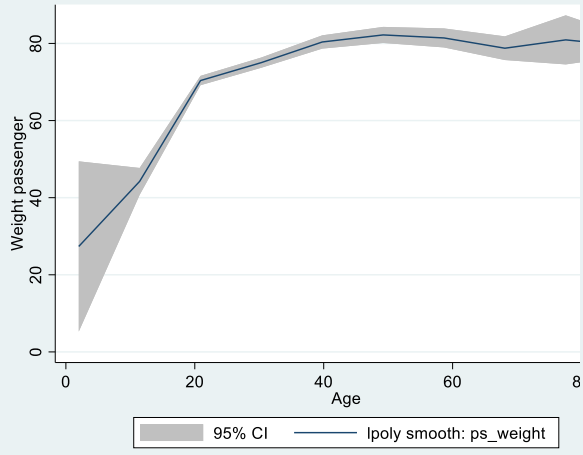
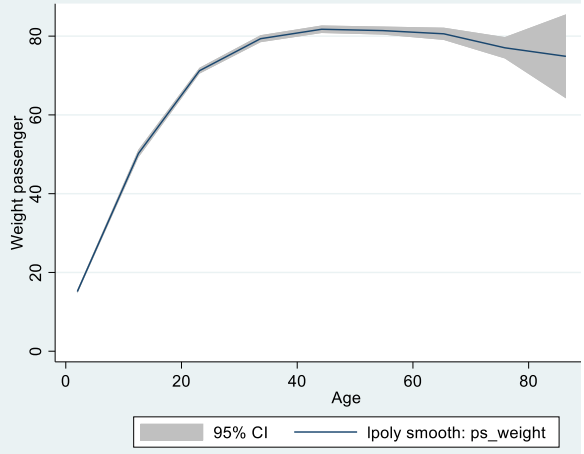


Figure 13 - Age with confidence interval in 2009



Left: Smooth linear spline at 10 interval points for 2022 date. Right: Polynomial unrestricted with ages lower than 85 for 2009 data.

Female passengers between 30 and 65 are underrepresented (Appendix C). This is similar to EASA 2008-9. In the age category under 16 years, females are also underrepresented. Data density for observations of passengers younger than 18 years but above 12 are relatively limited — similar to the 2008-9 survey. We expect that some or all of the following three reasons apply:

1. Children make aviation trips less frequently than adults
2. Fewer children traveled during the COVID-19 pandemic
3. Children are either less willing or not permitted to participate in the survey. There are regulations that restrict participation of children since parental consent is mandatory (see survey setup).

Since we have a similarly low number of observations for children as in the 2008-9 study, it is to be assumed that children are substantially less represented in the overall population that makes use of air transport.

4.1.3 Distribution of passenger, carry-on and checked luggage weights

The distribution of the passenger weights in 2022 approximates a normal distribution, as shown in Figure 16. This is similar to EASA 2008-9. As expected, both the 2022 and the 2008-9 research have few observations below 50 kg or above 125 kg.

Passenger weight distribution in kg

Figure 14 - Summer 2022

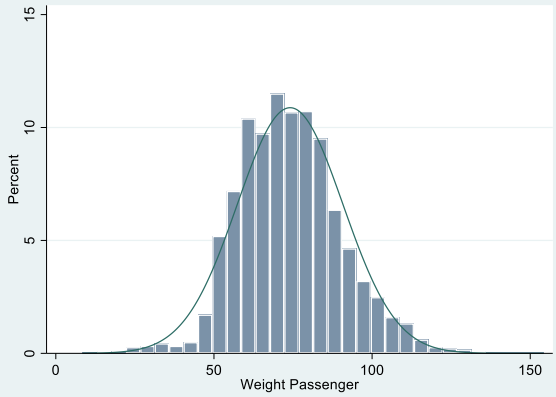


Figure 15 - Winter 2022

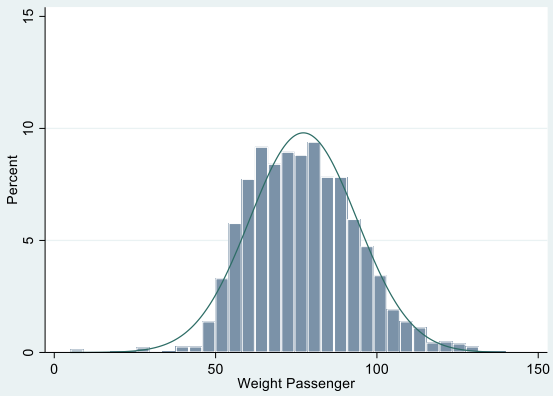


Figure 16 - Both seasons, 2022

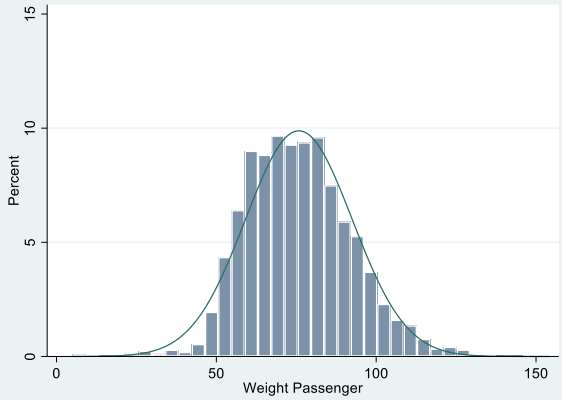
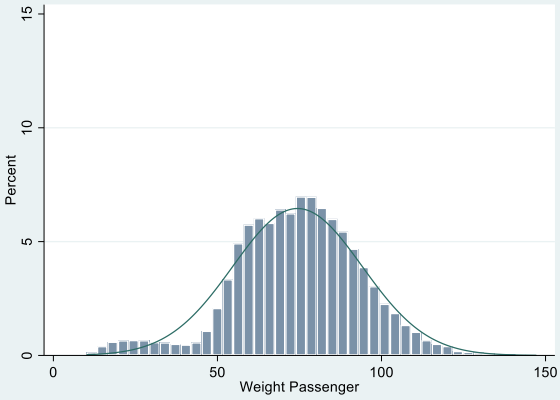


Figure 17 - Both seasons, 2009



In the distribution figures of the carry-on luggage, you can see that in all years and seasons, there are passengers who don't take any hand luggage. In 2022, this was almost 3 percent lower than in 2008-9. This can be explained by passengers taking more carry-on luggage as this is often free of charge, while the checked luggage was more often free of charge in 2008-9 while it requires an additional fee in 2022. Most passengers take between 5 and 8 kg since most airlines have a restriction of 8 kg on allowed carry-on luggage. An overview of the allowed carry-on luggage weight per carrier can be found in Appendix C.

Carry-on luggage weight distribution in kg

Figure 18 - Both seasons, 2022

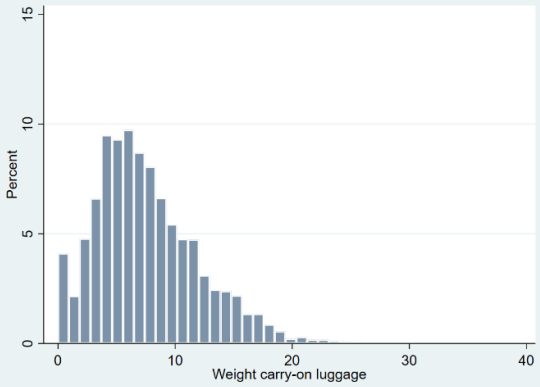


Figure 19 - Both seasons, 2009

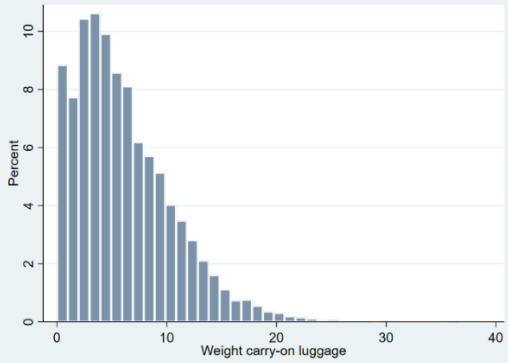


Figure 20 - Summer 2022

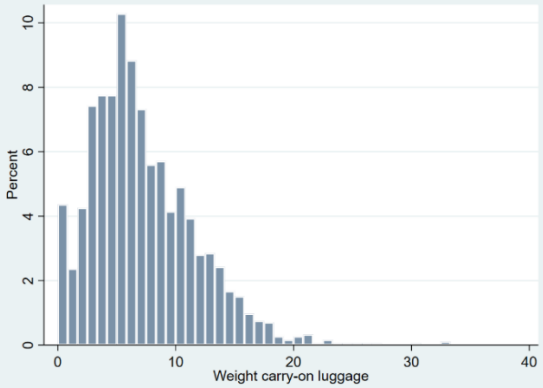
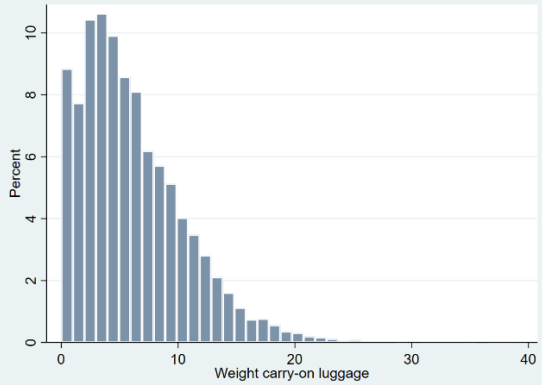


Figure 21 - Winter 2022



Note: All histograms of the carry-on luggage consider the carry-on luggage with a max of 40 kg and in 40 bins.

In the distribution of checked luggage, it is clear that there are certain thresholds. There are peaks at certain points, for example at 16 kg and 23 kg. Right before and after these thresholds, the percentage of people carrying that amount of checked luggage drops substantially. A plausible explanation for this can be that passengers take the allowed maximum kg's of checked luggage of their chosen carrier. This differs per carrier: an overview of the allowed checked luggage weight per carrier can be found in Appendix C.

Checked luggage weight distribution in kg

Figure 22 - Both seasons, 2022

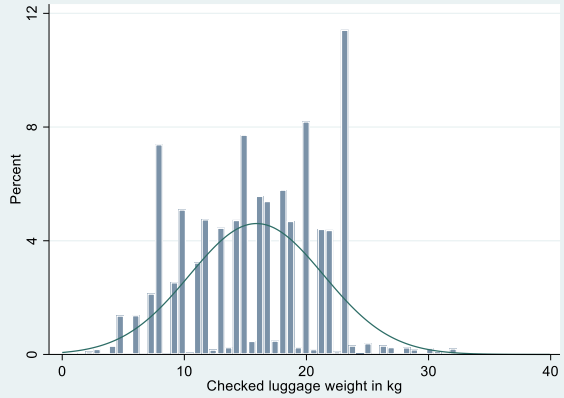


Figure 23 - Both seasons, 2009

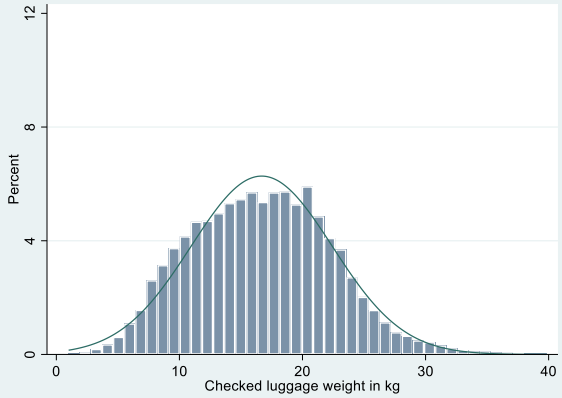


Figure 24 - Summer 2022

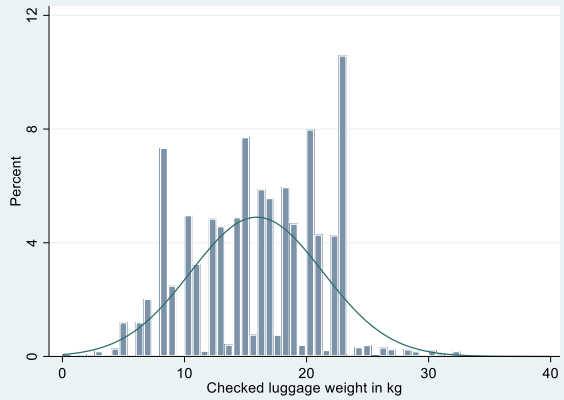
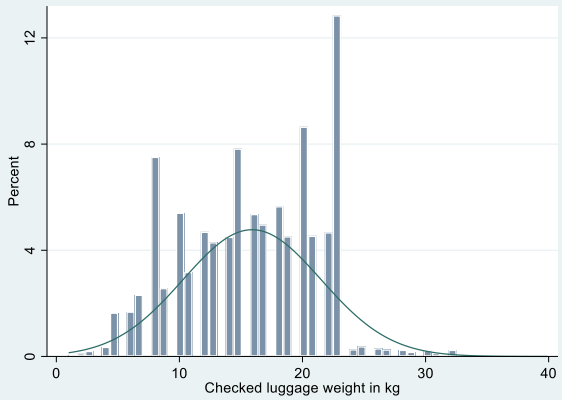


Figure 25 - Winter 2022



4.1.4 Weight by gender

4.1.4.1 Passenger and carry-on luggage

Males weigh on average 14.7 kg more than female passengers and their carry-on luggage is 0.3 kg heavier (7.8 versus 7.5 kg). Children weigh on average 30.4 kg and have carry-on luggage weighing 2.2 kg. Table 7 shows the different weights and distributions across genders. Just over half of the passengers in the survey are males without infants (56.3 percent). Female passengers without infants make up 38.3 percent of the observed passengers and about 1.5 percent are children. The average male passenger in 2022 weighs 82.2 kg compared to 67.5 kg for the average female passenger. The mean weight of the passenger incl. the carry-on

luggage is 83.3 kg.[9]

Table 7 - Passenger, carry-on and combined weight per gender category

2022 – Both season	Share (%)	Mean passenger weight (kg)	Mean carry-on luggage (kg)	Passenger incl. carry-on luggage (kg)
Male	56.3%	82.2	7.8	90.1
Female	38.3%	67.5	7.5	75.0
Child	1.5%	30.4	2.2	32.9
Male w. infant	2.2%	82.4	7.1	89.4
Female w. infant	1.8%	70.2	8.7	79.4
All adults	98.5%	76.3	7.7	84.0
Total	100%	75.6	7.6	83.3

Note: The combined passenger and carry-on luggage weight might deviate from the total of the two separate categories due to passengers only filing in of the three categories in the survey.

Female passengers in 2022 got 0.9 kg heavier compared to 2008-9, while males weigh 2.4 kg less than in 2008-9. Table 8 shows the development of weights between 2008-9 and 2022, over the gender categories presented in Table 7. For 2022, it also shows the differences between summer and winter. The distribution between the different gender categories is comparable between summer and winter observations of 2022. In 2008-9, the average female passenger weighed 66.6 kg and for 2022 this increased to 67.5 kg. The average male passenger weight decreased from 84.6 kg in 2008-9 to 82.2 kg in 2022. The amount of passengers who take carry-on luggage with them differs between 2008-9 and 2022. In 2008-9, 6.2 percent of passengers did not take hand luggage. In 2022, this was 3.3 percent.[10] This difference between the percentages has been confirmed by the survey team. Overall, carry-on luggage weight increased with 1.5 kg between 2008-9 and 2022. In the summer, passengers take an average of 7.3 kg carry-on luggage with them, while in the winter, they take an average of 0.6 kg more (7.9 kg). Especially female passengers take more carry-on luggage with them in the winter than they do in the summer. The difference for this is 0.9 kg, while for male passengers, the difference between seasons is 0.5 kg.

When considering the seasons, there is a clear difference in passenger weights, especially for male passengers. Males weigh 79.6 kg on average in the summer, while this increases with 4.8 kg in the winter (84.4 kg) probably to a large part due to clothing. Female passengers are also heavier in the winter than in the summer, but the difference is smaller than for the male passengers. Female passengers are 1.6 kg heavier in the winter (68.2 kg) than they are in summer (66.6 kg). Overall, passengers weigh 2.8 kg more in winter than in the summer of

[9] The combined weight of passengers and carry-on luggage slightly differs from the summed weights of the separate passenger weight and carry-on luggage weights. The reason behind this is that there are observations that only contain the combined weights, or only one of the separate weights.

[10] There is the possibility that in reality the share of passengers not taking hand luggage is lower. The survey was conducted in such a way that for passengers travelling in a group, only the hand luggage of the first person was measured. Therefore, passengers might have actually taken hand luggage, but this was not measured in the survey.

2022. In 2022, passengers take an average of 0.6 kg more carry-on luggage with them then in winter than they do in summer.

Table 8 - Passenger and carry-on luggage weight per gender, season and year

	Gender	Number of observations	Mean passenger weight (kg)	Std. Dev. passenger weight (kg)	Mean carry-on luggage weight (kg)	Std. dev. carry-on luggage weight (kg)
Total 2008-9	Male (M)	12,588	84.6	15.0	6.7	4.7
	Females (F)	8,351	66.6	12.7	6.0	4.4
	Children	1,420	30.7	11.7	2.0	2.6
	M + infant	298	83.0	14.6	7.0	4.9
	F + infant	244	65.7	12.4	5.5	5.0
	All	22,901	74.5	19.9	6.1	4.6
Total 2022	Male	2,342	82.2	15.3	7.8	5.0
	Females	1,595	67.5	13.1	7.5	5.0
	Children	62	30.4	12.4	2.2	2.6
	M + infant	91	82.4	15.3	7.1	3.7
	F + infant	74	70.2	13.5	8.7	4.9
	All	4,164	75.6	16.7	7.6	5.0
Summer 2022	Male	1,081	79.6	15.6	7.6	5.6
	Females	685	66.6	13.5	7.0	5.5
	Children	27	32.3	10.9	2.8	2.7
	M + infant	42	82.7	14.2	7.1	4.2
	F + infant	26	70.9	13.8	10.0	5.7
	All	1,861	74.0	16.9	7.3	5.5
Winter 2022	Male	1,261	84.4	15.0	8.1	4.4
	Females	910	68.2	12.8	7.9	4.5
	Children	35	28.9	13.4	1.7	2.4
	M + infant	49	81.6	16.3	7.0	3.4
	F + infant	48	69.8	13.5	8.0	4.2
	All	2,303	76.8	17.3	7.9	4.5

4.1.4.2 Checked luggage

Males carry on average 0.3 kg checked luggage less with them than female passengers (15.7 kg versus 16.0 kg). Children carry on average 13.1 kg. The average weight of checked-in luggage is 15.9. This is 0.8 kg less than the average checked luggage weight in 2008-9 (16.7 kg). Table 9 shows the different checked luggage weights across genders and the share per gender.

Table 9 - Values of checked luggage weight per gender, season and year

	Gender	Share (%)	N. obs.	Weight	Std. Dev.
Total 2008-9	Male	58.5%	7,408	16.5	5.9
	Female	40.4%	5,115	16.8	5.7
	Children (2 – 12 years)	1.1%	138	17.1	6.2
	N/A	-	-	-	-
	Total	100%	12,661	16.7	5.8
Total 2022	Male	50.4%	1,006,526	15.7	5.6
	Female	38.5%	768,909	16.0	5.5
	Children (2 – 12 years)	0.2%	3,252	13.1	6.2
	N/A	11.0%	219,383	17.3	5.7
	Total	100%	1,998,070	15.9	5.6
Summer 2022	Male	45.1%	565,921	15.5	5.5
	Female	37.9%	474,785	15.9	5.4
	Children (2 – 12 years)	0.2%	2,730	13.2	6.2
	N/A	16.8%	210,495	17.4	5.7
	Total	100%	1,253,931	16.0	5.5
Winter 2022	Male	59.2%	440,605	15.8	5.6
	Female	39.5%	294,124	16.1	5.6
	Children (2 – 12 years)	0.1%	522	12.7	6.5
	N/A	1.2%	8,888	14.4	5.6
	Total	100%	744,139	15.9	5.6

4.1.5 Weight by carrier type

4.1.5.1 Passenger and carry-on luggage

Two airline types are distinguished: 'low cost carriers' (LCCs) and 'full service carriers' (FSCs). Average hand luggage weights are lower for low cost carriers (LCCs) than for full service carriers (FSCs). Male passengers flying with full service carriers are, on average, 1.6 kg heavier than male passengers flying with low cost carriers. Females flying full service carriers are 0.1 kg lighter than those flying with a low-cost carrier (66.6 kg versus 66.5 kg). The mean passenger weights per carrier type can be found in Table 10. The difference between FSC and LCC in the different seasons of 2022 can be found in Appendix D.

Table 10 - Mean passenger weight per carrier types and gender for 2022 and 2009 (both seasons)

	Gender	Weight 2022	Weight 2009	Std. Dev. 2022	Std. Dev. 2009	N. Obs. 2022	N. Obs. 2009
FSC	Male	82.8	85.0	15.3	15.0	1,778	9,899
	Female	67.3	66.5	13.2	12.7	1,149	6,037
	Child	31.6	30.7	12.5	12.1	46	960
	Male with infant	81.5	82.8	15.4	14.9	74	238
	Female with infant	70.0	65.7	13.3	12.6	52	166
	Total	76.0	75.3	17.1	19.8	3099	17,300
LCC	Male	80.0	83.4	15.9	14.6	540	2,689
	Female	67.8	66.6	13.0	12.6	431	2,314
	Child	27.9	30.8	12.3	11.0	14	460
	Male with infant	85.6	83.8	14.0	13.1	15	60
	Female with infant	70.5	65.9	14.2	11.9	22	78
	Total	74.4	71.9	16.8	19.9	1022	5,601
N/A	Male	85.9	-	13.6	-	24	-
	Female	72.6	-	12.6	-	15	-
	Child	20.5	-	1.6	-	2	-
	Male with infant	91.3	-	27.4	-	2	-
	Female with infant	0.0	-	0.0	-	0	-
	Total	78.5	-	19.6	-	43	-
Total		75.6	74.5	17.1	19.9	4,164	22,901

4.1.5.2 Checked luggage

The allowed checked luggage weight differs per carrier. Full service carriers (FSCs) often allow more checked luggage than low cost carriers (LCCs). And indeed, the average weight of passengers flying with FSCs is 16.0 kg, while passengers flying with LCCs take on average 1.1 kg less (14.9 kg). The mean checked luggage weights, standard deviations and the number of observations of the different carrier types are presented in Table 12. When considering the number of observations per carrier types, it becomes clear that the number of observations for FSCs is larger than the number of observations of LCCs. The FSCs make up 95 percent of the sample, while LCC makes up 5 percent. In order to verify this split, we compare this to OAG Analyser data[11]. We compare the shares of LLC versus FSC within all datasets, see Table 11. The OAG data has a higher ratio of LLC than the other data sets, likely due to the surveying locations. We account for this in the econometric analyses and show that this difference does not affect our results.

Table 11 - Ratios low cost carrier and full-service carrier

Dataset	Type	Low Cost Carrier (LCC)	Full Service Carrier (FSC)
2009	Passengers and carry-on luggage	76%	24%
	Checked luggage	74%	26%
2022 Before resampling	Passengers and carry-on luggage	75%	25%
	Checked luggage	95%	5%
OAG Analytics	All passengers	61%	39%
2022 Resampled	Passengers and carry-on luggage	*No correction*	*No correction*
	Checked luggage	67%	33%

Table 12 - Mean Checked luggage weights per carrier types for 2022

Low cost or Full service carrier	Mean	Std. Dev.	N. Obs. 2022
FSC	16.0	5.5	1,246,088
LCC	14.9	5.5	72,511
N/A	15.9	5.6	679,471
Total	15.9	5.6	1,998,070

We compare the checked luggage weight distribution of FSC with LCC in Figure 26 and Figure 27. The distributional graphs are highly similar. However, FSC have a larger number of observations with checked luggage above 20 kg. LCC passengers often check in luggage of 8 kg. It is likely that these are observations where passengers decide to check in their carry-on luggage because they do not have any other checked luggage. The distributions are shown in Figure 26 and Figure 27. The distributions of checked luggage weight show that passengers take into account the regulations of carriers.

[11] OAG Analyser. (n.d.). Retrieved 21 September 2022, from http://analytics.oag.com/analyser-client/home

Checked luggage weight distribution in kg for FSC and LCC

Figure 26 - Checked luggage 2022 – FSC

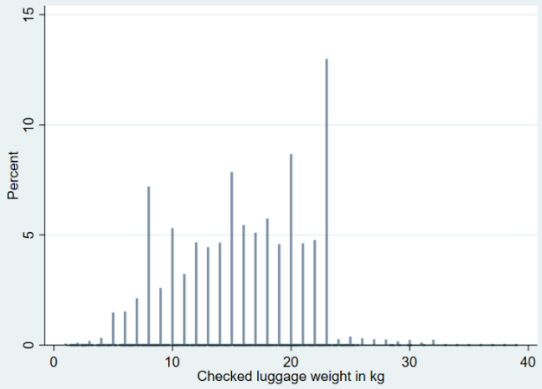
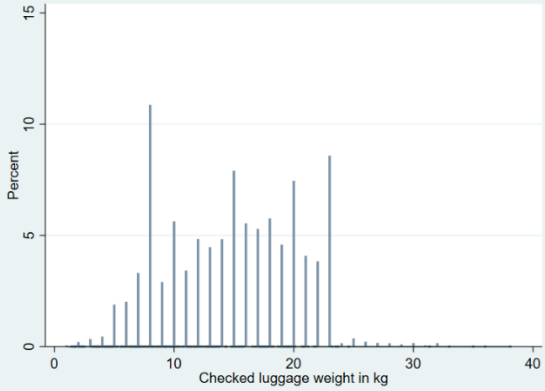


Figure 27 - Checked luggage 2022 – LCC



4.1.6 Weights by class

In this research, the different classes in an aircraft are divided into two categories. Passengers flying economy or premium economy are put together under the first category, while business and first class passengers are put under the second category.

4.1.6.1 Passenger and carry-on luggage

Passengers flying (premium) economy weigh, on average, 75.4 kg. For business and first-class passengers, this is 5.5 kg heavier (80.9 kg). However, it is important to look at whether this difference truly comes from the different flight classes, or that other underlying factors play along. An important factor here is that the share of male passengers is also higher among business and first-class seats than it is among (premium) economy. The (premium) economy class passengers exist for 56.1 percent of males (without infants) and also, 2.1 percent are children. While for the business and first class, 63.5 percent are males and only 0.8 percent are children. In these instances, these variations in passenger characteristics are controlled for in the econometric analyses later, so as to precisely pinpoint the determinants of mean weights. Standard deviations and the number of observations of passenger weights, carry-on luggage weight and the combined passenger and carry-on luggage weight can be found in Table 13. Carry-on luggage weights have an average of 7.6 kg for (premium) economy and 8.8 kg for business and first class.

Table 13 - Passenger and carry-on luggage per class in 2022

Class		Mean	Std. Dev.	N. Obs.
Passenger weight	Economy & premium economy	75.4	17.1	4,005
	Business & first class	80.9	17.0	126
	N/A	73.1	19.7	33
	Total	75.6	17.1	4,164
Carry-on luggage	Economy & premium economy	7.6	5.0	4,005
	Business & first class	8.7	5.2	126
	N/A	8.1	4.5	33
	Total	7.6	5.0	4,164
Weight passenger + carry-on luggage	Economy & premium economy	83.1	18.1	4,005
	Business & first class	89.9	18.8	126
	N/A	81.2	21.8	33
	Total	83.3	18.2	4,164

4.1.6.2 Checked luggage

Business and first-class travelers take an average of 1.4 kg more with them (18.7 kg) than (premium) economy passengers (17.3 kg). When acquiring a business or first-class ticket, there is often checked luggage included while it is not always for the (premium) economy class. Or, additionally, there is more checked luggage allowed than for (premium) economy class. Therefore, the expectation would be that business and first-class passengers take slightly more checked luggage than (premium) economy passengers. The results presented in Table 14 are in line with this expectation.

Table 14 - Checked luggage per class in 2022

Class	Mean	Std. Dev.	N. obs. 2022
Economy & premium economy	17.3	5.6	147,991
Business & first class	18.7	5.7	44,528
N/A	15.8	5.5	1,805,551
Total	15.9	5.6	1,998,070

4.1.7 Weights by aircraft size

In this study, small aircraft are considered to be aircraft that fit less than 100 seats, while large aircraft have a minimum of 100 seats.

Table 15 - Passenger weights for small and large airplanes for 2022

	Size	Weight 2022	Std. Dev. 2022	N. Obs. 2022
Weight passenger + carry-on luggage	Small (<100 seats)	86.3	17.7	285
	Large (>100 seats)	82.8	18.0	3,260
	N/A	84.3673	19.1506	619
	Total	83.3	18.2	4,164
Carry-on luggage	Small (<100 seats)	7.8	4.2	285
	Large (>100 seats)	7.5	5.1	3,260
	N/A	8.1	4.6	619
	Total	7.6	5.0	4,164
Passenger weight	Small (<100 seats)	78.4	17.0	285
	Large (>100 seats)	75.2	16.9	3,260
	N/A	76.0	18.1	619
	Total	75.6	17.1	4,164
Checked luggage	Small (<100 seats)	15.4	3.5	13,271
	Large (>100 seats)	17.0	6.0	211,891
	N/A	15.8	5.5	1,772,908
	Total	15.9	5.6	1,998,070

4.1.7.1 Passenger and carry-on luggage

Small aircraft have a higher average for passenger weights and for carry-on luggage. The average passenger weight of a small aircraft is 78.5 kg while for a large aircraft, this is 2.9 kg less (75.6 kg). The carry-on luggage has an average of 7.8 kg for small aircraft, while the average is 7.6 kg for large aircraft. The differences between small and large aircraft in the different seasons can be found in Appendix E.

4.1.7.2 Checked luggage

The average checked luggage weight of passengers travelling in a small aircraft is 15.4 kg. This is 1.6 kg less than passengers flying with a large aircraft. However, it is likely that small aircraft are used more for short-haul flights and large aircraft for long-haul flights. If this is the case, it is plausible that the difference between the weights of the small and large aircraft can actually be explained by the flight distance.

4.1.8 Weight by purpose

The purpose of the trip refers to the motive for travelling as stated by the passenger. Two categories are used: business and leisure. This factor is only known for passenger and carry-on luggage, but is not known for the checked luggage data. Passenger who travel for leisure are overall lighter than passengers who travel for business. Female passengers who travel for leisure are 3 kg lighter than those who travel for business, while male passengers travelling for leisure are, on average, 5.3 kg lighter than those travelling for business. The number of passengers who travel for business with an infant is low. See Table 16 for more details on the passenger weights per purpose and gender.

Table 16 - Passenger weights per purpose and gender for 2022 and 2009

	Purpose	Weight 2022	Weight 2009	Std. Dev. 2022	Std. Dev. 2009	N. Obs. 2022	N. Obs. 2009
Male	Leisure	80.6	83.2	15.4	15.0	1665	7861
	Business	86.0	87.1	15.0	14.5	672	4727
	N/A	96.0	-	16.3	-	5	-
	Total	82.2	84.6	15.3	15.0	2342	12588
Female	Leisure	66.9	66.5	12.9	12.7	1279	6617
	Business	69.9	66.6	14.0	12.6	312	1734
	N/A	69.7	-	19.5	-	4	-
	Total	67.5	66.6	13.1	12.7	1595	8351
Male with infant	Leisure	79.4	84.9	13.9	12.8	65	38
	Business	89.8	82.7	16.6	14.8	26	260
	Total	82.1	83.0	15.4	14.6	91	298
Female with infant	Leisure	70.0	72.2	13.8	13.7	63	63
	Business	71.1	63.5	12.1	11.0	11	181
	Total	70.2	65.7	13.5	12.4	74	244

Note: Travel purpose is not recorded for children.

4.1.9 Weights by flight distance

The flight distance of a flight is divided into one of the following three categories; short, medium or long-haul. Short-haul flights are flights less than 500 km long, medium flights are between 500 and 5,000 km and long-haul flights are 5,000 km or more. Flight distance is one direction; hence, it does not include the return flight.

4.1.9.1 Passenger and carry-on luggage weights

The average passenger flying long-haul weighs 74.2 kg. This is 2.5 kg less than the average passenger weight on short-haul flights (76.6 kg). The average weight of passengers flying medium-haul is 75.9 kg.

Table 17 - Passenger weights

Haul	Weight 2022	Std. Dev. 2022	N. obs. 2022
Short-haul	76.7	18.1	387
Medium-haul	75.8	16.6	1,485
Long-haul	74.0	18.3	33
N/A	75.2	17.3	2,259
Total	75.6	17.1	4,164

Note: For 2,259 observations, the flight distance could not be uniquely identified according to the associated flight number in the survey.

Passengers take an average of 7.5 kg carry-on luggage with them on short-haul flights. When flying medium-haul, passengers take 0.1 kg less than on short-haul flights (7.4 kg) and when flying long-haul, they take 0.1 kg more (7.6 kg). However, the number of observations for long-haul is not sufficiently large to conclude this statistical difference with certainty. Therefore, we propose that the passenger weights and carry-on luggage weights are similar between the different hauls.

Table 18 - Carry-on luggage

Haul	Weight 2022	Std. Dev. 2022	N. obs. 2022
Short-haul	7.5	4.1	387
Medium-haul	7.4	4.2	1,485
Long-haul	7.6	4.9	33
N/A	7.8	5.6	2,259
Total	7.6	5.0	4,164

Note: For 2,259 observations, the flight distance could not be uniquely identified according to the associated flight number in the survey.

4.1.9.2 Checked luggage weights

Passengers take on average 17.6 kg on long-haul flights. This is 1.3 kg more than on short-haul flights (16.3 kg). This is plausible, because passengers flying long-haul are more likely to travel for a longer duration onsite than passengers flying short-haul; meaning that they are inclined to take more belongings with them. The standard deviation of short, medium and long-haul is similar (5.4 to 5.6 kg), which is expected due to the high number of observations for all three categories.

Table 19 - Checked luggage

Haul	Weight 2022	Std. Dev. 2022	N. obs. 2022
Short-haul	16.3	5.4	343,208
Medium-haul	15.9	5.6	1,154,318
Long-haul	17.6	5.4	169,096
N/A	15.0	5.5	331,448
Total	15.9	5.6	1,998,070

Note: For 331,448 observations, the flight distance could not be uniquely identified according to the associated flight number in the survey.

4.1.10 Observations per airport

This section considers the distribution of passenger and trip characteristics of interest per airport. Table 20 below denotes the ratio of gender, season, class, purpose and haul per airport for passengers and carry-on luggage. Gender categories are similar over all airports. Male passengers without infants make up at least 50 percent of the flying population at every included airport. Females without infants make up between 33 and 44 percent of the flying population. Children, males with infants and females with infants all make up below 4 percent at every airport considered.

Most airports were visited in both seasons, Munich airport (MUC) only in winter, due to operational constraints. Furthermore, it becomes clear that most passengers fly economy or economy premium. For most airports, this share is 95 percent or higher. Munich (MUC) has the lowest percentage of (premium) economy travelers (91 percent). Furthermore, Brussels has the most business travelers (33 percent). A possible explanation is that Brussels is the political center of the European Union. When looking at the flight distance, it becomes clear that for many observations this classification cannot be made (that is, not applicable). The haul is based on the flight numbers as recorded in the survey. However, to compute the matching distance per flight number, the flight number has to correspond with the OAG database. When this does not correspond — due to differences in spelling or notation —, the distance and therefore the haul cannot be identified. We assume that the haul classification is not specified at random in the econometric analysis.

Table 20 - Ratios per airport of gender, season, class, purpose and haul for passenger and carry-on luggage

2022 – both seasons	Current airport	ATH	BRU	CPH	MUC	MXP	SOF	Total
Gender	Male	50%	58%	61%	51%	59%	54%	56%
	Female	42%	37%	33%	44%	38%	41%	38%
	Child	2%	1%	2%	2%	1%	2%	1%
	Male & Infant	3%	3%	3%	1%	1%	2%	2%
	Female & Infant	3%	2%	2%	2%	1%	2%	2%
Season	Summer	69%	28%	38%	0%	54%	51%	45%
	Winter	31%	72%	62%	100%	46%	49%	55%
Class	Economy / premium	98%	97%	95%	91%	99%	98%	97%
	Business / 1st class	2%	3%	5%	9%	1%	2%	3%
Purpose	Leisure	84%	67%	72%	74%	84%	70%	75%
	Business	16%	33%	28%	26%	16%	30%	25%
Haul	Short	29.5%	5.4%	7.6%	13.7%	0.6%	1.8%	9.3%
	Medium	30.2%	42.8%	36.9%	34.0%	0.8%	74.2%	35.7%
	Long	0.3%	2.5%	0.6%	2.4%	0.0%	0.0%	0.8%
	Not applicable	40.1%	49.4%	54.9%	49.8%	98.6%	24%	54.3%

Note: Haul not applicable for all Flights with flight numbers that could not directly be matched with OAG flight information.

Table 21 - Mean checked luggage per airport in 2022

Airport	Mean	Std. Dev.	N. obs. 2022
ATH	16.8	5.7	334,871
BRU	16.0	5.7	65,519
CPH	14.5	5.1	141,243
MUC	15.9	5.5	1,300,000
MXP	15.6	5.6	115,017
SOF	15.6	5.4	52,620
Total	15.9	5.6	1,998,070

Note: For 22,253 observations, the departure airport recording the weight information is not uniquely identifiable.

4.2 Econometric analyses

4.2.1 Models

For a more in-depth assessment of passenger weights, we carry out several econometric analyses. We perform regression analyses using ordinary least squares estimation (OLS). The variables of interest — the dependent variables — are passenger weights, carry-on luggage weights, the combined weight thereof, and checked luggage weights.

We merge the 2008-9 data set with the newly conducted survey data of 2022 to use in regressions with the repeated cross-sectional data thereby improving the estimation precision. This allows us to control for demographic trends (for example, age and gender) and flight characteristics (for example, survey airport and flight distance). Furthermore, we separate intercepts for the year of the survey and the season of the survey. The year intercept can be interpreted as the change in weight between the observation periods given controls for passenger and flight characteristics. Another advantage of enriching the data set with data from the previous study is the ability to deal with a lack of precision for the lower amount of observations for children and adults with infants.

For part of the specifications, we use the same explanatory variables as in the EASA 2008-9 survey to allow for comparison with the results of the former study. We improve upon EASA 2008-9 by motivating variable choice from scientific literature that we reference in the beginning of chapter 4. We report significance levels (p-values) and standard deviations in our results.

4.2.2 Measurement errors and biases

Sampling bias might be an issue for this study. Biases can arise from at least three different sources. First, certain passengers might purposefully avoid sampling due to any number of reasons: for example, time pressure, cultural aversion to participation, safety of personal related data, et cetera. A second likely source of sampling bias is the measurement location. While we chose measurement locations to ensure consistency with the previous EASA survey of 2008-9, it is possible that certain passenger groups enter the larger airport from other entrances and thereby random sampling might not be perfect. A third source for sampling bias is COVID-19 which possibly changes passenger compositions with respect to pre-COVID-19 levels.

We address sampling bias in a number of ways:

1) We choose measurement locations to avoid sampling bias (see survey setup)

2) We conduct random sampling and aim to avoid self-selected observation bias (see survey setup)

3) We search for population data on aviation passenger distributions from airlines and airports both pre-COVID-19 and during our survey timeframe to compare the distribution of age and gender. This would have allowed us to calculate the size of the potential bias with respect to pre-COVID-19 levels in our review. Contrary to our expectations, no suitable data was available despite intensive examination of scientific literature and investigating with airport stakeholders. After looking into the airlines, airports, OECD, Eurostat and academics, we were unable to determine the passenger population on a non-COVID-19 day in order to compare to aviation travel outside of COVID-19. The best comparison therefore is the 2008-9 data. Several academic sources have been consulted about weight developments for gender

and age groups.[12] The sources found make the information we have on the descriptive statistics and econometric analyses highly plausible and suggest that measurement errors are not a major issue within the 2022 study. However, these studies and the data contained therein do not provide sufficient information for econometric analyses to be taken further. As a suitable alternative, we compare the survey respondent characteristics between the 2008-9 and 2022 study. We find that COVID-19 had a measurable effect on the traveler composition in the winter 2022 measurements, but not with respect to the 2008-9 measurements.

4) We compare the gender and age distribution of the checked-in luggage data with the age distribution of the passenger weight survey data in 2022. Since checked-in luggage data originates to the largest extent from automatic registration of luggage data by airlines, it is a random sample of the true population. We can then compare the distribution of the true population among the gender categories (and, for a subsample, also age) with the survey data. This allows us to speculate on the presence and size of the potential survey sampling bias. We find no indication of sampling bias along these characteristics in this comparison, please see Table 22 and Figure 28 and Figure 29 . The male/female ratio per airport for the checked luggage data and the passenger and hand luggage data are very similar. This is relevant because it implies that the datasets are comparable in terms of gender and the likeliness that there is sampling bias in our survey is minimal or even absent. Similarly, checked luggage weights from the survey sampling is similar to the electronic sampling. Since the latter comprises all types of luggage, the similarity suggests that there is no bias in the former.

Table 22 - Gender ratios per airport and luggage type

2022 – both seasons	Checked luggage		Passenger & checked luggage weight	
	Male	Female	Male	Female
ATH	55.1%	44.6%	50.1%	41.7%
BRU	61.6%	38.3%	58.4%	36.8%
CPH	59.1%	40.7%	61.0%	32.6%
MUC	59.9%	40.0%	51.2%	44.0%
MXP	63.8%	35.9%	59.1%	37.8%
SOF	61.2%	38.8%	54.1%	40.8%
Total	59.9%	40.0%	56.3%	38.3%

[12] - Peralta, M., Ramos, M., Lipert, A., Martins, J., & Marques, A. (2018). Prevalence and trends of overweight and obesity in older adults from 10 European countries from 2005 to 2013. *Scandinavian journal of public health*, *46*(5), 522-529

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Age distribution

Figure 28 - Winter 2022 Checked luggage

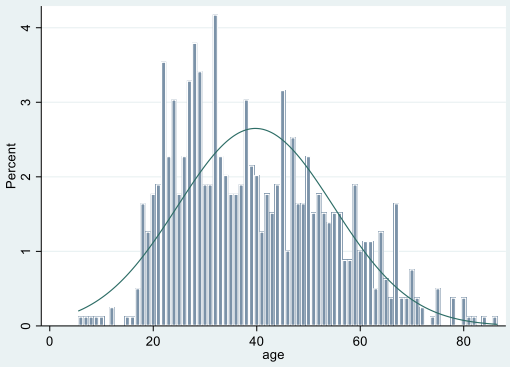
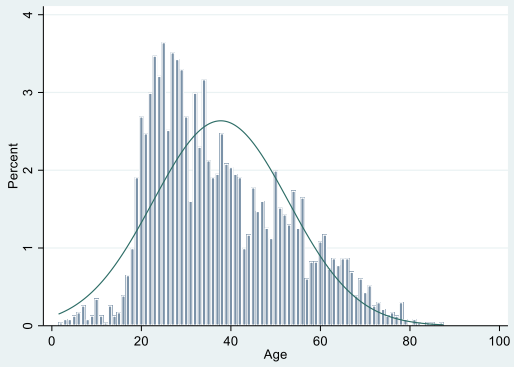


Figure 29 - Winter 2022 Passenger weights



5) We considered suitable empirical techniques to deal with potential sampling bias if suitable and necessary. Due to potential sampling bias, censoring as well as truncation of data, we considered employing a number of advanced empirical regression designs: truncated regression models to account for censored outcomes, sampling bias and truncation such as Tobit[13] specifications, Heckman Correction[14] specification to correct bias from non-randomly selected samples or otherwise incidentally truncated dependent variables. As noted earlier, we do not find sufficient indications of sampling bias or truncation to warrant the use of advanced empirical regression designs. We report outcomes of more advanced techniques in Appendix F for comparison. These outcomes are similar to the main results, but with a reduced statistical precision (as to be expected).

Should enriched data on children and infants remain too low for sufficient statistical precision, we proposed a Monte Carlo simulation where we assume traveler population age distribution to follow either general population age distributions or full sample distributions provided by carriers or airports. We find that the enriched data are sufficient for statistical inference regarding the research question, which renders Monte Carlo simulations for standard error reduction unnecessary. Furthermore, we do not find any evidence that traveler population characteristics of age and gender follow general population age distributions. Hence, this technique is not advisable since there is a strong indication that our surveyed data fit random sampling of the true aviation traveler population. Also, no better data and information on the true distribution of these group with lower representation are available to us to suggest any meaningful further investigation.

[13] Amemiya, T. (1985). Tobit Models. *Advanced Econometrics, 360-411*. Oxford: Basil Blackwell. ISBN 0-631-13345-3.
Breen, R. (1996). The Tobit Model for Censored Data. *Regression Models: Censored, Samples Selected, or Truncated Data,* 12-33. Thousand Oaks: Sage. ISBN 0-8039-5710-6.

[14] Heckman, J. (1974). Shadow Prices, Market Wages, and Labor Supply. *Econometrica, 42*(4), 679–694.

4.3 Econometric analyses

We carry out a regression analysis using Ordinary Least Squares (OLS) estimation with a range of explanatory variables, comparable to EASA 2008-9. We improve upon EASA 2008-9 by motivating our variable choice based on aviation and scientific literature. In our results, we include p-values, t-tests and confidence intervals.

4.3.1 Linear regression

OLS is used to estimate the coefficients of the explanatory variables. This technique determines the coefficients in such a way that it minimizes the squared difference between the observed mass of a passenger and the mass that the model would predict based on the explanatory variables (and a constant), summed over all passengers in the dataset. The following section presents the results of the OLS regression on passenger weights, carry-on luggage weights and checked luggage.

4.3.1.1 Passenger weights

The mean passenger weight increased by 2.2kg between 2008-9 and 2022 without controlling for passenger characteristics (that is, age and gender), see column I in Table 23. However, when controlling for passenger and flight characteristics, there is no significant difference in passenger weights between passengers flying in 2008-9 and 2022, see column II. In other words, the change in mean passenger weight between 2008-9 and 2022 stems from the change in passenger characteristics (potentially due to COVID-19).

The gender, age and seasons of travel matter for the mean weights of passengers, see Appendix G for detailed coefficients. Controlling for all other explanatory variables included in the model, passengers weigh on average 2.1 kg more in the summer than they do in the winter. The passenger weight increases over the course of passenger's lives when controlling for other background characteristics, see Appendix G for all coefficients omitted in Table 23. From age 41-45, men weight about 86.2 kg. Female passengers weigh 16.8 kg less than male passengers. Children (between 2 and 12 years old) weigh on average 30.5 kg.

Passengers flying for business purposes weigh 1.3 kg more than passengers flying for leisure. No significant difference is found between passengers flying medium or long-haul, compared to those who fly short-haul. Furthermore, there is no weight difference between passengers flying business class versus passengers flying economy. Neither is there a difference between passengers flying with low-cost carriers or full-service carriers. The latter two findings are likely related to the fact that people travelling for self-stated business purposes take 1.4 kg extra.

4.3.1.2 Carry-on luggage

When looking at the OLS results, most factors of interest included have a significant impact on the carry-on luggage weight. Passengers take on average 1.5 kg more carry-on luggage with them in 2022 than they did in 2008-9 reconfirming the results from the descriptive statistics. These findings can be found in Table 23, column III.

There also is a difference within the gender categories and the seasons: female passengers take 0.6 kg less than males, and passengers take on average 1 kg more carry-on luggage with them in winter than they do in the summer. Business travelers carry on average 1 kg more in their carry-on luggage than leisure travelers. There also is a significant difference in the distance of the flight. Compared to short-haul flights, medium-haul passengers take on average 0.2 kg more carry-on luggage with them and long-haul passengers take 0.4 kg more. And lastly, the average carry-on luggage weight is very similar for passengers between the ages 31 and 65.

Table 23 - Regression results on passenger weights, carry-on luggage weights and the Tobit model results on carry-on luggage of both seasons in 2022

VARIABLES (ref. = reference category)	Dependent variable						
	Passenger weight (kg) **OLS I**	Passenger weight (kg) **OLS II**	Carry-on luggage weight (kg) **OLS III**	Carry-on luggage weight (kg) **OLS IV**	Carry-on luggage weight (kg) **Tobit V**	Passengers + carry-on weight (kg) **OLS VI**	Passengers + carry-on weight (kg) **OLS VII**
Year (ref. is 2009)							
2022	2.256***	0.275	1.452***	1.277***	1.542***	1.718***	3.867***
Age	-	Appendix F	Appendix F	Appendix F	Appendix F	Appendix F	-
Gender (ref. is male)							
Female	-	-16.47***	-0.313***	-0.550***	-0.233***	-16.79***	-
Child	-	30.30***	1.541***	2.655***	0.330**	31.86***	-
Male with infant	-	-1.353*	-0.0578	-0.207	-0.0292	-1.424*	-
Female with infant	-	-16.05***	-0.491*	-0.645**	-0.454*	-16.45***	-
Airport	Appendix F	Appendix F	Appendix F	Appendix F	Appendix F	Appendix F	Appendix F
Season (ref. is summer)							
Winter	5.883***	2.118***	0.984***	0.999***	1.005***	3.115***	7.184***
Purpose (ref. is leisure)							
Business	6.861***	1.486***	1.138***	0.988***	1.205***	2.651***	8.353***
N/A (Purpose)	12.78*	11.09*	1.491	1.415	1.451	12.56*	14.35*
Haul (ref. is short-haul)							
Medium-haul	-0.935***	-0.243	0.210**	0.229***	0.201**	-0.0346	-0.778**
Long-haul	-0.586	0.0485	0.440***	0.385***	0.470***	0.495	-0.188
N/A (Haul)	-0.586	0.166	0.328*	0.453**	0.278	0.608	-0.216
Class (ref. is economy & premium economy)							
Business & first class	-1.096**	0.250	0.107	0.128	0.135	0.356	-1.121**
N/A (Class)	-5.353	-3.792	0.753	0.484	0.912	-3.056	-4.801
Carriertype (ref. is FSC)							
Low cost carrier (LCC)	-2.351***	-0.0943	-0.749***	-0.733***	-0.796***	-0.822***	-3.190***
N/A (carriertype)	0.175	1.870	-0.876	-0.549	-1.013	0.925	-0.883
Constant	71.18***	-		-	-	-	76.21***
Observations	27,065	27,065	27,065	25,506	27,065	27,065	27,065
R-squared	0.06	0.971	0.688	0.718		0.972	0.079

*Note: Standard errors in parentheses, significance *** p<0.01, ** p<0.05, * p<0.1. Column IV, missing hand luggage observations not included in regression.*

For the hand luggage and the checked luggage data, there is an additional bias to take into account, namely 'censoring'. Censoring refers to the situation where there is an upper or lower bound until which data can be measured and where observations exceeding these limits are censured. Then, there is the knowledge that there is an observation which equals at least the value of the limit. In this dataset, the carry-on luggage weight data are censored to the left (lower limit). This is because when people do not have carry-on luggage, it might be noted as

missing. Therefore, these observations are not included in the OLS, which could give a biased result. The Tobit model, also called the censored regression model, is an econometric technique suitable to correct for such instances. It replaces the missing hand luggage observations into zeros. The number of observations is slightly higher, because the observations where hand luggage is not measured are still included.[15] For example, the difference between hand luggage in 2008-9 and 2022 is 1.5 kg when using the Tobit regression. This is 0.2 kg more than what was measured with the OLS regression, which can be explained by the fact that there are more passengers with missing hand luggage in 2008-9 (6.2 percent) than there are in 2022 (3.3 percent). Because these observations are dropped in the OLS regression, but taken into account and measured as being zero kilos in the Tobit regression, the difference between 2008-9 and 2022 is larger in the Tobit regression. This reasoning applies to all coefficients that can be found when comparing the OLS results to the Tobit results. The results of this model are presented together with the regression results in Table 24. The first column includes the full sample but uses less variables due to missing entries. The second column, has the complete specification but hence less observations. The third column, adjusts the ratio of FSC to LCC according to the distribution in OAG schedule data by randomly drawing and omitting observations from FSC above the required share.

Due to the minor difference in coefficients and the high likelihood that missing observations of hand luggage are true measures of having no hand luggage, we recommend the use of the OLS specification in column III or the Tobit specification in column V. An alternative is to include the observations with missing hand luggage weights as zero kg in the OLS regression. This likely results in almost identical estimations as with the Tobit model. This is also the approach taken in the descriptive statistics section earlier.

Mean passengers and carry-on luggage weights increased jointly by 3.9 kg between 2008-9 and 2022 when not controlling for passenger characteristics, see column VII. When controlling for age and gender, the increase equals 1.7 kg, see column VI. Passenger characteristics explain almost 90 percent of mean passenger and carry-on luggage weights, where flight characteristics only explain 7 percent (see the difference of the R-squared between both regressions).

[15] This is under the assumption that missing hand luggage indicates that the passenger does not have hand luggage and it is therefore zero kg — and not that the passenger did have hand luggage, but for an unknown reason it is not measured.

4.3.1.3 Checked luggage

The first column includes the full sample but uses less variables due to missing entries. The second column, has the complete specification but hence less observations. The third column, adjusts the ratio of FSC to LCC according to the distribution in OAG schedule data by randomly drawing and omitting observations from FSC above the required share.

Table 24 - Regression results of checked luggage

VARIABLES (ref. = reference category)	Checked luggage (kg) Reduced form OLS	Checked luggage (kg) Complete OLS	Checked luggage (kg) OLS with sub sample
Constant			
Year (ref. is 2009)			
2022	-0.497***	-0.959***	-1.032***
Season (ref. is summer)			
Winter	0.124***	0.0278***	-0.0108
Gender (ref. is male)			
Female	0.309***	0.270***	0.285***
Children	-2.383***	-1.902***	-1.918***
Missing	1.383***	-2.049***	-1.839***
Airport (ref. is ATH)			
BRU	-0.159***	0.652***	0.857***
CPH	-1.620***	-0.852***	-0.795***
FRA	0.986***	-0.526**	-0.521**
LGW	0.147	-0.0276	-0.0289
MAD	-0.126	0.277	0.261
MUC	-0.222***	0.281***	0.374***
MXP	-0.487***	0.386***	0.545***
SOF	-0.518***	0.449***	0.414***
WAW	0.0812	-0.256	-0.255
AMS	1.637***	0.538**	0.514**
Haul			
Medium-haul		-0.556***	-0.554***
Long-haul		1.276***	1.401***
Carriertype			
Low cost carrier (LCC)		-0.437**	-0.391**
Observations	2,020,423	1,253,632	153,123
R-squared	0.013	0.018	0.021

*Note: Standard errors in parentheses, significance *** p<0.01, ** p<0.05, * p<0.1. OLS with sub sample accounts for the distribution of FSC to LCC in sample vs OAG route data and adjust data sampling distribution to the latter.*

Most factors of interest included in the OLS regression of the checked luggage have a significant impact. Passengers take on average 1 kg of checked luggage less in 2022 than they did in 2008-9. The difference between the average checked luggage weights in the summer or the winter is minimal, but significant, namely 0.03 kg. These results can be found in The first column includes the full sample but uses less variables due to missing entries. The second column, has the complete specification but hence less observations. The third column, adjusts the ratio of FSC to LCC according to the distribution in OAG schedule data by randomly drawing and omitting observations from FSC above the required share.

5 Summary of results and applicable regulation

5.1 Children masses plus carry-on luggage

As with the previous study, a large standard deviation can be observed in the findings for children. It is mainly due to the smaller sample and diversity of weight during childhood per age. From 2 to 12 years old children are subject with variance in specific age, but have a huge variance from 2 years till becoming 12 years old.

Data shows significant correlation between child weight and child age as expected. The mean masses including carry-on luggage was close to 34.3 kg, so slightly close to current 35 kg defined by regulation and slight below the previous study recommendation of 40 kg.

Despite obtaining data for children in all age from 2 to 12 years old and the corresponding weights being in line with what is expected for each age, the number of observations is too small to be necessarily representative of the profile of children who usually board flights. A more detailed study of the age profile of children on flights should be conducted to better define the average weight to be considered for the wide range of 2 to 12 years of age.

5.2 Passengers mean masses plus carry-on luggage

The main findings of the descriptive statistical analyses are that age and weights have similar distributions in 2022 as they did in previous 2008-9 EASA study.

The mean value of all passengers in 2022 is 75.6 kg and that of carry-on weighs is 7.6 kg on average. Male passengers have a mean passenger weight of 82.2 kg, which is 14.7 kg more than the average female passenger (67.5 kg).

When performing more advanced econometric techniques, it becomes evident that, under the assumption that the age distribution of passengers, the gender ratio and purpose remained constant over time, there was no significant weight gain or loss in the passenger's population.

The carry-on luggage has increased since 2008-9 with 1.5 kg.[16] Age, gender, season, purpose and haul all have a significant effect on the carry-on luggage passengers take with them. Overall, male passengers take more carry-on luggage with them than female passengers, business passengers take more than leisure travelers, and medium and long-haul passengers take more than short-haul passengers. Lastly, passengers flying in the winter take more carry-on luggage with them than those flying in the summer.

[16] This is when performing the Tobit regression. With OLS, this increase is 1.4 kg since 2008-9.

Table 25 - Mean weights per gender for 2022 and 2009

	Gender	Number of obs.	Mean passenger weight in kg	Std. Dev. passenger weight in kg	Mean carry-on luggage weight in kg	Std. Dev. Carry-on luggage weight in kg	Total Weight (body mass + carry-on luggage) in kg
Summer 2022	Male (M)	1 052	79.6	15.5	7.6	5.6	**87.2**
	Females (F)	664	66.6	13.2	7.0	5.5	**73.6**
	Children	27	32.3	10.9	2.8	2.7	35.1
	M + infant	40	82.7	14.4	7.1	4.2	89.8
	F + infant	26	70.9	13.8	10.0	5.7	80.9
	All	1809	74.1	16.7	7.3	5.5	81.4
Winter 2022	Male	1233	84.4	14.8	8.1	4.4	**92.5**
	Females	889	68.2	13.0	7.9	4.5	**76.1**
	Children	16	31.8	15.1	1.7	2.4	33.5
	M + infant	50	81.6	16.1	7.0	3.4	88.6
	F + infant	48	69.8	13.5	8.0	4.2	77.8
	All	2236	77.2	16.6	7.9	4.5	85.1
Total 2022	Male	2 285	82.2	15.3	7.8	5.0	**90**
	Females	1 553	67.5	13.1	7.5	5.0	**75**
	Children	43	30.4	12.4	2.2	2.6	34.3
	M + infant	90	82.4	15.3	7.1	3.7	89.2
	F + infant	74	70.2	13.5	8.7	4.9	78.9
	All	4 045	75.6	16.7	7.6	5.0	83.3
Total 2009	Male	12 588	84.6	15.0	6.7	4.7	**91.3**
	Females	8 351	66.6	12.7	6.0	4.4	**72.5**
	Children	1 420	30.7	11.7	2.0	2.6	32.8
	M + infant	298	83.0	14.6	7.0	4.9	90.1
	F + infant	244	65.7	12.4	5.5	5.0	71.3
	All	22 901	74.5	19.9	6.1	4.6	80.6

5.3 Ratio between female and male passengers and mean weight

The average ratio of men and women at all airports used for the survey equals about 60 percent men and about 40 percent women. Therefore, it is recommended to adopt a similar ratio if a single passenger weight is the goal.

A slight variation in the proportions of men and women could be observed at some airports. However, in no case was the share of men more than 61 percent. Thus, the adoption of the 60:40 ratio results in a conservative estimate in favor of safety.

Table 26 - Percentages of genders per airport

2022 – both seasons	Current airport	ATH	BRU	CPH	MUC	MXP	SOF	Total
Gender	Male	50%	58%	61%	51%	59%	54%	**56%**
	Female	42%	37%	33%	44%	38%	41%	**38%**
	Children	2%	1%	2%	2%	1%	2%	1%
	Male & Infant	3%	3%	3%	1%	1%	2%	2%
	Female & Infant	3%	2%	2%	2%	1%	2%	2%

Finally, the sum of the average weight of passenger mass and the mass of the carry-on luggage is 84.0 kg. This is almost the same as the total weight obtained in the previous EASA study published in 2008-9.

Table 27 - Mean adults passenger and carry-on luggage weights per season in 2009 and 2022

	Weight in kg	Winter	Summer	Total
2009	Passenger weight	79.6	75.1	77.4
	Carry-on luggage	7.0	5.7	6.4
	Total weight	**86.6**	**80.8**	**83.8**
2022	Passengers weight	77.6	74.7	76.3
	Carry-on luggage	8.0	7.4	7.7
	Total weight	**85.6**	**82.1**	**84.0**

5.4 Checked luggage mean masses

Considering the average weight of checked luggage, it averaged 16 kg, which is always limited by the luggage policies of each airline. This value was about 1kg below the value observed in the previous EASA study released in 2008-9.

Table 28- Mean checked luggage per season in 2009 and 2022

	Weight in kg	Winter	Summer	Total
2009	Checked luggage weight	16.6	16.9	16.7
2022	Checked luggage weight	15.9	16.0	15.9

6 Conclusion and recommendations

6.1 Survey results summary

- The mean value of all passengers in 2022 is 75.6 kg and that of carry-on weights is 7.6 kg on average.
- The mean all passenger weight plus carry-on luggage was 83.3kg.
- Considering only adults, the mean passenger weight plus carry-on luggage was 84.0 kg.
- Male passengers have a mean passenger weight of 82.2 kg, which is 14.7 kg more than the average female passenger (67.5 kg).
- Male carry-on luggage has a mean value of 7.8kg, leading to the total weight (passenger plus carry-on luggage) of 90kg.
- Female carry-on luggage has a mean value of 7.5kg, leading to the total weight (passenger plus carry-on luggage) of 75kg.
- Looking at the more advanced econometric techniques: under the assumption that the age distribution of passengers, the gender ratio and purpose remained constant over time, there was no significant weight gain or loss in the passenger population.
- The carry-on luggage increased with 1.5 kg[17] since 2008-9.
- Age, gender, season, purpose and haul all have a significant effect on the carry-on luggage passengers take with them
- Male passengers take 0.2 kg more carry-on luggage with them than female passengers
- Passengers flying with FSCs take 0.8 kg more than passengers travelling with LCCs
- Medium haul passengers take 0.2 kg more than short haul passengers
- In winter, passengers take 1 kg carry-on luggage more with them than in the summer
- Long haul passengers take 1.3 kg more checked luggage than short haul passengers
- According to descriptive statistics, there has been a 0.8 kg decrease in mean checked luggage between 2009 and 2022.
- The mean carry-on luggage weight in 2022 in 7.6 kg and the mean checked luggage weight in 2022 is 15.9 kg. The mean passenger weight in 2022 is 75.6 kg.
- The age and gender distributions of air travelers have an effect on mean passenger weights. The distribution of age and gender has remained similar to 2009 and 2022.
- The distribution of age and gender varies by season for unknown reasons, potentially due to COVID.
- The percentage of air travelers not taking carry-on luggage has decreased from 6.2% by around 3%. The share of air travelers not taking carry-on luggage in 2022 is 3.3 %.
- In the empirical analysis, controlling for flight and passenger characteristics (such as age and gender), we find no significant increase in passenger weights between 2009 and 2022.
- The change of mean passenger weights over time can, to a large extend, be explained by the change in passenger characteristics, i.e. age and gender.

[17] When considering the Tobit model

- Age and weights have similar distributions in 2022 as they did in 2008-9

6.2 Conclusion regarding data findings

The purpose of this research is to provide statistical support for EASA that the current passenger and baggage masses are adequately reflected in the AIR OPS regulations.

The main findings of the descriptive statistical analyses are that age and weights have similar distributions in 2022 as they did in 2008-9. The mean value of all adult passengers in 2022 is 76.3 kg and that of carry-on weighs is 7.7 kg on average. Male passengers have a mean weight of 82.2 kg, which is 14.7 kg more than the average female passenger (67.5 kg). However, when performing more advanced econometric techniques, it becomes evident that - under the assumption that the age distribution of passengers, the gender ratio, and purpose for travel (business and leisure) remained constant over time - there was no significant weight gain or loss among the passengers.

The carry-on luggage of adult passengers has increased since 2008-9 with 1.3 kg[18]. Age, gender, season, purpose and haul all have a significant effect on the carry-on luggage passengers take with them. Overall, male passengers take more carry-on luggage with them than female passengers, business passengers take more than leisure travelers, and medium and long-haul passengers take more than short-haul passengers. Lastly, passengers flying in the winter take more carry-on luggage with them than those flying in the summer.

6.3 AIR OPS regulation updates recommendations

Due to the complex changes in flight schedules, including significant reduction of flights due to the COVID-19 outbreaks during the project period, segregation of passenger profiles into “holiday charter” flights were not pursued.

It was felt that obtaining the weight of all passengers using a random and randomized approach during this period of significant change in airline operations would be most appropriate to obtain results adherent to the overall passenger weight profile, using a statistical approach to the results.

Thus, the average results obtained should be compared to the weight values recommended today and also to the values suggested in the 2008-9 EASA study. It is also worth noting that the results obtained in this study converge in their statistical distribution with those obtained in the 2008-9 EASA study, corroborating the representativeness of the data obtained now in 2022 despite the COVID-19 outbreak.

[18] This difference is found for both the descriptive statistics and the OLS regression.

The similar results to those observed in the 2008-9 EASA study would in principle be a contradiction to what is expected and reported on a scientific basis by WHO that the world population is heading towards overweight.

On the other hand, considering that aviation has been expanding consistently over the last few decades - especially with the entry of low-cost airlines - it is expected that air travel will, in a short period of time, serve a larger and more diverse spectrum of people. This includes different economical levels.

Last but not least, we should highlight that the current study was conducted during a pandemic, when economic uncertainties and ticket costs may have significantly kept the most economically vulnerable population away from flying. In general, this population may be the ones with less concern about dietary habits.

Table 29 - Air Ops regulation and previous EASA study

Standard masses for passengers - aircraft with a total number of passenger seats of 20 or more

Passenger seats	20 and more		30 and more
	Male	Female	All adult
AIR OPS Regulation			
All flights except holiday charters	88	70	84
Holiday charters	83	69	76
Children	35	35	35
EASA 2008.C.06 Study			
Scheduled	92	73	86
Non-scheduled	88	71	80
Children	40	40	40
Recommended standard masses by EASA 2008.C.06 Study			
All flights	94	75	88
Checked baggage			
All flights	17	17	17

As a result of the current study, the mean value of all passengers in 2022 is 76.3 kg and that of carry-on weighs is 7.7 kg on average, thus the mean passenger weight plus carry-on luggage is 84.0 kg for adults.

As regulation indicates 84kg, it is representing the current average passenger weight, therefore no need for an update.

It is important to emphasize that the previous study from 2008-9 that recommended the use of 88kg, adopted different assumptions to propose recommendations as follows.

In 2008-9, the previous study obtained a total weight of 91.3 kg for male passengers and 72.5 kg for female passengers, which includes hand luggage considering winter and summer. The table from the 2008-9 EASA study is reproduced below for reference.

Table 30 - 2009 EASA study results[19]

Passenger masses including carry-on luggage by season and gender (the figures for adult passengers include passengers carrying an infant)

Season	Gender	Mean	n	Std.dev.	Accuracy (%)	Conf. Range (95%)
Summer	All adults	80.8	10,412	17.5	0.4	0.34
	- Male	*88.7*	*5,899*	*16.3*	*0.5*	*0.42*
	- Female	*70.5*	*4,513*	*13.3*	*0.5*	*0.39*
	Child (2-12 years)	33.0	1,083	12.4	2.2	0.74
	Measured passengers[20]		11,495			
Winter	All adults	86.6	11,069	17.5	0.4	0.33
	- Male	*93.5*	*6,987*	*15.6*	*0.4*	*0.37*
	- Female	*74.6*	*4,082*	*13.8*	*0.6*	*0.42*
	Child (2-12 years)	32.0	337	13.5	4.5	1.44
	Measured passengers		11,406			
Total	All adults	83.8	21,481	17.7	0.3	0.24
	- Male	*91.3*	*12,886*	*16.1*	*0.3*	*0.28*
	- Female	*72.5*	*8,595*	*13.7*	*0.4*	*0.29*
	Child (2-12 years)	32.8	1,420	12.7	2.0	0.66
	Measured passengers		22,901			

Source: NEA

These figures are quite similar to the current study, which recorded 90 kg for men and 75 kg for women.

On the other hand, the 2008-9 EASA study decided to assume a more conservative mass for males and females to make recommendations. The value considered was 94 kg for males, which were recorded during the winter and 75 kg for females also recorded during the winter survey.

Not only the decision to consider the winter data, but also a different ratio between male and female was adopted by the previous study at the fixed ratio of 70/30.

In the current study it was decided to consider all observations and not a specific ratio between males and females. This decision is based on the fact that the airport surveys provided different proportions between the two groups, so it was understood that adopting the average mass value from all observations would be more representative.

[19] NEA: Survey on standard weights of passengers and baggage - Final report (R20090095.doc), p. 68

Table 31 - Sensitivity analysis using current data and 2009 EASA study male female ratio

	Male Mass + Carry-on baggage [kg]	Female Mass + Carry-on baggage [kg]	M/F ratio	Average Mass + Carry-on baggage assuming fixed ratio [kg]	All passengers + carry-on baggage and observations ratio [kg]	Difference from fixed ratio or regulation for all pax [kg]	Comments
EASA 2008-9 (Summer only)	88.7	70.5	70/30	83.2	80.8	-2.4	
EASA 2008-9 (Winter only)	**93.5**	**74.6**	**70/30**	**87.8**	**86.6**	-1.2	**2008-9 recommendation**
EASA 2008-9 All seasons	91.3	72.5	70/30	85.7	83.8	-1.9	
Survey (Winter only)	92.5	76.1	70/30	87.6	85.1	-2.5	Change M/F Ratio
Survey (Winter only)	92.5	76.1	60/40	**85.9**	85.1	-0.8	
Survey All seasons	90.0	75.0	70/30	85.5	83.4	-2.1	Change M/F Ratio
Survey All seasons	90.0	75.0	60/40	**84.0**	83.4	-0.6	
Survey (Summer only)	**All adults**				**82.1**	-1.9	Observation ratio
Survey (Winter only)	**All adults**				**85.6**	1.6	Observation ratio
Survey All seasons	**All adults**				**84.0**	0.0	Observation ratio
Regulation				**84.0**			

Performing a sensitivity study, see Table 31, if the current study considers the previous 70/30 ratio and only the winter data as suggested in 2009, the average recommended mass for passengers plus carry-on luggage would be 87.6 kg. Close to the value recommended by the previous study of 88 kg.

However, based on the current data, the assumption of a higher male to female ratio would not be supported as the overall ratio approaches the 60/40 ratio.

Therefore, considering a fixed 60/40 ratio and assuming only winter data, the average mass would be 85.9 kg. This would be around 2 kg above the current regulation, but more than 2 kg below the 2008-9 EASA study recommendation.

Additionally, assuming the average masses of all adults observations during the winter, the average value would be 85.6 kg, so 1.6 kg above the current regulation and 2.4 below the previous recommendation.

Observing only the summer data, the average mass observed would be 82.1 kg, almost 2 kg below the regulation and almost 7 kg below the previous recommendation.

This study could conservatively adopt a recommendation based on winter measurements, in which case we would suggest a mass of 86 kg obtained from all measurements; however, the study shows that variations in the proportion of males and females are more significant for a specific flight than the adoption of the weight observed only in winter as a safety margin.

If indeed regulation is needed to achieve even more conservative approaches to passenger weight, it is worth exploring in future studies the passenger weight observed in more severe winter locations, favoring winter times of the year and conducting the survey at airports more prone to lower temperatures.

As a fact, the mean masses of all observations during winter is 85.6 kg for adults, around 1.6 kg above to current regulation value of 84 kg.

Finally, moving towards a more representative picture of actual passenger weights for a safer operation, it is worth recommending that the regulation adopt standard weights by gender. As gender plays the most significant role in obtaining the passenger weight estimation, providing the recommended weight by gender may mitigate bias on flights or routes composed mainly with one gender.

Table 32 - 2022 final results and mass recommendation per gender and season

	Gender	Total Weight (body mass + carry-on luggage) in kg	Recommendation mass
Summer	Male (M)	87.2	88 kg
	Females (F)	73.6	74 kg
		82.1	**82 kg**
Winter	Male	92.5	93 kg
	Females	76.1	76 kg
		85.6	**86 kg**
Total 2022	Male	90	90 kg
	Females	75	75 kg
		84.0	**84 kg**

6.4 Impact in air operations payload in case of regulation change

Variations in the average weight assumed for weight and balance should be carefully evaluated. Changing it to values higher than the practiced will result in reduced payload availability or reduced range considered for the aircraft due to the possible reduction in the amount of fuel that could be considered to keep the aircraft up to the MTOW.

It is unlikely that short routes are affected in larger aircraft, however, as the regulation applies to smaller aircraft, for these, the adoption of higher values of average weight per passenger would most likely lead to reduced availability of seats or cargo in the baggage compartment.

Assuming the 4 kg increase suggested in the previous study, which was based on similar passenger and luggage weight results obtained during the current survey, but assuming the male/female ratio of 70/30, would add additional 1% of the MTOW weight estimation increase as per table below.

Table 33 - Additional passenger weight impact on payload availability

	SEATS	EXTRA WEIGHT PER PASSENGER [KG]	TOTAL EXTRA WEIGHT [KG]	MTOW [KG]	% of MTOW	MAXIMUM PAYLOAD [KG]*	% PAYLOAD
B378	160	4	640	79016	0.8%	20540	3.1%
B373 MAX	190	4	760	88300	0.9%	20882	3.6%
B773	312	4	1248	299370	0.4%	68500	1.8%
B789	285	4	1140	254011	0.4%	52587	2.2%
A319	128	4	512	75500	0.7%	14000	3.7%
A320	150	4	600	78000	0.8%	16600	3.6%
A321	212	4	848	93500	0.9%	27070	3.1%
A332	261	4	1044	242000	0.4%	70000	1.5%
EMB190	108	4	432	51800	0.8%	13047	3.3%
EMB175	80	4	320	40370	0.8%	10094	3.2%

* estimated

When considering possible payload reduction assuming extra 4 kg for each passenger, it may represent around 3% of payload capacity reduction.

As current data obtained through the current survey suggest the male/female ratio around usually 60/40 in all surveyed airports and mean masses obtained considering both seasons around are around 90 kg for male and 75 kg for female passengers, it may end up on 84 kg as currently defined on regulations. If adopted a conservative approach using only winter data, the mean masses would be between 86 kg and 85 kg as per current data analysis, thus up to 2 kg above the current regulation with impact in payload estimated around 1.5%.

From a safety point of view, the adoption of a higher standard weight will increase the safety margin of operations.

Smaller aircraft are more exposed to inaccurate weight values due to its difficulty to keep the center of gravity (CG) envelope as required. For these cases, the use of standard weight values per by gender might mitigate the issue.

One second concern is the actual takeoff weight being above the assumed takeoff weight for the runway takeoff calculation. Pilots are required per current regulations to calculate the required takeoff runway length based on the most restrictive criteria of the performance information contained in the Aircraft Flight Manual (AFM) and for twin engine aircraft, which are the majority of CAT operations, the field length limit weight is usually determined by one of the engine-out distance criteria.

Research into published studies on accidents and incidents that may have been caused by overweight were not conclusive, since in most events the actual weight data of the aircraft could not be confirmed. The risk of experiencing situations where the gross weight of the aircraft is above the assumed gross weight for the runway length calculation could be mitigated if the regulations would adopt different standard weights by season and gender, however, it will not eliminate the risk.

Therefore, improved runway safety areas (RSAs) shall be in place to mitigate risks involving the possibility of standard weights are not representing the actual weight.

According to a publication by the Civil Aviation Authority of New Zealand and FAA Pilot's Handbook of Aeronautical Knowledge chapter 11 from 2006, in general it is expected that a 2 percent increase in gross weight would increase takeoff distance by 4 percent and landing distance by 2 percent. So, adopting an additional 2 percent% increase to the standard weight based solely on the winter survey would be expected to impact the total takeoff gross weight of the aircraft by around 1 percent% at most. As a consequence, the runway calculation would expect to require a maximum additional 2 %percent in takeoff length.

Thus, if the actual gross weight of the aircraft is above 1% of the estimated weight, the aircraft would require an additional 2% of runway length to stop in case of engine failure, requiring the use of runway safety areas.

The use of regulations with distinct standard weights according to season, winter and summer, and the adoption of standard weights by gender, might mitigate the risk by improving the safety margin.

6.5 Future studies recommendation

The 2022 research has a combination of small and large airports, which is favorable for the overall sample. Concerning the number of airports that need to be taken into the sample, we recommend a minimum of the same amount of airports and preferably one or two additional airports with routes that have a higher share traffic of small aircraft and low cost carriers so as to reach a higher sample size for these travelers.

In future studies, we recommend to continue using survey and luggage data from this and previous research iterations, as shown in this analysis with data for 2008-9. This will allow to have higher estimation efficiency for passenger characteristics and flight characteristics than otherwise. Similarly, to compare full sample passenger ratios with survey sample passenger ratios, appears to be a sound methodology to identify bias in the research. When choosing

airports one main criterion should be less bureaucratic procedures to obtain permissions for the fieldworkers to access the security area of the airport.

Due to the impact of the COVID-19 pandemic on passenger composition, we suggest to conduct a similar study again in 5 years to exclude those effects and also potential changes on purpose of flight, e.g. due to remote working maybe less business travel and more leisure.

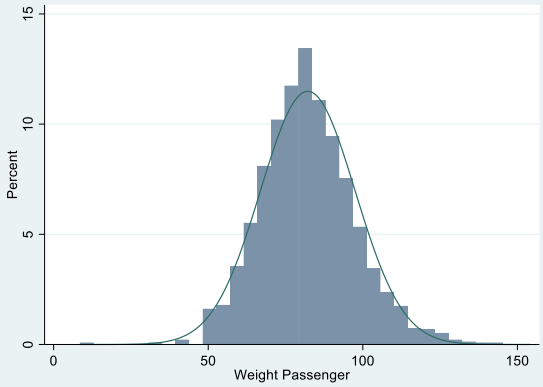
7 Appendices

Appendix A – Detailed results of the airport selection analysis

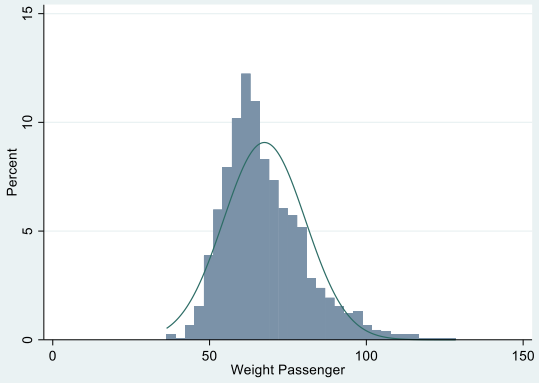
		Points awarded (1 indicates passing of criteria; 0 indicates fail of the criteria)																	
Region	**Analyzed airport**	**Yearly traffic size 2019 base**	**Traffic size February 2019 (low season)**	**Traffic size July 2019 (high season sample)**	**Average monthly traffic size in 2019**	**Domestic traffic**	**EU traffic**	**Non-EU traffic**	**% of Low-Cost-Carrier traffic**	**% of Business class passengers**	**Scheduled operation of turbo prop aircraft**	**Scheduled operation of narrow body jet**	**Scheduled operation of wide body jet**	**Scheduled operation of regional jets**	**Operation of LCC and full-service carriers from the same terminal / area**	**At least 10 published " holiday" destinations**	**LH Group station**	**Estimated difficulty of receiving approvals**	**Total score**
		Minimum of 2 Million passengers / year	Minimum of 500,000 passengers / month	Minimum of 500,000 passengers / month	Minimum of 500,000 passengers / month	Minimum of 1 Million passengers / year	Minimum of 1 Million passengers / year	Minimum of 1 Million passengers / year	Mini. of 30% and max. of 70% of total	Minimum of 2% of total	" Yes" for approval	" Yes" for approval	" Yes" for approval	" Yes" for approval	" Yes" for approval	" Yes" for approval	" Yes" for approval	" Yes" for approval (indicates low estimated difficulty)	
UK & Ireland	MAN (Manchester)	1	1	1	1	1	1	1	1	0	1	1	1	1	1	1	1	0	**15**
	LGW (London)	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	0	**16**
Benelux & France	AMS (Amsterdam)	1	1	1	1	0	1	1	1	1	1	1	1	1	1	1	1	0	**15**
	TLS (Toulouse)	1	0	0	0	1	1	0	1	1	1	1	0	0	1	1	1	1	**11**
	BRU (Brussels)	1	1	1	1	0	1	1	0	1	1	1	1	1	1	1	1	1	**15**
Portugal, Spain & Italy	MAD (Madrid)	1	1	1	1	1	1	1	0	1	1	1	1	1	1	1	1	0	**15**
	MXP (Milan)	1	1	1	1	1	1	1	0	0	1	1	1	1	1	1	1	1	**15**
	BCN (Barcelona)	1	1	1	1	1	1	1	1	0	1	1	1	1	1	1	1	0	**15**
	BGY (Bergamo)	1	1	1	1	1	1	1	0	1	0	1	0	0	1	1	0	1	**12**
	LIS (Lisbon)	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	**17**
Scandinavia, Finland & Iceland	ARN (Stockholm)	1	1	1	1	1	1	1	1	1	1	1	1	1	1	0	1	0	**15**
	CPH (Kopenhagen)	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	0	**16**
	HEL (Helsinki)	1	1	1	1	1	1	1	0	1	1	1	1	1	1	1	1	0	**15**
	OSL (Oslo)	1	1	1	1	1	1	1	1	1	1	1	1	1	1	0	1	0	**15**
Germany, Switzerland and Austria	FRA (Frankfurt)	1	1	1	1	1	1	1	0	1	1	1	1	1	1	1	1	0	**15**
	MUC (Munich)	1	1	1	1	1	1	1	0	1	1	1	1	1	1	1	1	0	**15**
	KLU (Klagenfurt)	0	0	0	0	0	0	0	1	1	1	1	0	1	1	0	1	1	**8**
	FMM (Memmingen)	0	0	0	0	0	1	0	0	1	0	1	0	1	1	1	0	1	**7**
	SCN (Saabrücken)	0	0	0	0	0	0	0	1	1	0	1	0	1	1	0	1	1	**7**
	VIE (Vienna)	1	1	1	1	0	1	1	1	1	1	1	1	1	0	1	1	0	**14**
Estonia, Latvia, Lithiania, Czechia, Slovakia, Poland, Slovenia, Hungary	PRG (Prague)	1	1	1	1	0	1	1	1	1	1	1	1	1	1	1	1	0	**15**
	TLL (Tallin)	1	0	0	0	0	1	0	0	1	1	1	1	1	1	0	1	1	**10**
	BUD (Budapest)	1	1	1	1	0	1	1	1	1	1	1	1	1	0	1	1	0	**14**
	WAW (Warsaw Chopin)	1	1	1	1	1	1	1	1	1	1	1	1	1	1	0	1	0	**15**
Greece, Cyprus & Malta	ATH (Athens Venizelos)	1	1	1	1	1	1	1	0	1	1	1	1	1	1	1	1	0	**15**
Romania and Bulgaria	SOF (Sofia Intl)	1	0	1	1	0	1	1	1	0	1	1	1	1	1	1	1	0	**13**

Appendix B – Male and female age distribution

Male age distribution 2022



Female age distribution 2022



Appendix C – Overview allowed carry-on luggage

Baggage Policy Overview
(retrieved 1.9.2022)

Carrier	Class	Carry-on		Checked	
		# Bags	Weight	# Bags	Weight
Lufthansa					
	Economy	1	8kg	1	23kg
	Premium Economy	1	8kg	2	23kg
	Business	2	8kg	2	32kg
	First	2	8kg	3	32kg
Air France					
	Economy	1	12kg	1	21kg
	Premium Economy	2	12kg	2	23kg
	Business	2	18kg total	2	32kg
	First	2	18kg total	3	32kg
Brussels Airlines					
	Economy	1	8kg	1	23kg
	Premium Economy	1	8kg	2	23kg
	Business	2	8kg	2	32kg
KLM					
	Economy	1	12kg total	1	23kg
	Premium Economy	2	18kg total	2	23kg
	Business	2	18kg total	2	32kg
British Airways					
	Economy	1	23kg	1	23kg
	Premium Economy	2	23kg	2	23kg
	Business	2	23kg	2	32kg
	First	2	23kg	3	32kg
Iberia					
	Economy	1	10kg total	1	23kg
	Premium Economy	1	14kg total	2	23kg
	Business	2	14kg total	2	23kg
TAP					
	Economy	1	8kg	1	23kg
	Premium Economy	2	8kg	2	23kg
	Business	2	8kg	2	32kg
Swiss					
	Economy	1	8kg	1	23kg
	Premium Economy	1	8kg	2	23kg
	Business	2	8kg	2	32kg
	First	2	8kg	3	32kg
Austrian					
	Economy	1	8kg	1	23kg
	Premium Economy	1	8kg	2	23kg
	Business	2	8kg	2	32kg

	First			3	32kg
LOT					
	Economy	1	8kg	1	23kg
	Premium Economy	2	12kg total	2	23kg
	Business	2	9kg	3	32kg
Condor					
	Economy	1	8kg total		20kg total
	Premium Economy	1	10kg total		25kg total
	Business	2	16kg total		30kg total
Eurowings					
	Economy	1	8kg		
EasyJet					
	Economy	1	15kg		
Ryanair					
	Economy	1	Personal item		
WizzAir					
	Economy	1	10kg		
Emirates					
	Economy	1	7kg		20kg total
	Premium Economy	1	10kg		35kg total
	Business	2	7kg		40kg total
	First	2	7kg		50kg total
Qatar					
	Economy	1	7kg		25kg total
	Business	2	15kg total		40kg total
	First	2	15kg total		50kg total
Etihad					
	Economy	1	7kg	2	23kg
	Business	2	12kg total	2	32kg
	First	2	12kg total	2	32kg
Delta					
	Economy	1	No limit	1	23kg
	Premium Economy	1	No limit	2	23kg
	Business	1	No limit	2	32kg
American Airlines					
	Economy	1	No limit	0	23kg
	Premium Economy	1	No limit	1	23kg
	Business	1	No limit	2	32kg
	First	1	No limit	3	32kg
United					
	Economy	1	No limit	1	23kg
	Premium Economy	1	No limit	2	23kg
	Business	1	No limit	2	32kg
	First	1	No limit	2	32kg
SkyExpress					
	Economy	1	8kg	1	15kg
Bulgaria Air					
	Economy	1	10kg	1	23kg

	Business	2	15kg total	2	32kg
SAS					
	Economy	1	8kg	1	23kg
	Premium Economy	2	8kg	2	23kg
	Business	2	8kg	2	32kg
DAT					
	Economy	1	8kg	1	23kg
Air Greenland					
	Economy	1	8kg		20kg total
	Premium Economy	2	8kg total		30kg total

Appendix D – FSC versus LCC in different seasons

2022	Gender	Summer	Winter	Std. Dev. Summer	Std. Dev. Winter	N. Obs. Summer	N. Obs. Winter
FSC	Male	80.3	85.0	15.7	14.2	828	903
	Female	66.6	68.0	13.3	12.9	518	599
	Child	33.2	29.9	11.6	14.1	22	13
	Male with infant	82.0	80.3	14.7	16.4	37	35
	Female with infant	71.4	69.1	14.9	12.3	21	31
	Total	74.5	77.7	17.0	16.6	1,426	1,581
LCC	Male	77.0	82.6	14.4	16.5	221	307
	Female	66.8	68.3	13.1	13.1	145	275
	Child	28.2	39.8	5.7	19.9	5	3
	Male with infant	91.4	84.1	7.5	15.1	3	12
	Female with infant	68.4	71.2	8.3	15.7	5	17
	Total	72.4	75.7	15.5	16.8	379	614

Appendix E – Small versus large aircraft in different seasons

	Size	Summer 2022	Winter 2022	Std. Dev. Summer	Std. Dev. Winter	N. Obs. Summer	N. Obs. Winter
Weight passenger + hand luggage	Small (<100 seats)	84.3	88.3	18.1	17.2	140	145
	Large (>100 seats)	81.1	84.6	17.9	18.3	1,721	2,158
	Total	81.4	84.8	17.9	18.2	1,861	2,303
Carry-on luggage weight	Small (<100 seats)	7.2	8.4	3.8	4.5	140	145
	Large (>100 seats)	7.3	7.9	5.6	4.4	1,721	2,158
	Total	7.3	7.9	5.5	4.5	1,861	2,303
Passenger weight	Small (<100 seats)	76.8	80.0	17.4	16.2	138	142
	Large (>100 seats)	73.9	77.0	16.6	16.6	1,670	2,091
	Total	74.1	77.2	16.7	16.6	1,808	2,233

Appendix F – Regression results on passenger weights, carry-on luggage weights and the Tobit model results on carry-on luggage of both seasons in 2022

VARIABLES (ref. = reference category)	Dependent variable: Passenger weight (kg) **OLS**	Carry-on luggage weight (kg) **OLS**	Carry-on luggage weight (kg) **Tobit**	Passengers + carry-on luggage weight (kg)
Year (ref. is 2009)				
2022	0.310	1.389***	1.669***	1.874***
Age cat.				
Child	31.38***	3.201***	0.370**	70.83***
Age 13 – 15	67.34***	1.389***	3.091***	80.76***
Age 16 – 20	76.17***	4.643***	4.349***	83.90***
Age 21 – 25	78.49***	5.630***	5.216***	86.97***
Age 26 – 30	81.27***	6.420***	5.504***	89.40***
Age 31 – 35	83.65***	6.730***	5.566***	90.92***
Age 36 – 40	85.24***	6.732***	5.494***	92.02***
Age 41 – 45	86.20***	6.661***	5.651***	92.65***
Age 46 – 50	86.91***	6.794***	5.586***	92.56***
Age 51 – 55	87.01***	6.671***	5.343***	92.62***
Age 56 – 60	86.95***	6.532***	5.492***	92.17***
Age 61 – 65	86.81***	6.625***	5.163***	91.58***
Age 66 – 70	86.50***	6.315***	4.871***	89.92***
Age 71 – 75	85.35***	5.999***	4.365***	88.73***
Age 76 – 80	83.96***	5.588***	4.622***	85.28***
Age 81 – 85	81.33***	5.627***	3.745***	89.20***
Age 86 – 90	83.69***	4.923***	5.406***	85.37***
Age 91 – 95	78.27***	6.279***	7.007***	
Gender (ref. is male)				
Female	-16.80***	-0.565***	-0.215***	-17.11***
Male with infant	-1.348*	-0.0639	0.0954	-1.234
Female with infant	-16.98***	-0.782**	-0.616**	-17.62***
Airport (ref. is ATH)				
BRU	-2.255***	-0.0752	-0.141	-2.266***
CPH	-0.0347	-0.0118	0.0486	-0.000357
FRA	-1.848***	1.028***	1.231***	-0.692*
GW	0.570	-0.0362	-0.00313	0.534
MAD	-3.240***	-0.0528	0.145	-3.171***
MUC	-2.321**	-0.500	-0.834**	-2.740**
MXP	-7.092	-0.848	-0.610	-7.746

SOF	-0.589	-0.645***	-0.723***	-1.324***
WAW	-0.271	-0.448***	-0.531***	-0.766**
AMS	0.891***	0.585***	0.482***	1.387***
Season (ref. is summer)				
Winter	2.122***	1.045***	1.065***	3.172***
Purpose (ref. is leisure)				
Business	1.332***	1.017***	1.234***	2.504***
Haul (ref. is short-haul)				
Medium-haul	-0.205	0.246***	0.219**	-0.0183
Long-haul	0.0926	0.399***	0.481***	0.514
Class (ref. is economy & premium economy)				
Business & first class	0.406	0.110	0.132	0.516
LCC/FSC (ref. is FSC)				
Low cost carrier (LCC)	-0.000791	-0.781***	-0.841***	-0.786***
Observations	24,748	23,322	24,788	24,788
R-squared	0.9708	0.718		0.972

*Note: Standard errors in parentheses, significance *** p<0.01, ** p<0.05, * p<0.1*

Appendix G – Gender ratio's, passenger and carry-on luggage weights per season

2022 – Only summer	Gender ratio	Passenger weight (kg)	Carry-on luggage (kg)	Passenger incl. carry-on luggage (kg)
Male	58.2%	79.6	7.6	87.2
Female	36.7%	66.6	7.0	73.5
Child	1.5%	32.3	2.8	35.1
Male w. infant	2.3%	82.7	7.1	90.3
Female w. infant	1.4%	70.9	10.0	80.8
Total	100%	74.1	7.3	81.4

2022 – Only winter	Gender ratio	Passenger weight (kg)	Carry-on luggage (kg)	Passenger incl. carry-on luggage (kg)
Male	54.7%	84.4	8.1	92.6
Female	39.5%	68.2	7.9	76.2
Child	1.5%	31.8	1.7	31.3
Male w. infant	2.2%	81.6	7.0	88.7
Female w. infant	2.1%	69.8	8.0	78.6
Total	100%	77.2	7.9	84.8

2008-9 – Both seasons	Gender ratio	Passenger weight (kg)	Carry-on luggage (kg)	Passenger incl. carry-on luggage (kg)
Male	55%	84.6	6.7	91.3
Female	36%	66.6	6.0	72.5
Child	6%	30.7	2.0	32.8
Male w. infant	1%	83.0	7.0	90.1
Female w. infant	1%	65.7	5.5	71.3
Total	100%	74.5	6.1	80.6

Appendix H – The Survey

Variable	Question	Options	P/B
To be completed before interview and pre-filled afterwards. Only change if applicable.			
Airport	Note current airport		
Location	Note location	before check in (B) after check in (P)	
Date, time	Saved automatically		
IWER	Note interviewer number		
Weather	Note weather outside	sunny/clear cloudy fog rain-/snowfall	
Temp	Note outside temperature	hot – 28+ °C warm – 22-28 °C neutral – 13-21 °C cold – 1-12 °C freezing – 0 or lower °C	
Language	Choose language (flag)	English, Dutch, French German, Danish, Bulgarian, Spanish, Greek	
Gender	Note gender of respondent	Male Female Other	
Infant	Note if respondent is carrying an infant (0-1 years) *They are included in the respondent weight. Children (2-12) are added later on.*	Yes No	
Flight no.	Could I see your boarding pass please? I would like to write down your flight number. *Remark: check the time of the flight. If the passenger is in a hurry, end the interview*	[open] Flight number unknown End interview (if in hurry)	
Airline	If flight number unknown: Which airline are you using?		
In/out	Are you transferring at this airport or departing?	Departing Transfer Final destination	P
Origin	If transfer or flight number unknown: Where have you flown from?		P
Destination	If flight number unknown: Where are you flying to?		
Purpose	Are you flying for business or for leisure?	Leisure Business	

Class	Are you traveling in business class or economy class today?	Economy Premium economy Business First class	
Luggage1	Do you have any checked in luggage?	Yes No -> skip weight	B
Luggage2	Is this luggage for you only?	For 1 person For 2 or more persons	B
WeightB1.1	Weight check in luggage *Please enter with one decimal place*		B
WeightB1.2	Weight check in luggage		B
WeightB1.3	Weight check in luggage		B
WeightB1.4	Weight check in luggage		B
WeightB1.5	Weight check in luggage		B
WeightP1	Note the number of pieces of carry-on luggage	0 → skips weightP1.2 1 2 3 4 5 or more	P
WeightP1.1	Ask the passenger to step on the scale and to stand as still as possible	Weight passenger incl. carry-on luggage *Please enter with one decimal place*	P
WeightP1.2	Ask the passenger to step off of the scale and put his/her carry-on luggage beside the scale. Then ask the passenger to step on the scale again and to stand as still as possible.	Weight passenger excl carry-on luggage *Please enter with one decimal place*	P
Age	May I ask your age please?	*Minimum of 13 years* No answer	
Age_no	If Age = no answer In that case, may I please note which age group fits you best? *Suggest one or two age groups based on appearance*	12-29 years 30-49 50-69 70-89 90 and above No answer	
Child	Are there any children (aged 2-12) traveling with you?	Yes, one Yes, two Yes, three or more No → go to other	
Child1	What is the age of your (first) child?	*Maximum of 12 years,* *minimum of 2 years.* *no answer* *skip to end if no child of 2-12 years*	
Luggage3.1	Does your child have any checked in luggage?	Yes No -> skip weight	B
WeightB2.1	Weight check in luggage child		B

	Please enter with one decimal place		
WeightB2.2	Weight check in luggage child		B
WeightB2.3	Weight check in luggage child		B
WeightP2	Note the number of pieces of carry-on luggage	0 → skips weightP2.2 1 2 3 4 5 or more	P
WeightP2.1	Ask the child to step on the scale and to stand as still as possible	Weight child incl carry-on luggage *Please enter with one decimal place*	P
WeightP2.2	Ask the child to step off of the scale and put his/her carry-on luggage beside the scale. Then ask the child to step on the scale again and to stand as still as possible.	Weight child excl carry-on luggage *Please enter with one decimal place*	P
Child2	If applicable: What is the age of your second child?	*Maximum of 12 years,* *minimum of 2 years* *no answer* *skip to end if no more children of 2-12 years*	
Luggage3.2	Does your child have any checked in luggage?	Yes No -> skip weight	B
WeightB3.1	Weight check in luggage child *Please enter with one decimal place*		B
WeightB3.2	Weight check in luggage child		B
WeightB3.3	Weight check in luggage child		B
WeightP3	Note the number of pieces of carry-on luggage	0 → skips weightP3.2 1 2 3 4 5 or more	P
WeightP3.1	Ask the child to step on the scale and to stand as still as possible	Weight child incl carry-on luggage *Please enter with one decimal place*	P
WeightP3.2	Ask the child to step off of the scale and put his/her carry-on luggage beside the scale. Then ask the child to step on the scale again and to stand as still as possible.	Weight child excl carry-on luggage *Please enter with one decimal place*	P
Child3	If applicable: What is the age of your third child?	*Maximum of 12 years,* *minimum of 2 years* *no answer* *skip to end if no more children of 2-12 years*	
Luggage3.3	Does your child have any checked in luggage?	Yes No -> skip weight	B

WeightB4.1	Weight check in luggage child *Please enter with one decimal place*		B
WeightB4.2	Weight check in luggage child		B
WeightB4.3	Weight check in luggage child		B
WeightP4	Note the number of pieces of carry-on luggage	0 → skips weightP4.2 1 2 3 4 5 or more	P
WeightP4.1	Ask the child to step on the scale and to stand as still as possible	Weight child incl carry-on luggage *Please enter with one decimal place*	P
WeightP4.2	Ask the child to step off of the scale and put his/her carry-on luggage beside the scale. Then ask the child to step on the scale again and to stand as still as possible.	Weight child excl carry-on luggage *Please enter with one decimal place*	P
Other	Note if there are other co-travelers above 12 years that would like to participate Maximum of 5 other passengers above 12 years and skip to end afterwards.	Yes → add new passenger No → go to end If yes: repeat questions: Gender, Infant, Frequent-Age_no. Skip the child section and back to 'Other'.	